INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (XXXX) XXX

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ScienceDirect

journal homepage: www.elsevier.com/locate/he

Review of the environmental policy instruments in the standardization of H_2 for the decarbonization of Mexico

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HIGHLIGHTS

- In Mexico there is a technical regulation (not mandatory) of H2.
- Instruments of environmental policy that legally justify.
- Key elements in the conformation of a norm are proposed.
- The proposal is based on the principle of legality.

ARTICLE INFO

Article history:
Received 24 October 2020
Received in revised form
5 December 2020
Accepted 3 February 2021
Available online xxx

Keywords:
Environmental policy instruments
Hydrogen
Legality
Official mexican standard

ABSTRACT

The objective of this work is to review the environmental and ecological policy instruments that Mexican legislation for existence of an Official Mexican Hydrogen Standard according to the premises motivates decarbonization. There is a worldwide interest in hydrogen (H_2) and its incorporation into legal systems. In Mexico there are large legal gaps that question the legality of H_2, because it is not recognized in a federal law and is only considered in technical standards of voluntary application. Also, Mexico has forest, agricultural, and livestock waste that, if properly used, can cover the energy demand of communities. The main findings of this study refer to the fact that, according to international standards for the management of H_2 and taking into account the regulatory limitations in Mexico, it is possible to promote, an Official Mexican Standard exclusively aimed at establishing the minimum requirements for the design, construction, operation and maintenance of H_2 storage, considering the areas of the opportunity offered by foreign experiences, according to the Mexican context. It is concluded that the parameters of legality exist in the instruments of environmental policy, to support the existence of an Official Mexican Standard of H_2.

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https://doi.org/10.1016/j.ijhydene.2021.02.019

Please cite this article as: Ávalos-Rodríguez ML et al., Review of the environmental policy instruments in the standardization of H_2 for the decarbonization of Mexico, International Journal of Hydrogen Energy, https://doi.org/10.1016/j.ijhydene.2021.02.019

Introduction

In the literature, several studies address the importance of hydrogen (H_2) as an energy carrier and not as an energy source, also highlights its benefits, energy benefits, and advantages in a circular economy, that favors eco-investments, waste management and promotes regulated schemes and practices [1]. Several developed countries have promoted scientific research to incorporate H_2 as a feasible means of energy, mainly because this element is combined with other elements (water, biomass, or oil) and one way to take advantage of it is through fuel cells [2–4].

Some studies have suggested that the availability of H_2 is in constant confrontation with the increasing demand of fuels coming from refineries [5] for what, diverse countries have looked for generating sure forms for the decarbonization of humanity, principally, with the use of fuel cells [6].

H_2 can become inexhaustible, which is why it has been an essential part of the new economic vision based on technological advances aimed at avoiding polluting gases. The so-called "hydrogen economy" is a reflection of this position and although it has been based on electrolyzers and fuel cells invented in the nineteenth century, before the invention of the internal fuel engine and the discovery of oil [7], it is until the last decade, that the interest of H_2 has been present in technological advances in first world countries, such as the United States (USA), Canada, China, Iceland, some European countries, Holland, Sweden, Germany, Denmark, Japan, South Korea, among others. Given this trend, it is important to motivate specific policies for H_2 to accelerate the adoption of low-carbon energies [8], encouraging biotechnology and bioeconomy through government intervention [9], political efficiency [10], and the design of mandatory standards [11]. Similarly, in the academic field, studies on H_2 have been carried out, such as Peschka, 1992; Lovins and Williams, 1999; National Research Council, 2004: Hoffmann, 2001; Rifkin, 2002; Wald, 2004; Service, 2004; Keith and Farell, 2003; Romm, 2004; Kreith and West, 2004; among others [7,12–20], which analyze the way it is extracted, produced, used, transported and stored, recognizing that it implies high costs in each of these stages, mainly in storage, and that at these stages no legislation supports these actions. Furthermore, it is argued that the economic cost will be offset by the ecological cost, especially when thinking on a large scale, for example, it has been estimated that, in terms of useful energy, 1 kg of H_2 is equivalent to more than 3.78 L of gasoline [21].

