HyLAW

National Policy Paper - Italy

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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 at 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

Energy, transport and industry are the biggest factors in driving the transition to a sustainable, low-carbon economy. In Europe, the goal for 2050 is to achieve 80-95% reduction of greenhouse gas (GHG) emissions (2011 Roadmap). In 2019 a *Mid-century zero-emissions European Strategy* would supersede the 2011 Roadmap for moving to a competitive low carbon economy in 2050 providing a cost-efficient pathway towards reaching the net zero emissions goal adopted in the Paris Agreement with a view to keeping the global average temperature rise well below 2 °C and pursuing efforts to limit it to 1,5 °C. Important sub-targets have been set to guide this transition, accompanied by relevant EU Directives[1,2].

Hydrogen has the potential to be a significant part of the solution aimed for, thanks to its qualities as a fuel, as a chemical, as an energy vector and storage medium. It can contribute to zero-emission transport, increase the flexibility of the electric grid, help to decrease pollutant and CO_2 emissions in industrial processes, favour the penetration of renewable energy sources and increase the efficiency of energy end use. However, hydrogen is still relatively unknown in these terms, or is burdened by a general misrepresentation of its potential dangers.

Nevertheless, there are renowned industrial excellences operating in Italy to bring the wide-spread application of hydrogen closer to the general public. In 2015, 68 businesses were operating in the hydrogen and fuel cells sector in Italy, ranging from one-man enterprises to companies with over 200M€/year turnover[3]. Italy is one of the leading countries in Europe in terms of research and demonstration in this field, with 128 projects financed by the European Commission in the period 2008-2017, involving over 80 Italian beneficiaries and mobilizing over 90M€ funding[4].

With [Legislative Decree n. 257 of 16 December 2016] the Italian government has adopted the European Directive 2014/94/EU for the creation of an infrastructure for alternative fuels, wherein hydrogen is officially included. Currently, in Italy, there are four Hydrogen Refuelling Stations (HRS) developed with private or state funds, which establish a minimum infrastructure, but this is still not sufficient to allow adequate commercialisation of hydrogen zero-emission vehicles. The most advanced is the HRS in Bolzano, with the potential hydrogen production of 180 Nm3/hr, for the refuelling of 15 bus and 700 cars per day.

Hydrogen production and handling has been managed by the Ministerial Decree of 31 August 2006 until 2018, which considered hydrogen as an industrial chemical produced at large scale with fossil sources, didn't take into account the possibility of localised, zero-emission production from water and electricity, and posed extremely stringent prevention measures on any plants for the storage of hydrogen, disregarding the latest technological developments in this field. Also, it left a lot of room for interpretation, increasing the uncertainty related to time and requisites of permission procedures.

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[1] Proposal for a Directive for "Clean energy for all Europeans" (amending Directive 2012/27/EU on energy efficiency): COM(2016) 761 final (30 Nov. 2016)

[2] Directive for an alternative fuels infrastructure (DAFI): 2014/94/EU (22 Oct. 2014)

[3] Survey held by the Italian Hydrogen and Fuel Cells association (H2IT), presented at the EFC "Piero Lugnhi" Conference, 15-18 Dec. 2015

[4] Information provided by the Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU), Feb. 2018

This Decree has been updated by the [Ministerial Decree of 23 October 2018] "Technical rule of fire prevention for design, construction and operation of hydrogen distribution facilities for automotive applications". The new regulation has been signed by the Ministry of the interiors and by the Ministry of infrastructure and transport and has been published on November 2018. Most of the significant barriers of the Decree of 2006 has been largely overcome thank to a very important and effective work among the Fire Department, Ministries, the Italian Association for Hydrogen and Fuel Cell and several interested stockholders, introducing an innovative approach where the perspective analysis has been supported by the risk analysis. The final decree, which substitute the one of 2006, allows for 700 bars and better alignment to ISO 19880.

