HyLAW

National Policy Paper - Spain

Main Authors: [Alfonso Bernad, Miguel Zarzuela]

Contributors: [Ana María Férriz, Alexandru Floristean]

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Table of abbreviations

APQ	Almacenamiento de Productos Químicos
ATEX	Appareils destinés à être utilisés en ATmosphères EXplosives.
BE	Belgium
BEV	Batteries Electric Vehicles
CDTI	Centro para el Desarrollo Tecnológico Industrial
CHP	Cogeneration Heat and Power
CNG	Compressed Natural Gas
CO2	Carbon Dioxide
DE	Germany
DK	Denmark
DSO	Distribution System Operator
EC	European Commission
EIA	Environmental Impact Assessment
EU	European Union
FC	Fuel Cell
FCEV	Fuel Cell Electric Vehicles
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
GWh	Giga Watts per hour
H2	Hydrogen
HCNG	Hydrogen-Compressed Natural Gas
HRS	Hydrogen Refuelling Station
IED	Industrial Emissions Directive
IMO	International Maritime Organization
ISO	International Standard Organization
LNG	Liquefied Natural Gas
MOVALT	Plan de Apoyo a la Movilidad Alternativa
MOVEA	Plan de Impulso a la Movilidad de Vehículos de Energías Alterntaivas
MW	Mega Watts
MWh	Mega Watts per hour
NOx	Nitrous Oxides
P2G	Power To Gas
P2H	Power To Hydrogen
PACE	Pathway to a Competitive European Fuel Cell micro-CHP Market
R&D	Research and Development
RIS3	Regional Research and Innovation Strategy for a Smart Specialization
SEA	Strategic Environmental Assessment
SMR	Steam Methane Reforming
TSO	Transport System Operator
US	United States

1. Introduction and summary

1.1 HyLAW Summary and Methodology

HyLaw stands for Hydrogen Law and removal of legal barriers to the deployment of fuel cells and hydrogen applications. It is a flagship project aimed to boosting the market uptake of hydrogen and fuel cell technologies providing market developers with a clear view of the applicable regulations whilst calling the attention of policy makers on legal barriers to be removed.

The project brings together 23 partners from Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Norway, Poland, Romania, Spain, Sweden, Portugal, the Netherlands and United Kingdom and is coordinated by Hydrogen Europe.

Through extensive research, interviews and legal analysis, the HyLaw partners have identified the legislation and regulations relevant to fuel cell and hydrogen applications and legal barriers to their commercialization.

This National Policy Paper provides public authorities with country specific benchmarks and recommendations on how to remove these barriers.

1.2 Policy Summary at National level

Looking for a sustainable and decarbonised future for Spain, hydrogen may be an alternative which allows decreasing the pollution in both the transport and energy sector, at the same time that helps the industry improving their energy efficiency and incomes.

Renewable energy generation is the only way towards a zero emissions society, and energy storage technologies as hydrogen have the ability to use large quantities of energy from surplus intermittent and renewable energy for a latter use in the scale of months. Convert the renewable energy to decarbonise others sectors is the main goal of hydrogen.

However, nowadays hydrogen is generally unknown to the Spanish society.

Despite this fact, there are already industrial actors which promote, invest in and try to introduce hydrogen in Spain. The current business volume in hydrogen in Spain is 594 M€ and it is expected to be around 22 000 M€ by 2030. Spanish companies are commercializing equipment to produce hydrogen without emissions (electrolysers), specific storage systems for hydrogen and fuel cells.

At the same time, there are currently 200 demo projects with an investment of 500 M€ that showcase the immense economic and environmental potential of hydrogen: for example, production of hydrogen in isolated systems by means of renewable energy (*Ely4Off*) and the production of synthetic methane by mixing (clean) hydrogen and CO_2. It is expected an accumulative investment by 2030 of 57 400 M€.

Spain has 196 entities with activity in the sector, of which 45% are companies and 22% are technological centers. It has national capacities throughout the chain: R&D, manufacture-distribution of equipment or components and specialized services. As for workers, the sector now has more than 850 professionals, rising to 227 000 by 2030.

Currently, in Spain, there are six Hydrogen Refuelling Stations (HRS) developed with private or state funds which establish a minimum infrastructure but still not sufficient to allow Fuel Cell Electric Vehicles (FCEV) commercialisation in Spain.

As a result of growing industrial interest, hydrogen has been introduced to international policies in the last few years. Examples of these policies include: the introduction of hydrogen and the FCEV in the National Framework of Alternative Energies in Transport, where the objective of 20 HRS and 500 FCEV by 2020 has been fixed; the introduction of FCEV in the MOVALT mobility plan to promote and incentivise this type of emission free vehicles. Nevertheless, these examples are only the first steps on a long path and need to be secure in order to achieve the objectives on time. At the regional level 11 of the 17 autonomous communities in Spain include hydrogen in their RIS3 (Regional Research and Innovation Strategy for a Smart Specialization).

In Spain, there is no specific financing for hydrogen but included together with energy and environmental topics. Between 2010 and 2017 the Energy Ministry funded 8 projects with more than 18 M€ which together with the CDTI funding makes a total amount of 30 M€ in 23 projects at national level. At European level, for the period 2014-2020 and only from the FCH JU a total of 226 projects have been funded with 841 M€, of which 22 have had Spanish representation.

Spain, with 46 million of inhabitants, should continue to promote emissions reduction and deep decarbonisation of all sectors, securing these goals by taking advantage of the economic and environmental potential of hydrogen technology and should:

- Promote sustainable mobility with hydrogen through incentives for vehicles and infrastructure.
- Introduce hydrogen by promoting large FCEV fleets such as dustcarts, busses or delivery vans in cities.
- Support the integration of renewable sources in the energy sector and the energy storage in order to achieve a deep energy transition which is clean, secure, and low emission. Hydrogen, as energy storage and carrier for renewable energy, is essential for supporting this objective.
- Reduce the legal and administrative barriers to the production, storage and distribution of hydrogen.
- Promote the injection of hydrogen into the gas grid in order to allow the interchange of energy between the electric and the gas grid, allowing the use of renewable energy on both sides.

By 2050, hydrogen will represent 18% of the total worldwide energy consumption. This would decrease the amount of CO_2 released into the atmosphere by 6 gigatonnes per year and, at the same time, create 30 million of jobs within an industry worth 2.5 trillion dollars annually[1].

These estimations, although ambitious, have already begun to be implemented in different nations: 400 HRS are planned in Germany in 2023; in Japan, hydrogen is being seen as the main energy vector of the future with the Olympic games in Tokyo putting hydrogen to the main stage. In France, the national “Plan Hydrogène” proposes to use hydrogen as a key solution for the energy transition of the country, in the US major fleets of hydrogen trucks and a large infrastructure of refuelling stations is under development. These are some of the examples that show that the world is starting to move towards the hydrogen economy.

Spain should not wait and must start to foster innovation and change and accelerate market deployment.