However, it has been estimated that the energy transition from H_2 will take between 30 and 50 years [7], so it is important to accelerate the pace to encourage technological innovations that compensate for the efficient use of H_2. In Mexico, it is important to consider that the energy access gap has to face political barriers centralized in refineries that divert attention from the technological advances on H_2 that have been developed in developed countries.

Mexican legislation presents important challenges, because the figure of H_2 is not present in a mandatory standard [22], despite the importance of seeking legal corrective measures [23] that in addition to meeting the demands of biofuels, guarantee more best practices [24] and close the gaps of social conflict due to discontent with social benefits [25].

The scenarios for the incorporation of H_2 in the decarbonization of developed countries appear to be optimal, however, for developing countries, some challenges go beyond environmental commitments and international agreements.

For Mexico, economic scenarios (circular economy), social scenarios (acceptance, participation, and commitment of the community), political and legal scenarios (absence of schemes and political instruments that link the use and exploitation of H_2, as well as scarce regulations that guarantee the success of the scarce political instruments) must be considered. Also, there are the cultural ones (based on ideologies thought in the advantages of fossil energy), the ecological scenarios (despite biological richness that Mexico has, environmental imbalances continue to be propitiated that affect the sustainable use of the natural elements in the short and long term) and, the educational scenarios there are few studies that contribute to the analysis not only of the energetic relevance of H_2, but also those that establish proposals of decarbonization embodied in strategies according to the reality of the Mexican people.

Mexico has focused little on renewable energy with geothermal energy at 69%, dual-energy at 12%, coal-fired at 7%, nuclear energy at 6% as well as geothermal energy at 6%, wind energy at 2%, and hydroelectric energy at 1%.

Besides, some projects seek to generate H_2 through auto thermal reforming of ethanol at high pressure, whose tests are still in the laboratory but have suggested that it is feasible to carry out a similar study with other gases, particularly methane [26,27], considering the residual biomass available in Mexico, which is estimated to be close to 278 million tons of solid waste, valuing an energy potential close to 2980 PJ, where 58% of the potential comes from forests and 27% from agricultural and livestock waste [28].

In Mexico, the Ministry of Energy (SEDER by its Spanish acronym) has defined agricultural waste as residual agricultural biomass according to the production cycle of crops temporary and perennial. It also includes forest residues from sawmills. For livestock waste, it considers the manure generated by cattle used to produce milk and as food, the manure from pigs and poultry, and the manure generated in pisciculture [29].

The residual livestock biomass is mainly derived from cattle and pig manure, but also poultry and aquaculture residues. In the case of residual livestock biomass from cattle manure, 60% of the cattle is concentrated in 6 states (Coahuila, Jalisco, Durango, Chihuahua, Hidalgo, and Guanajuato). In Coahuila and Durango, the animal population is found in the Comarca Lagunera [30].

At the national level and due to the deficiency of legally available information in this sector, 181 sources were located that would have a power generation capacity from CH_4 to 5722.52 TJ/a. The SENER indicates that this biomass is currently being used to generate energy, using covered lagoon type digesters [29].

More than 90% of the pig farms in Mexico are dedicated to breeding for meat production, in its different stages; which represent an important niche for the generation of energy from a waste of the livestock sector. On a national level, it was estimated that 15.54 million pigs are produced, of which 56% are distributed in 6 states: Jalisco, Sonora, Puebla, Veracruz, Guanajuato, and Yucatan [31].

In terms of biomass from pig waste, it is estimated that it represents 552,385.32 t SV/a (265,239,754.14 m^3 CH_4/a) included in the excreta and susceptible to biological transformation to biogas production. The capacity to generate energy with the corresponding CH_4 production would be 10,234.54 TJ/a [31].

Biomass from aquaculture waste, generated mainly in Puebla, Jalisco, Nuevo Leon, Durango, Guanajuato, and Yucatan, represents a niche energy opportunity for Mexico of because the techniques to achieve a use with the use of anaerobic digestion are not yet updated. It is estimated that the energy potential would be 48,721 tDBO/a, which, if transformed into methane, would mean 43,630,979 m3 CH_4/a [31].