Italy, as the fourth most industrialised country in the EU, should latch on to the opportunities provided by hydrogen in the transition of the national infrastructure towards an integrated, flexible, sustainable and energy-efficient system. Proactive policies such as those implemented by Germany, France and the UK – but even in the Autonomous Region of Trentino-Alto Adige, where hydrogen mobility has been embraced by local authorities – serve as examples to consider, in order to support Italian industry becoming a competitive player in the evolving market, reducing emissions in all sectors.

These goals can be secured, taking advantage of the economic and environmental potential of hydrogen technology, by:

- Reducing the legal and administrative barriers in the production, storage and distribution of hydrogen
- Promoting sustainable mobility with hydrogen through incentives for vehicles and infrastructure
- Introducing hydrogen as a fuel by promoting large hydrogen-powered fleets such as buses, garbage trucks or delivery vans in cities
- Supporting the further integration of renewable sources in the energy sector, where hydrogen is essential for large-scale energy storage and can help to stabilize the electric grid
- Promoting 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
- Introducing a long-term support approach for FC micro CHP, including not only direct financial support but also the recognition of fuel cells in the energy efficiency policy mechanisms.

By 2050, hydrogen will represent 18% of the total worldwide energy consumption. This would decrease the amount of CO_2 released in 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[5].

These estimations, although ambitious, have already begun to be concretized in different nations: 400 Hydrogen Refuelling Stations (HRS) are planned in Germany by 2023 and 900 in Japan by 2030 (transport within the 2020 Olympic games in Tokyo will be hydrogen-fuelled). In France, the national "Plan Hydrogène" proposes to use hydrogen as a key solution for the energy transition of the country, whereas in the US major fleets of hydrogen trucks and a large infrastructure of refuelling stations are under development. These are just some of the examples that show how the world is starting to move towards a hydrogen economy.

On September 17th, 2018 in Linz, the Austrian Presidency of the Council of the European Union proposed a Hydrogen Initiative that many member states, as Italy, approved of and signed; it concerns a policy document to support the development of sustainable hydrogen. Under this initiative, the signatory states commit themselves to continue research and investment in the production and use of hydrogen as a future oriented technology.

Italy is in the position to foster innovation and accelerate the market deployment of hydrogen leveraging its creativity and technological leadership: this opportunity should not be missed.

[5] Hydrogen Council, 2017

1.3 National Policy Papers

This document synthesizes the in-depth analysis of the hydrogen legislation of the HyLaw project, particularizing the situation in Italy 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 eight 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 in Italy.

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.

2. Production of Hydrogen: Industrial and Localised

Hydrogen production, distribution and storage are critical processes for hydrogen to be able to play its role in a low-carbon future. Hydrogen is currently produced above all as a bulk chemical for various industrial applications. Large-scale, centralized hydrogen production from fossil fuels, i.e. coal, oil, and natural gas, is the current industrial practice, and regulations that govern the ways in which hydrogen is handled generally reflect this. The technology used for the production of hydrogen from these sources is called **reforming**, and it produces fossil CO_2 as well as other (pollutant) emissions, inherent to the fossil fuels employed. It is an efficient technology, but becomes competitive only at very large scales.

But hydrogen can also be generated via multiple, renewable-based and sustainable pathways, increasing the further penetration of renewable energy sources. The main technology for this type of production is called **electrolysis**, and uses electricity (which can be 100% renewable) and water. It is an easily scalable technology that can be operated efficiently also at localized sites, e.g. where significant amounts of renewable electricity are produced or where hydrogen is needed to fuel a fleet of zero-emission hydrogen vehicles.

The constantly increasing installed capacity for unpredictable renewable electricity production through wind and photovoltaic technologies, and the need to match fluctuating supply and demand as well as guarantee grid stability, provides rich potential for hydrogen as an energy storage medium. Furthermore, hydrogen can be used as a high-added value chemical commodity (for the production of fuels, chemicals and even materials, or to decarbonise the steel, petrochemical and mining industries) or as a fuel for fuel cell electric vehicles (FCEV). Ultimately, it can also be re-electrified through conversion in stationary fuel cells. This flexibility greatly diversifies the end application and customer value of the energy stored in hydrogen.