1.3 National Policy Papers

This document synthesizes the in-depth analysis of the hydrogen legislation of the HyLaw project, particularizing the situation in Spain through a critical review of the current state, assessing not only the legal and administrative processes, but also developing the adequate recommendations to foster the deployment of hydrogen technologies and fuel cells.

The document is divided into seven sectors or categories in which the details of the technology are analysed in detail, as well as the problems and uncertainties when they undertake the legal and administrative processes necessary to start the operation on Spanish soil.

The objective of this document is to reach the relevant agents with potential capacity to influence policy makers to advocate for the elimination of the barriers detected, as well as to adopt the best practices obtained from the comparison with the other countries of the European Union.

The authors of the document are fully disposed to clarify, expand, defend or discuss the information presented in this document and invite the reader to contact them.

[1] Hydrogen Council, 2017

2. Production of Hydrogen

The primary consumption of energy in Spain is based on fossil fuels. 75% of the energy consumed in Spain in 2016 came from petroleum, natural gas and coal while only 15% came from renewable sources. With the increasing renewable energy generation due to lower costs and zero emissions, the electricity is going greener and greener and electrification of the whole energy demand becomes the key to accomplish the emissions reductions signed at the Paris Agreement.

That being said, the transition towards an intermittent renewable energy generation will need short and long term storage in order to use the renewable energy when and where is needed. Hydrogen as an energy vector is one of the candidates to use the renewable energy surplus by the means of electrolysis. This energy can be stored for long term (months) and be used in other sectors as transport, heating, or as a substitute for natural gas in its grid.

The hydrogen production can take place at industrial places or at Hydrogen Refuelling Stations (HRS). Unlike other fuels, hydrogen can be produced on site in the HRS, requiring only electricity and water. This avoids the extraction, refining and distribution stages of fossil fuels and, in addition, retains value creation in the regional area of influence. In this way, by guaranteeing a supply of renewable energy, the whole cycle of hydrogen is zero emission.

2.1. Overview and assessment of current legal framework

There are different pathways to produce hydrogen

Hydrogen as a fuel can be produced by the use of renewable sources when using an electrolyser by the only mean of electricity and water without any harmful emission. The hydrogen produced by electrolysis does not contain impurities as water and oxygen can be the only "pollutants", therefore, a high degree of purity is achievable and its quality can conform with ease the quality requirements for fuel cells.

Hydrogen can also be produced by reforming natural gas which has been the leading source of low-cost hydrogen gas for industrial use. The steam methane reformer uses the methane to produce H_2 and CO_2 and this hydrogen may require a purification process to conform further quality requirements for non-industrial use. This hydrogen is not emissions-free but can play a role in early stages before electrolysis becomes widely and economically available.

Hydrogen is not considered as an energetic facility yet

Hydrogen has been used historically as a reactant in many industries, from chemical and refining to metallurgical, glass or electronics. However, its production in an energetic facility (electrolyser) as an energy vector for a further use in fuel cells (re-electrification) is new and it is not recognized almost in none EU/national legislation. This is a problem as the new purposes of hydrogen cannot fall in current legislation and this is a major barrier for its introduction into the market.

In Spain, as in most of the EU states, the production of hydrogen is usually considered as a chemical/industrial facility for the production of an inorganic gas – as hydrogen is - regardless of the method of production of hydrogen, the daily amount produced, the storage capacity or the purpose of the gas. This consideration restricts this type of infrastructure to be constructed on industrial soil, limiting its implementation in other places as solar plants, gas stations or even for domestic uses.

Traditionally, the production of hydrogen in large quantities has taken place through industrial processes such as steam methane reforming, and the limitation of these activities to industrial zones is understandable. However, current legal and administrative processes would likely also relegate *non-emitting production processes such as electrolysis* to such zones, thereby unduly limiting the locations where such installations can be built.

Unaddecuate environmental assesements and lack of relevant legislation

As long as hydrogen production is considered for industrial use, smaller and large hydrogen production units suffer the same permitting processes than larger units. The absence of clear thresholds of production means that the development of small production units is as complicated as large ones. While this may be inconsequential for centralised production business models, it severally limits the potential for development of localised[2] production units, including HRSs with on-site production.

This problem is most acute when considering the integrated environmental obligations, as required by the IED whose application depends on the interpretation of "industrial scale" (which remains problematic, despite the clarifications provided by the European Commission) and the application Environmental Impact Assessment procedures under the EIA and SEA Directives which is often left at the discretion of implementing authorities.

[2] production of hydrogen for a given application on the same location, eliminating the need to transport the hydrogen outside a facility

Additionally, none of the requirements make any distinction between the diverse methods for hydrogen production, despite the significant differences in terms of the production process, presence of harmful substances and environmental impact. Furthermore, rules vary substantially from one Autonomous Community to another.

It is necessary to review these situations since an electrolyser has more similarities to an electrical transformer than with the petrochemical industry since it does not result in any emissions or pollutants. For this reason, the necessary environmental impact studies must differentiate between the production of hydrogen for industrial uses and the production of hydrogen as an energy carrier by means of electrolysis without emissions.

With the increasing penetration of renewable sources of generation, the storage of energy will be a need in the short/medium time. The possibilities of energy storage have to be considered now in order to adapt the legislation and prevent legal barriers to its implementation

2.2. Conclusions

A hydrogen production plant is considered as a traditional chemical production facility, without regard to the type of H_2 production or the presence (or absence) of hazardous substances involved in the process. This places a disproportionate burden on environmentally friendly production methods, as it subjects them to the same requirements as industrial, emission emitting processes.

Firstly, there is no specific legislation for hydrogen production and it is considered as any other inorganic gas production facility. Furthermore, there is no differentiation between SMR and water electrolysis. The absence of simplified processes for small quantity production leads to a restrictive environmental procedure which may discourage investors (environmental process equivalent to Wind Power Farm of more than 50 MW). This situation discourages development of environmentally friendly production methods and further exacerbates the lack of economies of scale issues faced by smaller units.

Secondly, (in terms of the process itself) irrespective of the production method and scale, the permitting process is long, costly, and its outcome is uncertain. Project developers and administrations themselves lack the sufficient knowledge to navigate the requirements smoothly and without significant efforts. This increases the costs for developers and delays the deployment of hydrogen technology.