The residual forest biomass in Mexico comes from sawmills, it has been estimated that about 728,846 t/a of biomass are generated, the energy potential of this residual biomass is 13,897 TJ/a. The generating sources have been classified according to the wood used: in tropical, coniferous, and leafy, representing the Conifers, a greater energy potential TJ/a [32].

Despite the availability of forest, agricultural, and livestock biomass in Mexico, there are still legal gaps that prevent its full use. It has been thought that the challenges go beyond economic, there are also the social, political, legal, technological, and cultural should be taken into account, according to the reality of the ecosystem. It has been identified, on the one hand, that there are gaps in Mexican legislation that cause political disengagement and effectiveness, as well as a lack of participation and social organization.

Mexican regulations consider policy instruments to bring energy advances closer, these instruments are the tools that promote, restrict, guide, or induce the achievement of certain fully defined policy objectives, they are usually of command and control and, of voluntary application.

The literature suggests five types of instruments: those of regulation (command and control) such as norms, permits, authorizations, prohibitions, etc.; those of direct pressure from governments such as environmental infrastructure, national parks, protected areas, rehabilitation of ecosystems, etc.; those of social and public participation such as voluntary agreements, associations, etc. Those involving social and public participation, such as voluntary agreements, associations, etc.; those involving the use of markets, such as the elimination of subsidies, environmental taxes, self-monitoring, etc.; and those involving the creation of markets, such as property rights, marketing, acquisition of environmentally friendly products, investment funds, international funds and incentives, and payments for environmental services, among others [33].

In Mexico, the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA by its Spanish acronym) incorporates since 1996 several instruments of environmental and ecological policy that can be vectors for promoting the use and exploitation of H_2 under a scheme of a circular economy for the decarbonization of Mexico, these instruments are divided into environmental and ecological. The first is Environmental Planning; Ecological Land Management; Economic Instruments; Environmental Regulation of Human Settlements; Environmental Impact Assessment; Mexican Official Standards in Environmental Matters; Self-Regulation and Environmental Audits and, Ecological Research and Education. The ecological instruments considered are Natural Protected Areas; Restoration Zones and, Flora and Fauna [34].

The instruments of environmental and ecological policy in Mexico are usually based on administrative steps to carry out an activity, without monitoring, feedback, and evaluation by the authorities.

Of these instruments, the environmental instrument of Mexican Official Standards is of particular interest, because through command and control regulation, the design, construction, operation, and maintenance of H_2 storage can be promoted.

The objective of this study is to review the environmental and ecological policy instruments that Mexican legislation considers to legally justify the existence of an Official Mexican Hydrogen Standard according to the premises that in the literature motivate decarbonization. To achieve this objective, the study is divided into four sections, the first referring to the international context that promotes H_2 norms, the second to Mexican legality binding on H_2, the third to the revision of environmental policy instruments that promote decarbonization in Mexico and, the fourth to the elements suggested for the conformation of an Official Mexican H_2 Norm, as a proposal according to the economic, technological, ecological and social conditions of Mexico.

Materials and methods

An exploratory and descriptive analysis was carried out based on a literature search in several scientific platforms of Sciencedirect, Redalyc, Scielo, Elsevier, Refseek, Scopus, Worldwidescience considering a period from 2000 to 2020 and using individual and compound search words: hydrogen, policy instruments, circular economy, decarbonization, H_2 normativity, and H_2 technical standards.

From the information obtained and in consideration of the search words, 105 scientific articles were identified, however, due to the relation with the topic under investigation, only fifty manuscripts were considered, of which, 10% have been published in the first half of 2020, 9% in 2019, 8% in 2018 and 2017, 6% in 2012–2014, 5% in 2011 and 2010 and the rest from 2000 to 2009.

Results and discussion

International regulatory context of H_2

The results show that there is a clear need to move towards an H_2 economy, based on its regulation to overcome the technological barrier [35,36].

Some studies have emphasized the use of H_2, its extraction, its storage, and its application, however, there is little research that talks about the importance of legally including the handling of H_2, due to the constant concern about the risks, damages, and dangers that its handling represents.