Most technologies in the hydrogen value-chain are proven, albeit at different stages of maturity. The adoption of renewable hydrogen (as well as the use of fossil-derived hydrogen, with or without CO_2 capture) as a viable energy vector strongly depends on its economic competiveness. Therefore, cost reduction is a key pre-requisite for hydrogen production plants, and the legal and administrative procedures required to obtain the necessary permits for hydrogen production, storage and distribution can greatly influence the effective pathway to commercialization.

2.1. Overview and assessment of current legal framework

Several legal and administrative processes are necessary to get the approval for the installation of a hydrogen production unit:

- Land use plan, including zone prohibition: to regulate land use in an efficient and ethical way, preventing land-use conflicts. It applies to manage the development of land within the jurisdictions of municipal, regional and national governments.
- Permitting process: where an applicant files forms to a (regulatory) agency/competent authority, to ensure in advance that the proposed operation will be in compliance with the applicable standards.
- Permitting requirements: the legal (regulations and standards) requirements for hydrogen production approval.

There are different pathways to producing hydrogen

The production of hydrogen, in Italy, is regarded as an industrial activity, irrespective of the production method, even when produced from non-emitting methods such as water electrolysis. Hence, such activity would only be permitted in an area designated as an industrial zone or, under specific conditions, in commercial areas. This limitation is understandable, given that, traditionally, the production of hydrogen has taken place through industrial processes at large scale. It also justifies the application of the EIA[6], SEA[7], IED[8] and SEVESO[9] Directives, which prescribe environmental impact assessment procedures. However, current legal and administrative processes also relegate non-emitting production processes such as electrolysis to such zones, thereby unduly limiting the locations where such installations can be built.

[6] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment

[7] Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment

[8] Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control

[9] Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances

Renewable hydrogen favours small-scale, localized production

It is important to distinguish and recognize that hydrogen production can take place in different ways and that some of these methods (e.g. electrolysis) have little environmental impact and generate little to no emissions. Furthermore, electrolysis is ideally employed for small-scale, localized production of hydrogen. Not having the administrative means to evaluate such a small-scale plant – which is then subject to the same procedures as a large-scale industrial plant – severely impairs potential ventures to install such a unit. While zone prohibition will continue to exist even in such situations, it is important that legal and administrative procedures recognize the differences and distinguish between the various production methods, thereby incentivizing renewable, low-carbon hydrogen.

Renewable, low-carbon hydrogen still requires a certification of origin

The certification and Guarantee of Origin of (renewable, low-CO_2) Hydrogen as fuel is not yet available. The CertifHy project[10] works in this direction and it is foreseeable that the new European Renewable Energy Directive will establish the traceability of renewable and low-carbon Hydrogen at European level, paving the way for the Guarantee of Origin scheme. This 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.

Moreover, the GO for Hydrogen is under evaluation by the Group CEN/CLC JTC 6 - Hydrogen in energy systems, and in particular by the WG 2 Guarantees of Origin with the Proposal for common standard on 'Guarantees of Origin'.

Regulatory and technical issues continue to be a barrier to the deployment of hydrogen

The permitting process for building and operating a hydrogen production facility are officially treated on a uniform basis throughout Italy. Specific municipalities can have different requirements in terms of land use, and these need to be taken into account when applying for permission to build and operate a hydrogen production plant. The applicant needs to accurately describe the destination and scope of the plant to be installed so that the municipal authorities can assess compatibility with the Land Use Plan. Then, the local Fire Department is responsible for providing an evaluation in terms of safety and fire prevention, based on which the permission is given to operate the plant. Depending on the location of installation, Regional authorities such as the Comitato Tecnico Regionale (CTR) and the Agenzia Regionale Protezione Ambiente (ARPA) also need to be consulted.

The environmental authorities in charge of the environmental permits often 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 equal restrictions. Also in this case, rules can vary substantially from one Region to another. It is necessary to review these situations since an electrolyser has more similarities with an electrical transformer than with the petrochemical industry, and 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.