National and local authorities should consider ways to streamline, simplify and shorten the process for permitting the construction and operation of hydrogen production units. A one-stop-shop authority should be designated to “lead” the administrative process, even when various other authorities are involved

2.3. Recommendations

- Adapt rules and administrative practice to promote environmentally friendly methods of hydrogen production.
- Establish simplified processes for small scale hydrogen production and for non-emitting production methods by making clear thresholds differentiating domestic, small and industrial scale.
- Eliminate the barriers to the production of hydrogen *in-situ* in the service stations due to the fact that hydrogen production is considered as industrial activity of chemical production regardless of the source of production.
- Review the criteria for Environmental Assessments in all Autonomous Communities for guaranteeing an reasonable and homogeneous process nationwide in regard to hydrogen production
- Develop clear permitting guidelines for both administration and project developers

3. Hydrogen Refuelling Infrastructure and Hydrogen as fuel

Hydrogen Fuel Cell Electric Vehicle (FCEV) passenger cars could represent almost 3% of new vehicle sales by 2030 (i.e. 4 million cars sold in 2030), ramping up to 35% by 2050[3]. Hydrogen refuelling infrastructure is essential to a transport sector which allows emission-free FCEVs to operate. This infrastructure would not only service cars, buses or trucks on public roads as it is also necessary for the refuelling of captive fleets of forklifts and other special vehicles for material handling.

Once hydrogen has been produced and stored it can be used in mobile applications, generating zero emissions when driving. The deployment of Hydrogen Refuelling Stations (HRS), self-standing or integrated into existing refuelling infrastructure will be necessary to refuel these vehicles. Unlike other fuels, hydrogen can be produced on site in the HRS, requiring only electricity and water. This avoids the extraction, refining and distribution stages of fossil fuels and, in addition, retains value creation in the regional area of influence. In this way, by guaranteeing a supply of renewable energy, the whole cycle of hydrogen is zero emission.

3.1. Overview and assessment of current legal framework

Hydrogen mobility requires refuelling infrastructure

Spain has laid down in December 2016, the National Framework of Alternative Energy in Transportation which includes a plan to reach 20 HRS by 2020. However, this plan does not detail the efforts nor measures necessary to accomplish this objective. In 2018 there were 6 HRS operating in Spain, all of them developed within demonstration projects partly funded by the EU, however, none of them are open to the public. While in other countries, a small but growing refueling network already exists thanks to the efforts of national governments, in Spain HRS are still testimonial and associated with small demonstration projects.

There are different pathways to producing hydrogen

Hydrogen as a fuel can be produced by the use of renewable sources when using an electrolyser by the only mean of electricity and water without any harmful emission. The hydrogen produced by electrolysis does not contain impurities as water and oxygen can be the only “pollutants”, therefore, a high degree of purity is easily achievable and its quality can easily conform the quality requirements for fuel cells.

Hydrogen can also be produced by reforming natural gas which has been the leading source of low-cost hydrogen gas for industrial use. The steam methane reformer uses the methane to produce H_2 and CO_2 and this hydrogen may require a purification process to conform further quality requirements for non-industrial use. This hydrogen is not emissions-free but can play a role in early stages before electrolysis becomes widely and economically available.

Renewable, low-carbon hydrogen requires a supporting regulatory environment and certification of origin

The certification and Guarantee of Origin of (renewable, low CO_2) Hydrogen as fuel is not yet available. The CertifHy project works in this direction and it is foreseeable that the new European Renewable Energy Directive will define the character of renewable and low carbon Hydrogen at European level, paving the way for the establishment of the Guarantee of Origin scheme. Independently of the EU status, several countries (BE, DE, DK) have tried to define renewable hydrogen within their national frameworks. A Guarantee of Origin scheme will be needed to determine the carbon emissions of the fuel when it was produced and to promote low carbon hydrogen production at national and EU level.

Regulatory and technical issues continue to be a barrier to deployment for hydogen as a fuel

Currently, only the Royal Decree 639/2016 in Spanish law establishes a framework of measures for the implementation of an infrastructure for alternative fuels in which the technical specifications of the hydrogen refuelling points are established, indicating exclusively that they must comply with various ISO standards relating to the supply of gaseous hydrogen. This is the partial transposition of the EU Directive of Alternative fuels but does not reach the level of detail as gas stations have.

In addition, due to the very high purity requirements for hydrogen, standard ISO 14687–2:2012 is costly to implement, measure and enforce. Importantly, purity requirements should be verifiable, which is not the case in Spain. The reason for this is that there are just a few independent laboratories (in the world) who can verify the purity required by ISO 14687–2:2012. In other words, the purity of hydrogen for FCEV cannot be guaranteed because the required measurements to show compliance with the standard are expensive/not available. MetroHyVe project is working to solve this setbacks.

[3] Hydrogen Council, Scaling up study, November 2017

Quality of fuel is an obvious matter of importance, but it should be taken in account in a reasonable way, not detracting the marketing of hydrogen due to extremely technical measures that cannot be satisfied in an economical way today.

In Spain, no dedicated legislation has yet been developed regarding the designing, permitting, building and operating HRS as it has been done for other infrastructure associated with alternative fuels such as CNG or LPG. Therefore, a potential operator of a HRS faces difficulties, complex processes for permitting, unreasonable high requirements resulting from the lack of experience and tailored rules, etc. In the absence of a reasonable treatment for HRS, competent administrations may consider a potential HRS as a set of independent facilities for the production and storage of inorganic chemical products resulting in high requirements, costs and significant prohibitions. The lack of experience of the authorities and the lack of relevant legislation regarding HRS is toughening the administrative process to obtain the necessary permits causing delay and extra costs.

Unaddecuate environmental assesments and lack of revelant legislation

The environmental authorities in charge of the environmental permits, who establish the environmental studies, do not take into account the differences in the various sorts of hydrogen production technologies (as electrolysis or reforming) and their applications and often impose the same restrictions. Furthermore, rules vary substantially from one Autonomous Community to another.

HRS with on-site production has clear advantages in terms of refuelling and managing the energy, storing surplus renewable energy to satisfy energy demand of transportation. However this kind of HRS is discouraged by the administration due to severe barriers for its construction. HRSs with on-site production are usually considered as a chemical facility for the production of an inorganic gas such as hydrogen, regardless of the method of production of hydrogen, the daily amount produced or the storage capacity. This consideration restricts this type of infrastructure to be constructed on industrial soil, limiting its implementation on other places as existing gas stations or in other kinds of strategic locations.

It is necessary to review these situations since an electrolyser has more similarities with an electrical transformer than with the petrochemical industry since it does not result in any emissions or pollutants. For this reason, the necessary environmental impact studies must differentiate between the production of hydrogen for industrial uses and the production of hydrogen as an energy carrier by the means of electrolysis.

Looking at the whole picture, in absence of a national network of HRS, the manufacturers of fuel cell vehicles do not see Spain as a potential market where they can invest, develop and sell their technology.

3.2. Conclusions

The effective deep decarbonisation of transport involves electrifying all means of transport, either directly using electricity (catenary), storing this energy in electrochemical devices (batteries) or in fuels that act as an energy vector (hydrogen) that subsequently generates electricity on board the vehicles.

In the case of hydrogen, the energy used to produce the fuel must come from local renewable energies, favouring management of the intermittency of these sources, while at the same time retaining the value generated in the regional area of influence and avoiding the external energy dependence based in fossil fuels.