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However, at the international level, countries that have promoted techniques for the management of H_2 have also adjusted their laws to guarantee their regulation, as is the case of Denmark, Brazil, India, Germany, Spain, Finland, among others. In the case of Mexico, some strategies were incorporated into a failed National Climate Change Plan, energy reforms, and promotion of technical standards that indicate the methods of measuring variables for calculating the percentage of fuel-free energy and the procedure for evaluating conformity (see graph 1).

In the last decade, efforts have been made to develop technical standards to regulate the handling of H_2, especially in the USA, the European Union, Norway, Canada, Japan, and China [35], focusing on the requirements for the design, type of material, manufacture and testing of H_2 container cylinders. Leaving aside the next phase, the transport and use of it.

It is important to differentiate between a technical standard and coercive regulation, the former involving specific aspects that must be addressed, usually not mandatory; while coercive regulation is mandatory. Some studies seek to differentiate the scope between regulations, codes and standards promoted by the International Organization for Standardization (ISO), concluding that the difference lies in the technical requirements of codes and standards [37].

In 1988, the ISO/TC 197 Technical Committee was created to develop standards for systems and devices for the production, storage, transport and use of H_2 (Table 1).

Despite this, the main findings show that current regulations, whether they are called laws, codes, or standards, are an obstacle to the management of H_2 [36,38] because they are international standards that have not been brought into local regulation and are left to the will of the people to observe them.

There are even studies that have compared the regulations of countries that pioneered the regulation of H_2 and observed that they bet on promoting incentives for transport, infrastructure and certifications [35].

This is the case in Mexico, which, lacking mandatory standards, continues to focus energy satisfaction on oil-based energy and to neglect the advances in H_2 energy.

Binding Mexican legislation on H_2

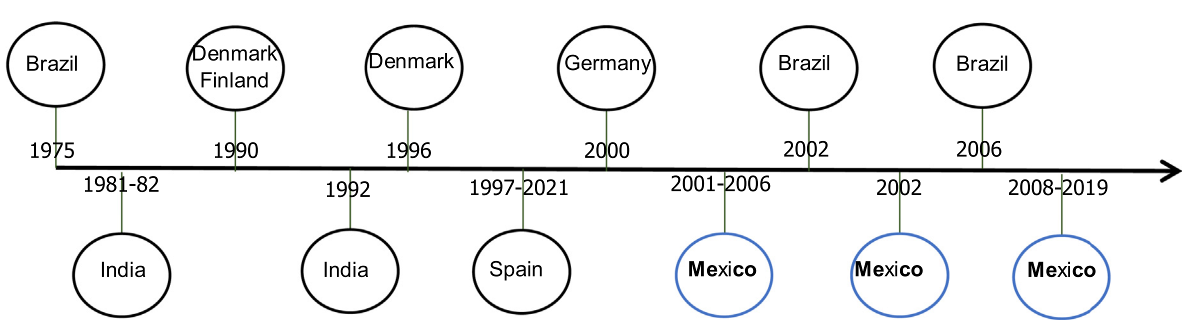
Legality emerges from formally valid law, that is, the set of legal norms that have emerged from a legislative procedure made up of the stages of the initiative, discussion, approval, sanction, publication and validity. In other words, legality is associated with the legal system in force.

The results show that in Mexico the legal provisions on energy focus their attention on fossil sources and, to a lesser extent, on renewable energies, even though it has been recognized that the emphasis on alternative energies based on H_2 is prevalent in the country [39–41].

The current legislation in Mexico binding on energy is as follows:

- Political Constitution of the United Mexican States of 1917;
- General Law of Ecological Equilibrium and Environmental Protection of 1988
- Geothermal Energy Act of 2014;
- Field Energy Act of 2002;
- Electric Industry Act of 2014;
- The Coordinated Energy Regulatory Bodies Act of 2014;
- Law for the Promotion and Development of Bioenergy in 2008;
- Energy Transition Law of 2015;
- Law Declaring the Uranium, Thorium and other substances from which fissile isotopes are obtained that can produce nuclear energy of 1950 as National Mining Reserves;
- Various regulations such as the Geothermal Energy Law (2014); the Field Energy Law (2003); the Public Electricity Service Law on Contributions (1998); the regulations of the Law that Declares the Deposits of Uranium, Thorium and other Substances from which Traceable Isotopes that Can Produce Nuclear Energy are Obtained as National Mining Reserves (1952).

