Running Hydrogen on Diesel Era Tracks: Regulatory Gaps in India's Hydrogen Railway Program

- GOWRIPRIYA S & KSHITIZ KUMAR[1]

Abstract

"India completed high-speed testing and officially launched its first indigenous hydrogen fuel-cell train on 17 July 2026 on the Jind-Sonipat route in Haryana."[2]. The move comes as part of the National Green Hydrogen Mission, which aims for hydrogen to decarbonise parts of transportation where overhead electrification is not cost effective, and India's Net Zero commitment by 2070[3].2 But the law has not yet caught up with the technology. Indian Railways continues to be governed by a statute that was designed for steam, diesel and electric traction; two regulators, the Railway Board and the Petroleum and Explosives Safety Organisation, have overlapping jurisdiction; and environmental clearances are framed around the concepts of industrial pollution and not fuel-cell risk. This article examines whether the present law (encompassing the Railways Act, 1989, the Environment (Protection) Act, 1986, the Disaster Management Act, 2005, etc.) provides adequate regulation for the storage, transport, and use of hydrogen on the rail network or if there is a case for having a standalone Hydrogen Transportation Law. It then shows, using a doctrinal approach which analyzes the relevant statutes in light of hydrogen's type of hazard, and in light of comparative law in Germany, the European Union, Japan and China, that the existing law is reactive, multi-regulated and largely lacks standards for liability, given its very different risk profile than diesel. It finds that a dedicated law, built on clearly established safety measures, a single regulator, and a codified liability regime is essential to get India's hydrogen rail project beyond a demonstration phase.

I. Introduction

India's railways have historically decarbonised through electrification rather than through a change of fuel. By the end of 2023, Indian Railways had electrified almost its entire broad-gauge network. Hydrogen changes that calculus for narrow-gauge heritage lines, hilly sections, and low-traffic branch lines, where the capital cost of stringing overhead wires does

[1] *Authors are (2nd Year, B.A.LL. B) students at (National Law University Odisha)*
[2] Press Information Bureau, *India's First Hydrogen-Powered Train: Advancing Green Rail Mobility* (July 16, 2026), https://www.pib.gov.in/FactsheetDetails.aspx?Id=150774&reg=3&lang=1.
[3] *Id.*; Press Information Bureau, *Cabinet approves National Green Hydrogen Mission* (Jan. 4, 2023), https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=1888545.

not make commercial sense. It was on one such route, the roughly ninety-kilometre Jind-Sonipat section in Haryana, that Indian Railways commissioned its first hydrogen fuel-cell train, retrofitting a diesel electric multiple units with hydrogen fuel cells and onboard storage.[4]

The problem is that India is running a fuel product on a chassis that is legally designed for a different type of hazard, one that has a much broader flammability range, low ignition energy, and has a tendency to leak through seals that would be filled with diesel or natural gas. The Railways Act, 1989 was written for diesel and electric traction, however, and is silent on hydrogen storage pressures, refueling procedures or fuel-cell failure modes. [5]The Environment (Protection) Act, 1986 and the clearance process established under the act was developed based on the contamination of industry, and was never intended for the assessment of a hydrogen storage facility co-located with a railway platform.[6] Categories of hazardous materials and substances are identified in the Disaster Management Act, 2005, and provides the authorities with powers on how to respond to industrial accidents, but these rules were not drafted for the case of a HR station located at a railway junction.[7] The main question of the article is whether the existing framework, which is applied to railways and comes from various fields of law such as railway law, environmental law, disaster management law and industrial safety law, is sufficient to regulate hydrogen-powered railways, or whether there is a need for a separate Hydrogen Transportation Law that specifically addresses the issue. There are three subsidiary questions, namely, does the current railway safety legislation consider a fuel such as this one; if so, to whom does the liability to prevent any accident accrue, the Indian Railways or the supplier, manufacturer and/or contractors; and is this question better suited to be dealt with incrementally through amendment to existing law or is something new needed to be developed. The article analyzes the relevant Indian legislations and policy measures, and reads them through Indian courts' previous doctrines that developed under the energy companies in the context of hazardous energy companies, and provides lessons from Germany, European Union, Japan and China by focusing only on hydrogen as a railway traction fuel and not as a feedstock in road transport, aviation and industries.