For any of these solutions to work, an appropriate legislation is needed to facilitate the deployment of the necessary infrastructure. To promote the installation of HRS, it is necessary that the concept of hydrogen as an energy carrier is known by the administration and the authorities and furthermore, that the legal and administrative processes to develop such infrastructures are clear and do not produce uncertainty in its development.

Clear legislation in this regard can pave the way to establish our nation as suitable for the development of hydrogen trucks, or for facilitating the logistic warehouses to easily incorporate hydrogen fuel cell forklifts within its fleets. A clear and ambitious legislation will finally promote that the national companies that develop this technology will increase their sales with the result of further cost reductions and increased market share.

3.3. Recommendations

- Strengthen and secure funding for HRS in the National Alternative Fuels Plan considering the necessary actions for these objectives to materialize
- Develop specific legislation for HRS, establishing technical requirements at the national level, limiting the uncertainty of the administration and delimiting the necessary permits for their construction and commissioning.
- Ensure that HRS are treated in the same way as conventional refuelling stations from the perspective of land-use-plans, allowing HRS to make use of existing refuelling infrastructure .

- Eliminate the barriers to the production of hydrogen in-situ in the filling stations due to the fact that hydrogen production is considered an industrial activity of chemical production regardless of the source of production and its emissions.
- Review the criteria for Environmental Assessments in all Autonomous Communities for guaranteeing an reasonable and homogeneous process nationwide in regard to hydrogen production.
- Establish a competent authority responsible for verifying the quality of hydrogen as fuel.
- Establish and promote at EU level a Guarantee of Origin system similar to that of the electricity to determine the carbon intensity of the generated hydrogen.
- Considerate a minimum fraction of renewable hydrogen to be sold at nozzle in public HRS as California does.

4. Stationary storage of hydrogen

Hydrogen as an energy vector is produced by the means of electrolysis and consumed by fuel cells for the re-electrification. However, an intermediate step of storage underlies in between.

The hydrogen has the highest energy per mass of any fuel, however, its low ambient temperature density results in a low energy per unit volume for gaseous storage, therefore requiring the storage at high pressure for higher energy density.

The storage of hydrogen at high pressure is the most economical and reliable way to store hydrogen. This storage allows the massive storage of energy in the order of MWh for a further use without any loss or leaks over the time. For this reason, hydrogen storage allows using the surplus energy from one session to another.

Storage facilities are expected in the nearby of Hydrogen Refuelling Stations as a buffer storage is needed in order to guarantee the refuelling over the day. Other production sites of hydrogen may have compressed hydrogen storage as intermediate stage previous for its transportation, use, or injection into the gas grid. The storage of hydrogen in the gas grid or salt caverns is developed in other section of this paper.

4.1. Overview and assessment of current legal framework

Hydrogen needs a commercial treatment other than industrial

Hydrogen is considered for a legal and administrative perspective a chemical storage of flammable and dangerous gasses almost in all EU. As any other flammable gas considered in the APQ (Chemical Products Storage), the storage site has to comply with some safety requirements and distances when the tanks are placed. While these safety distances are based on good practices some new applications may not be possible with this generic regimen.

With the increased use of Hydrogen in various commercial applications (e.g. as a fuel, sold in hydrogen refuelling stations or consumed by micro-CHP's), the storage of hydrogen should be permitted where the demand can be located, including residential areas. The multi-refuelling station may be discouraged to use hydrogen when applies soil restriction or unreasonable safety distances. At the same time, hydrogen is a flammable, explosive gas; hence restrictions and prohibitions are, to a certain extent, necessary.

In order to operationalise and codify this recommendation, it is necessary to establish the meaning of "commercial" use of hydrogen, as a means to distinguish from industrial use, thereby giving legislation and administrative practice a realistic opportunity to differentiate the two.

Simplified processes for small-scale projects are needed

Massive storage of hydrogen and its applications should follow the necessary permitting processes in order to be placed and operate. Nevertheless, small scale applications of hydrogen should not have complex, tight processes for legalising the installation. Hydrogen for self-consumption energy facilities or hydrogen refuelling stations for small fleets should not have complex requirements. A clear threshold delimiting large scale industrial applications and small scale for domestic / commercial use should be established.

On the other side, environmental impact assessment may have unexpected large quantities of hydrogen for requiring the study. Spain reports that if the storage is less than 200,000 tons and more than 100 m^3, a simplified environmental assessment is needed, whereas if the storage is at least 200,000 tons (which equal to 7.200 GWh, half of the monthly consumption of electricity in Spain) an ordinary environmental assessment is needed. This highlights that thresholds for hydrogen are not coherent in Spain, both, in the upper and lower limit. Nonetheless, the strict fulfilment of this criteria provokes that even small quantity storage projects may require the environmental assessment.

Competent administration and environmental bodies need guidelines

The development of a document which establishes the storage needs of various hydrogen applications which are ready for commercial deployment may help the permitting processes for the administration, including various models of HRS (e.g. "public urban" – those which service a small number of medium size FCEVs; "medium fleet management" those which service a small fleet (e.g., taxis) of medium sized FCEV on a daily basis; "large fleet management" which service fleets of buses / trucks; "highway" - those who service a large number of passenger FCEV as well as buses / trucks; "maritime" - those who service FC boats / ships; "micro-CHP" - residential / commercial).

Such a document can serve as a basis for individual recommendation to competent administration to amend their legislation and administrative practice to allow the storage of quantities below such pre-determined thresholds alongside the application they service.

4.2. Conclusions

The permitting process for the storage of hydrogen relies on the general rules applicable to the storage of flammable chemicals and gases. While this is not problematic in itself, it can potentially lead to uncertainties with respect to the scope of applicable obligations and requirements, in particular, those associated with safety distances. An excess in precautionary measures can lead to structural barriers that prevent the development of commercially viable applications.

Furthermore, environmental protection obligations associated with the storage (and potential leakage) of chemicals are sometimes automatically applied to hydrogen storage, despite the reduced risk of environmental damage resulting from hydrogen leakage.

Subjecting hydrogen storage to risk assessments, in accordance with the SEVESO and ATEX Directive is in line with the purpose and intention of these acts, however, the application of the EIA and SEA Directives and other environmental permitting may result in disproportionate administrative burden on project developers and economic operators wishing to bring hydrogen applications (e.g HRS's and micro-CHPs to market) despite the extremely low environmental risk posed by hydrogen and hydrogen leakage. In addition, the process itself (involving several permits, provided by different authorities, and requiring much time and effort) imposes high costs on operators and further delays the commercial deployment of these applications.

4.3. Recommendations

- Establish the storage needs of various hydrogen applications which are ready for commercial deployment and which require the storage of hydrogen outside industrial zones in order to show the needs to the administration
- Adapt national and local regulation and administrative practice to ensure that the storage of hydrogen, in the quantities in which it is required should be allowed in the same zones where the application consuming the hydrogen is or can be located
- Avoid the unnecessary application of environmental impact assessments, as foreseen under the EIA and SEA Directive for facilities storing small amounts of hydrogen for commercial (e.g. HRS's) or personal (e.g. Micro-CHPs) uses.