There are also several complementary provisions such as the statute of the Professional Career Service of the Energy Regulatory Commission (2019); the statute of the Human Capital Management System of the Energy Regulatory Commission (2018); the organic statute of the National Energy Control Center (2018); the Manual of Criteria for the Dispatch and Unbundling of Energy for Jointly Owned Units in the Wholesale Electricity Market (2018); the manual of provisions related to the supply and sale of electric energy for public service (2013); the Short-term Energy Market manual (2016); the General Organization Manual of the National Commission for the Efficient Use of Energy (2011); the General Organization Manual of the National Energy Control Center (2018); among others.



Graph 1 – Timeline of when some countries have pushed for H_2 regulations. Source: Own elaboration.

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Table 1 – Technical standards related to hydrogen.

Technical Standard	Year	Considered	Scope
ISO TR 15916	2015	Basic Considerations for the Safety of Hydrogen Systems	Provides guidelines for the use of hydrogen in its gaseous and liquid forms as well as its storage in either of these or other forms (hydrides). It identifies the basic safety concerns, hazards and risks, and describes the properties of hydrogen that are relevant to safety. Detailed safety requirements associated with specific hydrogen applications are treated in separate International Standards.
ISO 14687-2	2012	Hydrogen Fuel - Product Specification, Part 2: PEM fuel cell applications for road vehicles	Specifies the quality characteristics of hydrogen fuel to ensure uniformity of the hydrogen product as dispensed for utilization in proton exchange membrane (PEM) fuel cell road vehicle systems.
ISO TC197	2010	Working Group 9 (ISO 16110-2) Hydrogen Generators Using Fuel Processing Technologies Part 2: Test Method for Performance	Provides test procedures for determining the performance of packaged, self-contained, or factory-matched hydrogen generation systems with a capacity less than 400 m3/h at 0 °C and 101,325 kPa, referred to as hydrogen generators, that convert fuel to a hydrogen-rich stream of composition and conditions suitable for the type of device using the hydrogen (e.g. a fuel cell power system, or a hydrogen compression, storage, and delivery system).
IEC 60079-29-2	2015	Explosive atmospheres	Explosive atmospheres – Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen.
ISO/TS 19880-1	2016	Loading stations	It standardizes H_2 charging stations and the creation of infrastructure for H_2. This international standard covers the production and supply of H_2, considering the storage and fueling of an H_2 vehicle.
ISO/TS 19881	2018	Containers for the storage of H_2	It contains requirements for the material, design, manufacture, marking and testing of mass-produced refillable containers intended solely for the storage of compressed hydrogen gas for the operation of land vehicles [38].
No 406/2010 of the Commission Regulation (EU)	2010	On type-approval of hydrogen-powered motor vehicles	On type-approval of hydrogen-powered motor vehicles, Promulgated by The European Union.
GB/T 35544	2017	cylinders	Fully-wrapped carbon fiber reinforced cylinders with an aluminum liner for the on-board storage of compressed hydrogen as a fuel for land vehicles, promulgated by General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China and Standardization Administration of the People's Republic of China.
SAE J2579	2018	Hydrogen vehicles	The standard for fuel Systems in fuel cell and other hydrogen vehicles, promulgated by SAE International in the United States.

Source: Own elaboration, 2020.

Technically, there are NOM'S from the Ministry of Labor and Social Security (STPS by its Spanish acronym) that outline safety provisions, such as NOM-026-STPS-2008, on safety and hygiene colors and signs, and identification of risks from fluids conducted in pipes, and NOM-018-STPS-2000 on the system for the identification and communication of dangers and risks from hazardous chemical substances in the workplace. On the other hand, the Mexican standard (not mandatory): NMX-R-019-SCFI-2011 on the harmonized system of classification and communication of hazards of chemical products stands out.