At the same time, procedures should continue to be simplified and streamlined; local authorities should act as one-stop-shops to systematically process permitting and zoning in a centralized manner and the duration of the process should be decreased and transparent, in order to reduce the economic cost borne by economic operators engaged in such activities.

Looking at the whole picture, with a large proportion of uncertainty and unpredictability in the permitting process for the construction and operation of hydrogen production plants, the manufacturers of these systems hesitate to see Italy as a potential market where they can invest, develop and sell their technology, which impairs the potential for deployment.

2.2. Conclusions

Hydrogen has the potential to significantly contribute to zero-emission transport, to increased flexibility of the electric grid, cleaner industrial processes, and to further promote the penetration of renewable energy sources. Hydrogen can be generated at large scale via fossil fuels, or locally via renewable electricity and water. The adoption of renewable hydrogen as a viable energy carrier is already technically feasible, but depends strongly on its economic competiveness, and this can be greatly facilitated by a supporting regulatory environment.

One of the key obstacles in this respect is the lack of distinction between emitting and non-emitting hydrogen production processes at administrative level. Also, the large room for interpretation provided by Ministerial Decree of 2006 caused uncertainty as to the safety measures that need to be adopted for a given hydrogen production facility, which can thus be heavily over-prescribed. Most of the significant barriers of this Decree of 2006 has been largely overcome thank to the

[10] http://www.certifhy.eu/

Ministerial Decree of 23 October 2018, a new technical rule for the design, construction and operation of hydrogen refuelling stations for automotive applications, allowing for 700 bars and with a better alignment to ISO 19880.

Irrespective of the production method and scale, the permitting process is long, costly, and its outcome is uncertain. This increases the costs for developers and delays the deployment of hydrogen technology. It is necessary therefore 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 Italy as a leading country in the development of zero-emission transport and the efficient exploitation of renewable energy sources. A clear and ambitious legislation will finally promote that the national companies in this sector will increase their sales with the result of further cost reductions and increased market share.

2.3. Policy Recommendations

- Develop guidelines for specific requirements and zone prohibitions when a hydrogen production unit is installed, distinguishing between production through industrial pathways (e.g. reforming), from non-emitting, environmentally friendly methods such as electrolysis

- Develop clear permitting guidelines for both administrations and project developers. These guidelines should cover mandatory permitting steps, with reference to EU directives and best practices that need to be applied when a hydrogen production unit is installed. This document should attempt to differentiate between hydrogen production methods (reforming, electrolysis, gasification, etc.) and the plant scale (centralized or localized)

- Develop clear and simplified guidelines for hydrogen production by electrolysis.

- Simplify and streamline the permitting process for hydrogen production plants: a one-stop-shop authority should be designated to “lead” the administrative process, even when various other authorities are involved.

- Streamline existing regulation (at EU and national level) to consider the specificities of localized hydrogen distribution (e.g. for mobility purposes). Permitting requirements applicable to hydrogen production at national level should be identified and studied and their links to obligations established at EU level should be reassessed, highlighting where requirements go beyond those established by the EU acts. National rules should be adapted to reflect the changes at EU level.

- Establish simplified processes for small-scale hydrogen production and for non-emitting production methods. The absence of simplified processes for small quantity production leads to a restrictive environmental procedure, which may discourage investors. This situation discourages development of environmentally friendly production methods and further exacerbates the (lack of) economies of scale issues faced by smaller units.

- Promote simplified processes for demo units (installations used for research, development or testing of new feedstocks, fuels or processes in laboratories or in pilot plants) to foster the deployment of hydrogen production units throughout Italy.

3. Stationary storage of Hydrogen

Hydrogen storage is a key enabling technology for the advancement of hydrogen and fuel cell technologies in applications including stationary power, portable power, and transportation. This has implications for land use planning as well as for the safe operation and maintenance of hydrogen equipment. How to store hydrogen efficiently, economically and safely is one of the challenges to be overcome to make hydrogen an economically viable source of energy.