5. Towards zero emissions in transport.

The transport sector is currently, at a national level, the main CO_2 producer as it has been presented by the Ministry of Agriculture, Fishing and Environment, being a 26% of the total amount of CO_2 of the nation. Among all the subsectors that are covered by transport, the main pollutant is the road transport.

These data demonstrate that if Spain wants to achieve their objectives in the emissions reduction that are purposed for 2050, the introduction of alternative zero emissions vehicles must be promoted. The Zero Emissions vehicles does not damage the environment in its operation, but the drastic CO_2 reduction along the whole life cycle can only be achieved by the promotion of the renewable energy for all the stages of manufacturing, use and disposal.

The alternative propulsion vehicles have demonstrated there is reliability and viability along all Europe. Examples of this mobility are the Batteries Electric Vehicles (BEV) and the Fuel Cell Electric Vehicles (FCEV). Nowadays, there are commercial vehicles of both alternatives, however, in Spain there is a lack of infrastructure for the last, and thus FCEV can not be sold in Spain

FCEV are a real alternative to reduce the emissions in this sector. As all the other alternatives, they have advantages and disadvantages. As an example, the autonomy that these vehicles present is competitive in a comparison with the traditional vehicles, with cases as Nikola One Truck (in development), with almost 1 500 kilometres of autonomy. With this autonomy, the truck operators are able to maintain the routes of long hauling being also capable of fast refuelling. At the same time, FCEV are refuelled in Hydrogen Refuelling Stations (HRS), which has a typology and an operation similar to the current gas stations, avoiding that the end users of the vehicles have to change habits, which could be a barrier in the introduction of the FCEV.

The focus should not only be placed on FCEV as cars, because the main advantages of the fuel cell electric powertrains came for heavy duty vehicles. The use of fuel cell electric buses, trucks and delivery vans may fulfil the actual requirements of high availability, long range and short refuelling required for industrial vehicles. The market for this type of vehicles today has not reached yet a wide commercial availability, but hydrogen is a promising technology for these heavy duty vehicles with large energy demand.

However, in Spain, the infrastructure of HRS currently is far away of the 20 HRS that has been estimated for the year 2020 in the National Framework of Alternative Vehicles. The development of this infrastructure should come from national schemes at the very beginning, while operators of FCEV fleets may build their own HRS.

This FCEV promotion, linked with the promotion of BEV, could help to decrease importantly the amount of emissions in the vehicles. Long hauling, trains in non-electrified lines, heavy duty transport or material handling are the niche markets that already have commercial products and are ready to increase uptake with reliable, environmental and economically viable solutions.

5.1. Overview and assessment of current legal framework

When the demand to introduce the FCEV in Spain appears, the lack of infrastructure for the refueling materializes. Due to it, these vehicles which are an alternative to the fossil fuel vehicles are not commercialize in Spain yet.

In order to be allowed to run in the national roads, these vehicles need to have the type approval. Thanks to information provided by agents of the manufacturing sector, it is known that the type approval process will not be a problem. However, the differences between procedures among the countries of the European Union are, at least, notably.

In fact, a need for common rules that applies in all the countries should appear, considering not only the environment protection but also the safety of the people. These rules should be ambitious and consider new technologies as hydrogen motorbikes could be.

Being classified as zero emission vehicles, FCEVs have not enough incentives. In order to improve the situation, some measurements could be made common for all the country, as the measures taken by the Madrid or Barcelona local City Council which allows to the electric vehicles to run without restrictions during air pollution episodes. Severe restrictions to old and pollutant vehicles should be taken nationwide and a clear pathway for the future of powertrains from the national government is needed. Technology neutrality is fine as long as it can fulfil the objectives for decarbonisation by 2030 and 2050.

Finally, a special point not only for the employees but also for manufacturers is the training of the technicians which will participate in the vehicle inspection. Each day, the vehicles are more complex and have more systems, as high voltage batteries. These systems mixed with the storage and use of gas systems that FCEV may require a higher degree of specialisation from these professionals. It seems necessary to train properly them.

New vehicles as hydrogen and natural gas vehicles may lead to motor vehicle repair workshops adaptation needs, introducing in the current workshops active and passive measures to prevent issues with hydrogen or other gasses.

5.2. Conclusions

Homologation and type approval for FCEV as cars and vans will not be difficult for the uptake of these vehicles on the road, nonetheless, other kinds of vehicles as trucks or trains may need a revision of the basis of type approval as there is no precedent in this kind of vehicles

The infrastructure is a need for the commercialisation of the FCEVs, commercial vehicles will not be sold in Spain until a wide network of HRS is available. Thus, enhancing the development of HRS and favouring its legal and administrative process will facilitate public and private development.

The national government should study which technologies will truly decarbonise the transport, *ergo* foster the clean technologies with straightforward objectives and the measures to achieve intermediate goals in 2030 and 2050.

While most of the daily commute takes place nearby the cities, the local city council should develop clean air zones and programs, while having guidelines from the central government and inspiration from the cities of Europe that already have implemented restrictions to the most pollutant vehicles.

5.3. Policy Recommendations

Type Approval.

- Spain should work in the direction marked by the Regulation 858/2018, participating actively in the Forum for Exchange of Information on Enforcement, promoting thus a better communication among all the countries in the European Union, in order to avoid duplicities and ensuring a high level in the health and environmental protection.
- In the Forum, the Spanish representation should promote the legislative changes in order to improve the study targets, including new vehicles as the L categories ones.

Promotion of FCEV

- Ensure an effective and long time implementation of the Alternative Fuel Directives, allowing the market growth at a progressive rhythm to all hydrogen vehicles via:
    - Incentives to purchase the vehicles and to implement infrastructure, via mobility plans as MOVEA and MOVALT.
    - Decrease the fiscal taxes for these types of vehicles.
    - Use of the public resources favouring alternative mobility by, as an example, creating a minimum purchasing quota for the public entities
- Offer financial incentives for captive fleets, promoting the alternative mobility: long hauling, police vehicles, taxi fleets, buses and distribution companies.
- Establish national traffic exemptions to promote the alternative vehicles. These rules may be traffic limitation inside natural, cultural or scientific interest zones.
- At the same time, promote urban zones as clean as possible, looking for the use of zero emissions vehicles instead of fossil fuel ones. As examples: prohibition of fossil fuel cars inside city centers (Madrid, Barcelona), congestion charge (London).

Vehicle Repair Workshops

- Design training plans for the employees of workshops, in order to know how to work with the new typology of vehicles.
- Collaborate with manufacturers and designers of M, N, O and L vehicles and with the workshops in order to create guidelines and manuals for the workshops for a future maintenance of hydrogen vehicles, looking not only on the gas part but also the high voltage one.
- Develop guidelines for firefighters, rescue teams, police and first responders who can be involved in an accident, to teach them how to act and how to work with these new vehicles.