In 2018 the Project NOM-017-CRE-2018 was presented on the measurement methods of variables for the calculation of the percentage of fuel-free energy and procedure for the evaluation of conformity, which aims to establish the necessary metrological requirements and measurement methodologies to be used in Power Plants that require obtaining the values of the variables to be used in the determination of Fuel Free Energy (FFE) from certain values of electrical energy, thermal energy and the fuels used, among others.

The cases in which it is required to calculate the percentage of fuel-free energy should be for efficient cogeneration power plants; clean power plants that use fossil fuels; low-emission technology and thermal plants with geological capture and storage processes and carbon sequestration; the use of H_2, and the methodology for calculating the power density of hydroelectric plants.

Regarding the use of H_2 where it will be considered for production, to know the calorific value, the energy of fossil fuels used in the process of production of H_2 and, to determine the usable energy of the hydrogen produced.

However, it is appreciated that this NOM Project emphasizes the percentage of fuel-free energy required for the operation of power plants, leaving aside the regulation of environmental and social security conditions in the handling of H_2.

Added to this is the poor regulation of risk and damage. In the literature, the risk is defined as the probability of causing harm; harm is considered as loss or impairment, and the hazard will be the condition or situation of causing harm, that is, it depends on the levels of risk [36].

Concerning the damage, in the Mexican legislation, there is the Federal Law of Environmental Responsibility that specifies a process to claim the damage caused, its repair or compensation but does not refer to the possible damage by H_2.

The first approach to risk is the regulation of gas storage present in the Draft Mexican Official Norm PROY-NOM-013-SECRE-2012, which addresses safety requirements for the design, construction, operation and maintenance of liquefied natural gas storage terminals that include systems, equipment and facilities for the reception, conduction, vaporization and delivery of natural gas.

However, it can be assumed that this NOM is centralized to petroleum products and only in its section on "Hazards of internal origin that are not specific to liquefied natural gas" refers to services and chemicals from compressed gases, nitrogen and hydrogen, among others.

The above-mentioned allow supposing that the safety of the H_2 is limited to the possible risks that imply its manipulation on the part of the human being, from an effect in him, centralizing its attention in the STPS; a reason why it can be thought that other environmental, economic and technological factors are absent; Hence the need to consider the preparation and publication of a NOM from the SENER with the support of the Ministry of the Environment and Natural Resources (SEMARNAT by its Spanish acronym) and the participation of the STPS and the Ministry of Communications and Transport (SCT by its Spanish acronym), to cover the actions of handling H_2, from its obtaining, storage (ventilation conditions, materials of the storage cylinders, leak detection, condensation characteristics and entry of fluids, among others), as well as its transport and use.

Also, there are elements in Mexican legislation that have been considered as environmental policy instruments that reinforce the argument of the viability and feasibility of an H_2 NOM.

Environmental and ecological policy instruments for decarbonization in Mexico

The decarbonization scenarios in Mexico have focused on recognizing strategies linked to energy efficiency, electrification and fuel switching in final energy uses in all sectors and low-carbon electricity [37], taking into account the comprehensive vision of decarbonization that globally seeks energy efficiency and security through research and development in environmentally friendly technologies.

It has been recognized that in Mexico, as in other Latin American countries, there are decarbonization routes that are the currently challenges and opportunities. One of the challenges is the regulatory framework that promotes environmental policy instruments, such as market instruments that accelerate the coordinated technical processes between industry, commerce and society [37]. This is an opportunity because in the absence of regulation of H_2 as an instrument of environmental policy, various elements can be included that involve all social sectors.

In LGEEPA there are instruments of environmental and ecological policy. The instruments of environmental policy are the Environmental Planning; the Ecological Ordering of the Territory; the Economic Instruments; the Environmental Regulation of the Human Settlements; the Evaluation of the Environmental Impact; the Mexican Official Norms in Environmental Matters; the Self-regulation and Environmental Audits and, the Ecological Investigation and Education and are indicated in articles 18 to 41 of the LGEEPA, under a scheme of environmental planning where the ecosystems are a common heritage of society and should be privileged its balance to enable life and productive activities, assuming common but differentiated responsibilities between authorities and society [34].