II. Understanding Hydrogen Rail Technology and Its Legal Significance

[4] Press Information Bureau, *supra* note 1.
[5] Railways Act, 1989, §§ 5-7 (India).
[6] Environment (Protection) Act, 1986, § 2(e) (India).
[7] Disaster Management Act, 2005, No. 53 of 2005 (India).

Hydrogen is defined by the technology employed in production of this gas. The grey hydrogen is generated by steam methane reforming and involves emission of CO2. Blue hydrogen is obtained via the same process but it involves capturing of emissions. The green hydrogen is obtained by electrolysis of water using the renewable energy sources. Only this variant allows the reduction of lifecycle emissions. That is the reason for focusing national mission exclusively on this kind of hydrogen.[8]

After being produced, hydrogen is compressed under extremely high pressure (350 to 700 bar for transportation purposes) and introduced into a fuel cell. In a fuel cell it reacts with oxygen thus generating electricity and leaving water vapour as a byproduct. Generated electricity is supplied to traction motors that are identical to those that are employed by electric locomotives.

However, hydrogen poses its unique risks that should be accounted for during drafting legislation. The presence of storage tanks under high pressure creates serious mechanical danger since explosion of such tank contains enough energy for explosion, even if no ignition occurs.[9]

The pilot project in India's Jind Sonipat takes into account these risks through special considerations regarding hydrogen storage and fuel cell installation and refueling infrastructure, developed jointly with RDSO.[10] Still, the pilot project is incapable of establishing statutory framework. There are many important issues left open: who will certify the storage vessels, who will inspect the refuelling stations, who will compensate damages of the injured passenger and who will be liable for accidents.

III. Existing Legal Framework Governing Hydrogen Railways in India

The Railways Act, 1989 is the basic act under which all railways in India are constructed, maintained and operated, in the process bestowing important administrative and safety powers on the Railway Board and the Commissioner of Railway Safety.[11] Establishes a reporting system for accidents for railway administrations and gives the Commissioner the power to investigate the causes of accidents; and gives the Central Government the powers to

[8] Press Information Bureau, *supra* note 2.
[9] *Id.*; ISO 14687:2019, *Hydrogen fuel quality - Product specification*; ISO 19880-1:2020, *Gaseous hydrogen - Fueling stations - Part 1: General requirements*.
[10] *Id.*
[11] Railways Act, 1989, §§ 5-7 (India).

establish technical and operational safety standards. [12] It also provides for no-fault compensation liability for the railway administration in instances of train accidents and untoward incidents, without restricting it to steam, diesel or electric traction.[13] The problems arise with the subordinate rules which were created around the failure modes that can occur with diesel and electric equipment including brake failure, signal failure, axle defect, etc. As a result of the introduction of hydrogen, there are new modes of failure such as rupture of storage vessels, thermal runaway in fuel cells, or leaks in enclosed coaches that do not fit into any known inspection checklists. While the Commissioner may do so with projects (such as the pilot for Jind-Sonipat), it is an administrative possibility and not a rule, so it is unclear whether hydrogen can be added to the range or whether every future project would require an ad hoc approval process.[14]

Environment (Protection) Act, 1986, which gives the government, the power to fix emission limits, control hazardous substances, and also mandate environmental clearance for certain categories of industries.[15] The framework only applies to a conventional electrification project, but it is possible that, depending on the scale, a hydrogen production and storage facility at a railway junction could trigger this framework, although not specifically. In *Vellore Citizens' Welfare Forum v. Union of India*, courts have given a wide sustainable development mandate to the Act that provides interpretive support to green hydrogen but not a definite regulatory pathway. [16]