6. Towards the zero emissions in transport. Ships and hydrogen

Among the countries with coastlines within the European Union, Spain has the great potential of being open to both the Mediterranean Sea and the Atlantic Ocean. Due to this characteristic, Spanish based maritime transport is an important part of the worldwide transport, as a result, it seems obvious to investigate ways to make it more efficient, not only from the logistic point of view but also from the environmental perspective.

Within the maritime sector, vessels exist in very different sizes: from small recreational crafts, medium sized ferries to large merchant ships which transport a huge amount of freight across the Oceans. In all categories, fossil fuel powered vessels are characterised by high fuel consumptions, high greenhouses gasses emissions and thus, exhibit a high potential for improvement.

The International Maritime Organization (IMO) recognises the potential of improvement of the maritime sector in terms of emissions and other pollutants and has committed the sector to reduce its environmental impact via the use of alternative fuels such as biogases, hydrogen and other power sources more respectful of the sea and the environment.

Fuel cells and hydrogen technologies are evolving continuously at a speed which potentially places them to be a solution. Meanwhile, projects such as the *Energy Observer*[4] while still prototypes, are sending a clear message to society, showing the direction in which the transport sector will evolve in the future. Recognising the need to adopt new technologies such as hydrogen, large companies active in the sector have developed Fuel Cell Electric Ferries and are beginning to consider the introduction of these technologies into real applications at commercial scale. Consequently, our nation should participate as much as possible in this evolution, in order to be pioneers in a clean and sustainable maritime transport.

The Iberian Peninsula is a strategic zone for refuelling ships. Thanks to hydrogen, as an energetic vector, Spain has the opportunity of export energy and to generate wealth and prosperity in the country and change the current situation of energetic dependency on fossil fuels.

6.1. Overview and assessment of current legal framework

The fleet of vessels has to reduce its emissions

The Commitment by the International Maritime Organization (IMO) to reduce CO_2 emissions (50% reduction by 2050) and the rules on other pollutants such as Sulphur (0.1%-0.5% limits) requires the maritime sector to look at hydrogen or hydrogen-based fuels, along with other low emission alternative fuels to power the world shipping industry of the future.

Fuel cell technology onboard vessels start to be present in Spain, however, these fuel cells consume methanol and are only used as power auxiliary units. Several fuel cell vessels developed in Europe are beginning to showcase the use of hydrogen fuel cell power and demonstrate the viability and efficiency of this technology as a means of propulsion, free of emissions.

Type approval of fuel cell powered vessels needs development

In order for this technology to be a reality in the Spanish maritime sector, it is necessary to create rules which clarify and simplify the process of approval of such vessels for maritime use. Currently, the process of type approval of vessels incorporating hydrogen fuel cell technology as part of their propulsion system is based on the alternative design type approval process, which is extremely complicated and lengthy, and not suitable for commercial deployment, limiting the potential for decarbonising the maritime sector.

These problems, born from a lack of experience and the absence of specific rules, can be best solved by working in a strong cooperation with the international maritime organizations, as IMO. While the IMO is currently working on developing rules for the type approval of vessels powered by fuel cells, these will only cover natural gas as fuel, and not hydrogen.

Maritime hydrogen refuelling infrastructure should be planned

In the future, it will become necessary to also study the equipment maintenance, their technical reviews and the problems related to their docking and their refuelling in the harbours of the nation. The same recommendations for land Hydrogen Refuelling Stations (HRS) should be taken into account for harbours and large bunkering facilities.

This refuelling infrastructure will need a different approach than the given to land HRS due to the large amount of fuel that all kind of vessels requires. This is a major issue that should be treated in the long term as long it is known that the technologies depending on fossil fuels will not fulfil the requirements of reduction in emissions for 2050 and beyond.

[4] First hydrogen vessel powered by renewable energies that is travelling around the world.

6.2. Conclusions

Hydrogen propulsion shows the change in the direction and future trends in the maritime sector. Meanwhile, it is true that it brings about a major change of direction and a paradigm shift. The use of hydrogen as the fuel for propulsion or as an element of the hybridization with other technologies such as batteries or biogases will become a reality in the near future given the need to deep decarbonize the sector and the inability of other fuels to deliver on such targets.

The infrastructure for refueling will play a major role in the energy flows of the country and this should be taken into account years before its implementation.

Additionally, it is important to consider that, in the case of an incident at sea; the massive leakage of hydrogen will not cause an environmental problem as is the case with conventional fossil fuels.

6.3. Policy Recommendations

We ask to the decision-makers to promote and help the decarbonisation of the maritime sector, promoting and aiding to the introduction of new technologies such as fuel cells and hydrogen not only in the merchant ships but also in the recreational crafts, in order to preserve the environment.

Decision-makers are invited to play an active and positive role in the international maritime committees to help draft rules supporting of the technology.

Hydrogen Fuel Cell vessels will need a refuelling infrastructure that does not exist and will be required at the harbours. National efforts should focus on development of both, vessels and infrastructure.

Additionally, at the national, regional and local level, decisions makers should look into ways to promote the adoption of this new technology in our coasts and harbours and attract international and national investment.

7. Energetic vectors integration. Power to Hydrogen in Spain

Spain is a country with a large potential for a high penetration of the intermittent and non-manageable renewable energies as photovoltaics or wind power. Nevertheless, the non-manageability should be solved if Spain wants to decrease or even avoid the use of carbon or nuclear power plants, which currently produce the base demand of the electricity sector.

A wide range of energy storage technologies is available now. Each technology works better in a window of time, with hydrogen as the energy vector for medium and long term storage. The electrolysers are able to use the surplus of renewable energy to split water and storage hydrogen for the long term. This hydrogen can be used when and where it is needed. Transport, stationary fuel cells for heating, cogeneration or back-up and its injection into the gas grid are the main applications of the hydrogen.

The production of hydrogen from electricity is defined as Power to Hydrogen (P2H) and it has not been yet recognised as an energy storage system neither from the electric grid or the gas grid.

The electrolyser is able to change the power that it absorbs from the electricity grid in order to adequate the production both to the most economical electricity cost and the grid restrictions (adequate ancillary services needed). The hydrogen produced could be used as automotive fuel for FCEV, be stored for a further use, or be injected directly into the gas grid.

This hydrogen can be injected into the gas system directly, or by methanisation with CO_2 (Power to Gas), which creates synthesis natural gas. These alternatives, mixed with the diverse technologies used nowadays to produce biogas, will promote an important change in a key sector which is the gas sector. The gas sector has started to move also in this direction, and to investigate these technologies, as presents the agreements signed between Enagas (Spanish TSO) and the Aragonese Government less than one month ago.

In the case of the injection of hydrogen into the natural gas network, there are studies which look for knowing how much hydrogen could be injected with the current natural gas. As an example, in the United Kingdom, it has been estimated that 30% of hydrogen is technically feasible without affections of the domestic consumers[5].