The ecological instruments according to this law are the Natural Protected Areas, the Restoration Zones and the Flora and Fauna, which are regulated in the LGEEPA in articles 44 to 81 Bis2 and establish aspects of scope and limitations in the conservation of biodiversity.

The elements that integrate and define each instrument are mainly reflected in the Political Constitution of the United Mexican States, in the LGEEPA, and in-laws, regulations, and complementary norms. All of the instruments are made operational through a system of competitions that defines the powers of the federation, the states, and the municipalities [34,45].

According to the analysis made, of the environmental and ecological policy instruments existing in Mexico, and the availability of biomass assessed by federal agencies, it is observed that, through proper planning and ecological management of the territory, a national strategic plan can be developed for the use, storage and marketing of biomass, extracting H_2 and using fuel cells.

It has been observed that some of the economic instruments have been directed towards the sustainable management of the forest, as is the case of the Payment for Environmental Services. However, other mechanisms could be revalued (because they have already been implemented, but with little success), such as the Clean Development Mechanisms (CDM), which seek to reduce polluting emissions in terms of the Kyoto Protocol and promote financing from developed countries for developing countries and receive in exchange Certificates of Emission Reduction applicable to their reduction commitment [46,47].

It is estimated that the registration of projects in Mexico exceeds 50% worldwide, that is, it has 203 registered projects [48] which constitutes an area of opportunity, especially in the western region that has considerable forestry activity.

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The CDM projects can consider the forest exploitation and the use and energetic use of forest, agricultural and cattle residues; constituting a possibility to promote the community forest organization in the management of the forest and with it, to foment the management of the H_2.

Also, the recent national strategy for the reduction of degradation and deforestation, as well as the inclusion of community participation in the management of forests to reduce emissions from degradation and deforestation, as well as the increase of forest stock and the management of the forest in a participatory manner.

Both instruments are political tools on which any energy project can be based, to efficiently use forest resources such as resin, sawdust, and forest, agricultural, and livestock waste (such as wood chips, leaf litter, biomass, manure, etc.).

Elements for the NOM of H_2 handling

It is noted that the NOM on the handling of H_2 must be based on the provisions of the CPEUM, the Federal Law on Metrology and Standardization; the Geothermal Energy Law (2014); the Field Energy Law (2002); the Law of the Coordinated Energy Regulatory Bodies (2014); the Law on the Promotion and Development of Bioenergy (2008); the Energy Transition Law (2015); the Law Declaring the Deposits of Uranium, Thorium, and Other Substances from Which Crackable Isotopes May Be Produced to be National Mining Reserves (1950); the Federal Environmental Responsibility Law (2013), as well as various regulations, statutes, and manuals.

Under this argument and considering that H_2 presents extreme flammability in the air compared to other gases, physiological, physical, and chemical risks must be considered, establishing a section in the NOM on the main risks associated with the handling of H_2 from leaks, dispersion, failures in storage cylinders, failures in the opening and closing systems of the cylinders, purging, failures in the vaporization systems, air condensation, leaks, and explosions; risks from freezing, respiratory diseases and asphyxiation.

Likewise, the proposed NOM must consider the characteristics on the containment, detection and ventilation of H_2, according to the storage area, the conditions of storage away from combustible material, indirect heating, attend to the ventilation before the loss of H_2, ensure the continuous renewal of air to avoid concentrations of H_2, avoid electrical sources of ignition, among others.

Also, the NOM must contain mandatory and binding aspects to the actions of transport, production and storage of H_2.