The Disaster Management Act, 2005 established the National Disaster Management Authority and also the State/ District Level Disaster Management Bodies for prevention, mitigation and response to hazardous industrial accidents and natural disasters at national and State/ District level.[17] It lays responsibility for institutions in a wide-breadth but it doesn't dictate on a substance-by-substance basis. Fire extinguishing is difficult with a nearly invisible flame and trains cannot be extinguished using ordinary fire extinguishers, but there remains no specific evacuation radius protocol, extinguishing protocols or coordination of

[12] *Id.* § 6.
[13] *Id.* § 124.
[14] Press Information Bureau, *supra* note 1.
[15] Environment (Protection) Act, 1986, § 2(e) (India).
[16] *Vellore Citizens Welfare Forum v. Union of India*, (1996) MANU/SC/0686/1996.
[17] Disaster Management Act, 2005, No. 53 of 2005 (India).

railway service and fire service, and staff trained for diesel fires are not prepared for fire extinguishing in hydrogen situations. [18]

The Occupational Safety, Health and Working Conditions Code 2020 brings together previous factory safety codes, and mandates employers to ensure safe working environments, while giving the government the power to set standards for hazardous substances.[19] Specific conditions such as intervals between pressure vessel inspections, purging, and the use of appropriate protective equipment for use with hydrogen are not yet clearly defined for railway workshops handling hydrogen but would be covered under the general duty.[20]

PESO is the regulator for storage of petroleum, explosives and industrial gases, including hydrogen, and already issues licenses to the storage of hydrogen in the fertiliser and refining sectors. [21] In between, however, a refuelling site is in railway land, which is not under the control of PESO's licensing authority and which is not under the exclusive jurisdiction of the Railway Board; the result is that there is a licence/railway seam that can be a source of delay and conflicts.[22] Lastly, the National Green Hydrogen Mission, is an executive policy and not a legislation. It provides a funding source for production incentives, establishes some targets for the transport sector, but cannot establish enforceable safety standards, a definition of civil liability, or resolve the jurisdictional dispute between the PESO and the Railway Board, which requires legislative powers the Mission lacks.[23]

IV. Major Legal Challenges in Regulating Hydrogen Railways

India has a fundamental vacuum in its regulations in the field of hydrogen railways. No Hydrogen Transportation Act, no one safety body for low-height hydrogen use, statutory hierarchy to solve disputes between Railway Board, PESO and state pollution control boards.

Technical standards are needed, not ad hoc administrative decisions, in the case of safety regulation, where the technical risks already identified above require binding technical standards. Presently, the Indian hydrogen train programme moves forward based on a specific agreement among the Railway Board, Research Design and Standards Organisation and the Commissioner of Railway Safety. While this could work for a single pilot, it won't work for a

[18] Press Information Bureau, *supra* note 1.
[19] Occupational Safety, Health and Working Conditions Code, 2020 (India).
[20] *Id.*
[21] Petroleum and Explosives Safety Organisation, *Guidelines for Storage of Hydrogen*, https://peso.gov.in.
[22] Railways Act, 1989, §§ 5-7 (India).
[23] Press Information Bureau, *supra* note 2.

complete programme, and there should be a single document that combines the rules on the specification of the storage vessels, distances to and from refuelling stations, leak detection and personnel training under the Railways Act, PESO's explosives rules and the Occupational Safety Code.[24]

Another challenge remains unanswered is liability. The Indian tort law provides useful tools but none tested to this specific set of facts. The Supreme Court in *MC Mehta v Union of India* further expanded upon the doctrine of *Rylands v Fletcher*, deleting all exception and obligations, and substituted it with an absolute non-delegable responsibility to all business enterprises involved in hazardous activities.[25] *Indian Council for Enviro-Legal Action v. Union of India* further elaborated this as the polluter must pay principle [26] and *Charan Lal Sahu v. Union of India,* a case decided after Bhopal, has dealt with the restitution liability of the State for mass industrial injury.[27] When taken together, these precedents imply that hydrogen storage and fueling would be considered a hazardous activity and hence would fall under the absolute liability standard, but do not define the apportionment of liability between Indian Railways, manufacturers, suppliers and infrastructure contractors.[28] Public Liability Insurance Act, 1991 only provides for minimum interim relief and not liability allocation, which would lead to long drawn out, first-of-its-kind litigation should there be an accident.[29]