This hydrogen could be used as a substitution of the natural gas, by using hydrogen boilers, fuel cell electric vehicles, and it can be used also for the electricity production via fuel cells. The last of the presented uses allows creating a closed loop, which integrates the gas and the electricity sectors. It allows to produce hydrogen when the electricity demand is lower than the production and to use this hydrogen to produce electricity when the demand is higher than the electricity production, reducing then the use of fossil fuels and creating a higher penetration of renewable energies.

7.1. Overview and assessment of current legal framework

Electrolyser can play a role in the storage of energy and balance of the grid

The main electrochemical devices used by hydrogen technologies are electrolysers and fuel cells. The connection of an electrolyser to the electricity grid is straightforward as an energy consumer. However, electrolysers in Spain cannot participate in some of the ancillary services that they can provide. This is basically because there is almost no mechanism for the demand side in Spain apart from the *interruptibility* management system. This framework requires from the electrolyser a minimum power of 5 MW, or be part of a demand of that power. In the frequency balance, primary, secondary and tertiary regulation, the electrolyser is not allowed to participate, because in Spain the frequency balance is done from the production side.

The scheduling and dispatch only apply at the generation side, while electrolysers on demand side could vary on short timescale up and down the demand being able to participate in other services. This electrolyser may work at the multi MW scale, therefore can absorb all the necessary time large amounts of energy while storing hydrogen.

The fuel cell, which produces electricity with hydrogen, should be registered in the general producers' regime, but without any incentive, as it may have in the special regime of *renewable energy, cogeneration and waste*. The fuel cell is able to participate in the frequency ancillary services. Nevertheless, in the rest of Europe, a discrepancy about in which of the ancillary services should fuel cell participates exists.

[5] D. R. Jones, W. A. Al-Masry, y C. W. Dunnill, «Hydrogen-enriched natural gas as a domestic fuel: an analysis based on flash-back and blow-off limits for domestic natural gas appliances within the UK», *Sustainable Energy & Fuels*, vol. 2, n.º 4, pp. 710-723, 2018.

Renewable energy can be injected into the gas grid by means of hydrogen

Looking further in sector coupling, electrolysers or power to gas plants are not recognised as energy storage facilities either from the energy producer side nor as the energy consumer. With the capability to inject hydrogen into the gas grid the two main grids of energy in the country will have an interaction, being able to transfer the surplus electricity into the gas grid reducing its emissions and dependence on fossil fuels.

Injection of the hydrogen should be considered at transmission level (TSO) and distribution (DSO). It is increasingly recognized that the injection of hydrogen from renewable sources in the natural gas network would effectively use the transport and storage capacities of the existing gas network infrastructure for indirect electricity transport, for energy storage and for meeting decarbonisation targets.

There are, however, widely varying national approaches for managing natural gas composition including permitting process to connect/inject hydrogen, payment arrangements, gas quality requirements, and safety requirements for injection and end-user equipment. All of them have to be studied and defined in Spain.

It is possible to inject pure hydrogen directly into the gas grid because a homogenous mixture can be achieved in a short distance; notwithstanding, the mixture is significantly dependent on the flow speed of the gas stream. In Spain, this is not allowed, but TSO of Germany, Austria and other countries permits the direct injection of hydrogen.

Admissible hydrogen concentration varies between countries

Injection of hydrogen in the gas grid has negligible effects until 10% or even more (admissible hydrogen concentration in Germany). Studies reflect that the gas grid could work on 100% hydrogen by adapting the gas burners of some equipment. But some member states, as Spain, do not allow the injection of more than 0.2% of hydrogen into the gas grid. Germany is the only one that has a supportive framework for the injection of hydrogen having considered all the technical and payment requirements while in other countries there is no regulatory principle for hydrogen.

Spain is far behind the development of technical and legal legislation than other members of the EU. Some parties have stringent restrictions for the injection of hydrogen while in other countries has been proved that 10% concentration of hydrogen is admissible for all kind of equipment.

Blending of natural gas and hydrogen may be beneficial for gas vehicles

Compressed Natural Gas (CNG) vehicles may be refuelled by enriched hydrogen from the gas grid. Gas storage cylinders should have a conservative limit of 2% of admissible hydrogen concentration. Nevertheless, operators of CNG trucks have tested the blending of hydrogen-compressed natural gas (HCNG) with the result of lower emissions of NOx, and CO_2 emissions as compared to that of a CNG engine. With a cleaner combustion the maintenance is reduced and the longevity increased. Therefore a revision of the impact of hydrogen in CNG vehicles has to be revised.

A common approach at European levels is needed with the same technical restrictions.

7.2. Conclusions

The integration of the gas and electricity sectors will be a key milestone in the future, providing versatility to the energetic systems in a way never seen before. It will help to reduce the energy dependence of our country by the production of our proper raw energy sources as gas meanwhile the environment is maintained.

It is essential that the operational framework for Power to Gas be clarified and given a legal definition. This needs to give due regard to the combination of electrolyser plant and related energy storage facilities – in both energy consumption and energy generation (ancillary services) mode. It is also essential that the extent to which safety requirements are covered under existing legal code and regulatory frameworks and not added as supplementary requirements. The avoidance of ‘double charging’ and a clear basis for tailored support mechanisms for Power to Gas operation and services should also be covered

A legal status and a way to facilitate the use of this equipment in the ancillary services in the gas and electricity systems could be the basis in a future energy system which will be sustainable and flexible.

To ensure wider utilization of electrolysers in the provision of ancillary services it is essential that the operational framework and technical capabilities (and merits) are more coherently framed and should meet all applicable EC regulatory frameworks

Gas networks are traditionally managed against safety, system technical integrity and gas quality parameters for natural gas. Hydrogen, as an energy storage vector and use of hydrogen in support of decarbonisation targets, is not widely recognized at the grid level and there are diverging limits to the level of hydrogen permitted in national gas grid networks – and no consistent or coherent policy and regulatory framework to allow connection / injection of hydrogen to the grid.

7.3. Policy Recommendations

To promote along the European Union the Power to Hydrogen / Gas in hydrogen electrolysis production facilities, it becomes essential to clarify the legal basis, evaluate the requisites of security which are covered currently under different regulations, and reviewing the supporting mechanism from which P2G could be benefited and could benefit. This review should be done from a European perspective and also from at national level, tending to a general trend to promote this technology in Europe.

To ensure a wide use of electrolysers in the ancillary services and to avoid the differences among the EU it becomes essential that the criteria from the operational and technical perspective will be more coherent and will achieve the European standards.