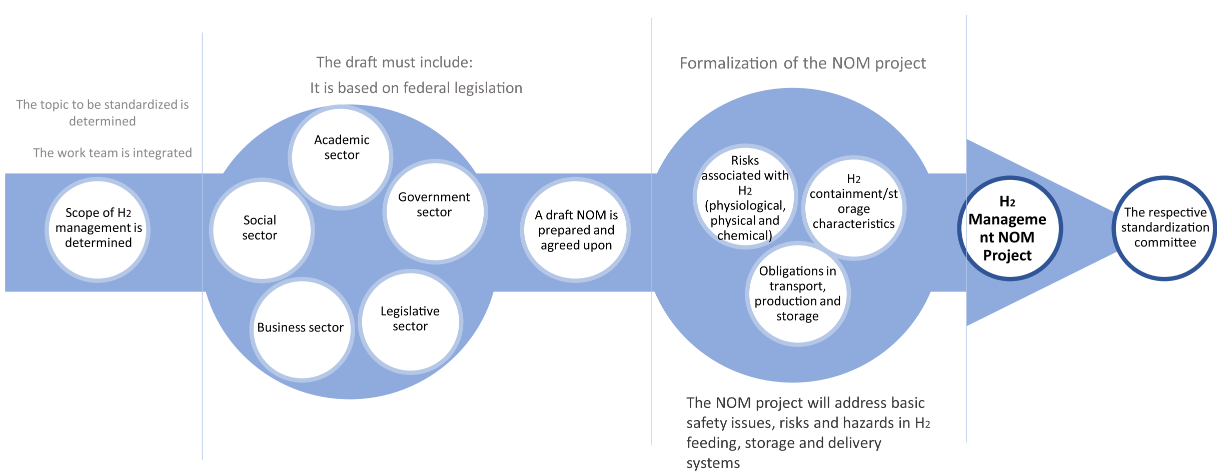
Finally, a risk study should be requested due to the H_2 handling activity and all the measures pertinent to a highly risky activity, of federal competence, should be adopted (See graph 2).

These considerations go beyond the risks that any person faces when handling H_2 because it is necessary to consider the environmental conditions to minimize the dangers, the risks, and, therefore, the damages that can not only be social but also environmental.

Conclusions

The objective of this work was to review the instruments of environmental and ecological policy that Mexican legislation considers to justify from the legality, the existence of a Mexican Official Hydrogen Standard according to the premises that in the literature motivate the decarbonization, the main findings indicate that, the legality of any action, policy or strategy, lies in the existence of existing laws and that according to the review made, Mexico, has a law (LGEEPA) that mentions the instruments of environmental policy as the NOMS that are mandatory legal systems.

It was observed that H_2 as any gas represents a risk, however, it has been observed that it is not toxic, it diffuses rapidly which means less damage than an explosion based on another fuel because the explosion zone is smaller than the zone of other fossil fuels. This allows us to suppose that the environmental damage could be minor (in the expansion) but, the conditions to produce are different from fossil fuels, the reason why it is necessary to have a NOM that forces the one who handles the H_2 in terms of environmental and social security.



Graph 2 – Diagram for the consolidation of the H_2 NOM. Source: Own elaboration.

Please cite this article as: Ávalos-Rodríguez ML et al., Review of the environmental policy instruments in the standardization of H_2 for the decarbonization of Mexico, International Journal of Hydrogen Energy, https://doi.org/10.1016/j.ijhydene.2021.02.019

According to international standards for the handling of H_2 and taking into account the regulatory limitations in Mexico of this element, it is possible, from the academia, to promote an Official Mexican Norm directed exclusively to establish the minimum requirements for the design, construction, operation and maintenance of the storage of H_2, considering the areas of the opportunity offered by the experiences of the foreigner, according to the Mexican context. The conclusion is that there are legal parameters in environmental policy instruments to support the existence of an Official Mexican Standard for H_2.

The experience of the work done has shown that the trend in the regulation of H_2 is present in developed countries and that as areas of opportunity, should be complemented by mandatory regulation with technical aspects that allow the extraction, storage, transport and use of H_2, one of the means with greater presence is the fuel cells that can be used not only in transport, but in infrastructure and portable equipment.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

To the Center for Research in Environmental Geography of the National Autonomous University of Mexico, Morelia Campus; to the University of Michoacan of San Nicolás de Hidalgo and, a special thanks to all the people involved for their contributions, corrections, and suggestions.

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