Environmental governance is not developed either. Correct accounting of the climate impact of hydrogen production will involve life cycle emissions such as electricity use for electrolysis, water use, and hydrogen emissions from the electrolysers and fuel cells, while hydrogen tail pipe emissions will be attributed to the tail pipe. No climate accounting or certification is mandated for hydrogen production in India to identify ‘green’ hydrogen from ‘grey’ hydrogen as the hydrogen is used at the tail pipe. Another major shortcoming of clearance processes is the lack of consideration of how water-intensive electrolysis is, especially in regions where there is water stress.[30]

Last but not least, with regard to insurance and international comparison, Germany's Alstom Coradia iLint met the quality criteria of existing pressure vessel and vehicle regulations prior

[24] *Id.*
[25] *M.C. Mehta v. Union of India*, MANU/SC/0396/1987.
[26] *Indian Council for Enviro-Legal Action v. Union of India*, (1996) MANU/SC/1112/1996.
[27] *Charan Lal Sahu v. Union of India*, MANU/SC/0285/1990.
[28] *M.C. Mehta*, AIR 1987 SC 1086.
[29] Public Liability Insurance Act, 1991, No. 6 of 1991 (India).
[30] Press Information Bureau, *supra* note 1.

to series production. In India, it is the other way round: they pilot their train first, and are about to implement a certification process around a train that already is in operation.[31]

V. Comparative International Regulatory Framework

The European Union thus adds a supranational aspect to national laws. The principle of implementation of interoperability and safety certification between member states is present in its framework of railway safety regulations, and the European Green Deal's 'hydrogen strategy' has compelled harmonisation of technical standards for refuelling stations, based on the ISO 14687 and 19880 standards for the quality of hydrogen fuels and the design of fueling stations, respectively.[32] Again, it provides a standard baseline for European operators when certifying, or in the case of India, a structure that is not available in the fragmented market[33]. Japan's strategy, focused on the HYBARI trial train developed by East Japan Railway Company, runs under the rigor of Japan's railways safety law, set by the Ministry of Land, Infrastructure, Transport and Tourism, charging part of the country's other hydrogen society strategy, which considers railway hydrogen one part of a coordinated national hydrogen infrastructure development. Most applicable to the Indian context is the coordination between the transport regulator and the hydrogen strategy – something that is currently lacking between the National Green Hydrogen Mission and the Railway Board.[34]

China's hydrogen railway pilots, including hydrogen trams in Foshan and hydrogen-hybrid trials on other urban transit systems, proceed under a state-directed regulatory model in which technical standards are issued centrally and implementation is coordinated through state-owned operators, allowing rapid scaling once a standard is set, though with less transparency around certification than the German or EU models.[35]

None of these four jurisdictions has enacted a freestanding hydrogen railway law; each instead has extended or adapted an existing, already-robust railway safety regulator, with hydrogen-specific technical standards layered on top and, in the EU's case, harmonised across borders. [36] What distinguishes all four from India is the existence, in each case, of a single competent regulator whose authority over hydrogen rolling stock is not contested by a

[31] Alstom, *supra* note 5.
[32] ISO 14687:2019, *supra* note 13; ISO 19880-1:2020, *supra* note 13.
[33] IEC 63341-1:2025, *Railway applications - Hydrogen and fuel cell systems for rolling stock - Part 1: Fuel cell system* (2025).
[34] Press Information Bureau, *supra* note 2.
[35] T/FSQX 004-2021, *Hydrogen Energy Tram Operation Management Specification* (Foshan Hydrogen Energy Industry Association 2021).
[36] Alstom, *supra* note 5; *FV-E991 series*, *supra* note 41; T/FSQX 004-2021, *supra* note 43.

parallel industrial safety regulator. The seam between the Railway Board and PESO that troubles the Indian framework does not have a real equivalent in Germany, the EU, Japan or China, because railway safety regulation there has jurisdiction broad enough to absorb the new fuel without an external turf dispute.[37]