The main recommendations are:

- Establish a legal basis for P2H/P2G plants and related energy storage facilities that convert electricity into hydrogen by means of electrolysis.
- Clarify the operational framework for electrolysers to participate in capillary services and the legal basis to do so.
- Review relevant technical and gas quality issues for injection and use of hydrogen in the Trans-European gas networks and establish legal pathways to support Power to Gas operations and increased hydrogen use in gas networks.
- Establish an operational basis and legal framework for hydrogen access to European gas grids.
- Review billing, measurement and administrative requirements with appropriate legal frameworks to allow increased hydrogen flows in European gas networks.
- Review of safety requirements and corresponding legal frameworks for safety compliance to allow increased hydrogen flows in European gas networks.
- Asses of the need for gas appliance modification to accommodate safe operation with higher hydrogen content gas.
- Develop the implications for CNG vehicles with a higher hydrogen content gas.

8. Efficient cogeneration with hydrogen in Spain

Since a long time ago Spain is looking for ways to improve and increase the energetic efficiency in heating and electric sector from the consumer point of view. Improvements as the efficient isolation of buildings or zero energy building houses are a reality. Following this trend, the micro-cogeneration (Combined Heat and Power, CHP) fuel cells are an alternative in Spain to cover the energetic needs of building with just single equipment. Heat and power demand can be covered at the same time with fuel cells.

The fuel cell input is or hydrogen or natural gas from the national gas grid. Fuel cells cover the heat and power demand for a building and, depending on the size of the fuel cell and the demand, this equipment is able to produce enough electricity and an extra surplus. This surplus of electricity can be introduced into the electricity grid of the country, reducing the need for big generation groups with high CO_2 emissions, promoting the distributed generation.

There are manufacturers that have started to commercialize these devices as Viessmann, SolidPower or Elcogen. At a European level, there are also projects that have demonstrated the viability and reliability of these technologies as the ene.field project or the PACE initiative. Following the European trend, it is coherent to follow the same strategy in Spain.

Spain, should order a compromise with this technology, looking for a system as diverse and efficient as possible. Moreover, this technology could help to benefit and to promote the use of the Power to Gas and thus, integrating two big systems that are currently presented in Spain, the gas grid and the electrical one, with the interaction of the energetic vector of hydrogen.

8.1. Overview and assessment of current legal framework

In Spain, there is no single precedent for the installation of a hydrogen fuel cell for cogeneration purposes, what does not mean that this equipment is not allowed to be connected to the national gas grid. There is no specific process to connect a fuel cell in Spain, which means that the procedure should be similar to the connection of traditional equipment. Fuel cells are able to work, as it has been presented before, with natural gas or with hydrogen.

As far as there is a lack of experience with fuel cells in Spain, this can be a cause for time delays. Nevertheless, and as it is presented in other points of Europe, the boiler connections are equivalent for fuel cells. This equivalence must help to avoid new legal and administrative processes which could be unnecessary for fuel cells and facilitate the operation of the technicians responsible for the installation.

For the operation of fuel cells, it becomes necessary to have natural gas or hydrogen, independently if the gas comes from the gas grid or from a storage vessel that is grid independent. In the last case, hydrogen could be produced *in-situ*, via renewable sources, and allowing the use of this green hydrogen when the solar electricity is not available. Moreover, these equipment are able to produce electricity and at the same time heat, allowing thus the cogeneration.

It is worthy to mention that fuel cells are modular equipment, which allows them to adapt to different demands and thus to different buildings. Nonetheless, a lack of regulation can damage the implementation of the fuel cells in Spain.

In order to sell the surplus of electricity to the grid, and then contribute to a more sustainable electricity mix, it is needed to guarantee the access to the grid of the electricity produced from high-efficiency FC micro-CHP systems and provide support mechanisms for its uptake. Nevertheless, these processes in Spain are sometimes complex and high time consuming. Even though the Fuel Cells are considered as high-efficiency cogeneration systems in other countries is not the case in Spain.

Although the European experience has been positive, and this appliance has demonstrated their reliability and benefits in countries as Germany, at a national level there is a lack of support to allow fuel cells operate in Spain.

Finally, and looking for the legal basis of the fuel cells, they do not fall under the definition of cogeneration unit directly in the Royal Decree 413/2014, even though they were mentioned in the non-actual version, the Royal Decree 661/2007. This situation can cause that the fuel cell generators do not have the same benefits as the cogeneration units from natural gas, avoiding the promotion of the fuel cells.

Moreover, they are considered in Spain neither as generator nor heat producer, causing that they do not heave energetic efficiency label that allows them to be compared with other equipment as boilers.

8.2. Conclusions

Future follows the path of renewable sources integration, improvement of the efficiency, management and production of sustainable energy. Spain needs to go ahead and promote in the best way possible these technologies which may help the country with the final objectives of emissions reduction for 2050.

According to the Energy Efficiency Directive, the Member States may particularly facilitate the connection to the power grids of electricity produced from high-efficiency cogeneration from small-scale and micro-cogeneration units. Therefore, the network operators shall adopt simple grid connection 'install and inform' procedures. In addition, the gas grid operators shall provide priority or guaranteed access to the grid, priority dispatch and guaranteed transmission and distribution of electricity from high-efficiency cogeneration. Despite this, in Spain, the fuel cells are not recognized as high-efficient cogeneration devices and cannot benefit from the special regimen of electricity producers.

The Energy Efficiency Directive requires the Member States to assess the potential for CHPs, including micro –CHPs, and introduce policies to promote them. All of this depends on the national implementation and transposition of the Directives, whether the FC micro-CHP systems will be recognised as an eligible technology for reducing the CO_2 emissions of the buildings, achieving energy saving and providing smart grid solutions. This should be reviewed as fuel cells were recognised in the RD 661/2007 but not in the RD 413/2014.

Fuel cells are also an alternative for isolated systems as it possible to provide electricity to remote locations where there is no power grid at the same time as GHG emissions are completely avoided by using renewable energies integrated into the hydrogen cycle.

8.3. Recommendations

- Establish an integrated policy and legal approach, recognising the energy efficiency and the smart grid functionality of the residential stationary fuel cells and promoting them as high-efficiency micro-cogenerations
- Decrease the legal and administrative processes for the connection and use of the infrastructures from the gas and electricity systems, avoiding an extra-regulation for fuel cells.
- Ensure that in national legislation the requirements of the Energy Efficiency Directive regarding priority access, dispatch, transmission and distribution of electricity from high-efficiency cogeneration are transposed and prioritised for micro- CHP systems.
- Reintroduce fuel cells specifically in the electricity special regime of production to promote the implementation at the same time that their knowledge to the society, as it had been done in the Royal Decree 661/2007, making the fuel cells falling under the scope of cogeneration units, including the use of hydrogen as fuel.
- Guarantee the access to the grid of the electricity produced from high-efficiency FC micro-CHP systems and provide supportive mechanisms for its uptake.
- Include FC micro- CHP systems as high-efficiency technology in national strategies and public procurement rules for decarbonisation of the building stock
- Develop a study to check the possible integration of fuel cells in the Spanish houses, creating then an alternative to improve the energetic efficiency of the houses which benefits the small consumers.