VI. Why India Needs a Dedicated Hydrogen Transportation Law

India has not yet a law for hydrogen trains is not an argument that exists for the case of having a separate hydrogen railway law. It's based on a much trickier premise: the current laws are fragmentary, lack any obligation on regulators to coordinate, are reactive (as in having a pre-existing pilot to certify after the fact, rather than before) and are unclear about liability and insurance coverage (when things go wrong, you know). No Hydrogen Transportation Law should have to supplant the Railways Act, Environment (Protection) Act, or PESO's jurisdiction; it would merely have to fill the spaces where they do not overlap: a single competent authority to enforce safety, enforceable technical standards, and statutory answers on liability and insurance, as opposed to case-by-case litigation.[38]

The investor-confidence aspect is there as well. A single-window scheme would reduce risk premium in the cost of funding the electrolyser production, refueling infrastructure and rolling stock, with private capital. Such a law would have chapters on the definition of green hydrogen and storage parameters, safety requirements, storage and transport, environmental compliance (lifecycle emissions and water use), mandatory insurance cover, and civil/criminal liability that codifies the courts' absolute liability principle, plus an additional chapter that sets out who shall have the authority to enforce for the railways or industry regulators in the event of any conflict.[39]

VII. Recommendations

The legislative action should be to enact a Hydrogen Transportation Act similar to the above, and to make changes to the Railways Act, 1989 so as to expressly include the Commissioner of Railway Safety's powers in terms of certification of hydrogen and other alternative fuel rolling stock.[40]

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[37] Press Information Bureau, *supra* note 1.
[38] *Id.*
[39] *Id.*
[40] Railways Act, 1989, §§ 5-7 (India).

On the regulatory side, the Government should announce a National Hydrogen Safety Code based on the ISO 14687/19880 series of standards instead of creating ad hoc standards and designate one of the regulators, either perhaps a restructured PESO with explicit railway competence / an independent joint regulator, to make the final judgment on certification. [41] All future hydrogen routes should be subject to a formal certification process, based on the same principle as Germany, certifies before deployment.[42]

From the environmental perspective, hydrogen infrastructure connected to the railway network should be explicitly included in EIA and subjected to a carbon audit over its entire life cycle, and a renewable hydrogen certification scheme should be ensured to ensure that Indian Railways is not using grey hydrogen that is merely being repackaged for a carbon tax subsidy.[43]

On the institutional side, structured trainings of Indian Railways personnel to address emergencies related to hydrogen fuel should be carried out, which are separate from the existing diesel-fire guidelines, and public awareness campaigns should be created to address passenger concerns related to the fuel.[44]

VIII. Conclusion

The hydrogen-powered railways are not some fleeting experiments, but a solution that fits the two commitments India has made publicly, the Net Zero by 2070 and a National Green Hydrogen Mission backed by substantial and adequate public investment, with the particular pathway of the trains that will never justify overhead wires. However, as this legal discussion shows, the current statutory regime offers only partial and ad hoc protection from the risks this technology poses. And Indian tort doctrine is also well developed with the absolute liability principle in *M.C. Mehta* but yet to test the doctrine to apportion liability between an operator, a manufacturer, a supplier and a contractor in a hydrogen railway accident.[45]

"None of this should deter India from advancing its hydrogen railway programme", it is merely that the legal framework must align with the engineering before it goes from a single pilot to the several announced. Technological development is not the only solution for India to rise as a global leader in green hydrogen production. It needs to be backed by a robust

[41] ISO 14687:2019, *supra* note 13; ISO 19880-1:2020, *supra* note 13.
[42] Alstom, *supra* note 5.
[43] Press Information Bureau, *supra* note 1.
[44] *Id.*
[45] *M.C. Mehta*, AIR 1987 SC 1086.

legal structure with safety and accountability features, environmental integrity and public trust. A dedicated Hydrogen Transportation Law would not just be about the regulation of a new form of transportation but would also provide a legal basis for India's shift towards a sustainable hydrogen economy.[46]

[46] Press Information Bureau, *supra* note 1.