Currently, hydrogen can be stored as compressed hydrogen, liquid hydrogen and as storage material. The storage of hydrogen in conventional gas tanks, metallic cylinders and composite vessels has been considered in all states: gas (under pressure at various levels of pressure), liquid, and solid (in the form of metal hydrides).

In particular, hydrogen can be stored physically as a compressed gas (CGH2) or as a cryogenic liquid (LH2). Gaseous hydrogen storage systems typically require compressed-gas vessels, i.e. tanks able to withstand up to 1000 bar pressure. Storage of hydrogen as a liquid requires extremely low temperatures because its boiling point at 1 atm pressure is -253°C. LH2 storage is commonly used for bulk hydrogen storage and transportation. Hydrogen can also be stored in materials: on the surfaces of solids (by adsorption) or within solids (by absorption).

Depending on applications and end use, different sizes of storage of hydrogen may be necessary, e.g. small cartridges are sufficient for hand-held applications or ultra-light mobility, whereas industrial-scale storage is required to buffer energy, stored as hydrogen produced by water electrolysis, caused by fluctuations in availability of renewable electricity.

This application deals with the storage of hydrogen in conventional gas tank, metallic cylinders and composite vessels. All states of hydrogen are considered: gas (under pressure at various levels of pressures), liquid, and solid (in the form of metal hydrides). As far as stationary storage is concerned, tanks in vehicles are not covered by this application.

3.1. Overview and assessment of current legal framework

Several legal and administrative processes are necessary to get the approval for the installation of a hydrogen stationary storage plant, that concern:

- the land use plan, including zone prohibition: this corresponds to a branch of urban planning encompassing various disciplines which seek to order and regulate land use in an efficient and ethical way, thus preventing land-use conflicts. Governments use land-use planning to manage the development of land within their jurisdictions.

- the permitting requirements/process, including safety distances. These correspond to a process in which an applicant files forms to a (regulatory) agency/competent authority with required narratives, maps, etc., to ensure in advance that the proposed operation will be in compliance with the applicable standards. Permitting requirements are the legal (regulations and standards) requirements. An internal safety distance is the minimal separation distance between a potential hazard source (e.g. equipment involving dangerous substances) and an object (human, equipment or environment), which will mitigate the effect of a foreseeable incident and prevent a minor incident escalating into a larger incident (also known as domino effect).

The technical rules for hydrogen storage are established by the Ministerial Decree of 23 October 2018 “Technical rule of fire prevention for design, construction and operation of hydrogen distribution facilities for automotive applications”, where the maximum foreseen storage pressure is 1000 bar, with a maximum hydrogen quantity of 6000 Nm^3.

Hydrogen Stationary Storage doesn’t imply changing land use plan

A hydrogen storage facility cannot be installed everywhere; the Regulatory Plan (Piano Regolatore Generale) should be analyzed before the planning of the project to choose the appropriate area for the storage facility. There are no specific requirements or zone prohibitions for hydrogen storage facilities in the land use plans. Typically, application locations are industrial zones, in accordance with the traditional view that hydrogen is an industrial gas.
Nevertheless, a feasibility study on hydrogen storage facilities is the preliminary action based on national and local regulations on security safety distances. Changing the land use plan is not necessary; it entails a lengthy process that may take several years depending on the change needed.

There is no uniform permitting process within the country

Concerning permitting requirements, the Operating Permit from the Municipality is based on different local regulations. Requirements include the authorization from the local Fire Department, from the regional environmental protection agency (ARPA) and local safety authority (ASL).

The Ministerial Decree of 23 October 2018 is the only one that considers the application of hydrogen safety distances.

National transposition of Directive 2006/42/EC (machinery Directive), Directive 2014/34/EU (ATEX) and Directive 2014/68/EU (PED) are the reference EU laws applicable to hydrogen storage.

Regulatory and technical issues continue to be a barrier to the deployment of hydrogen

The permitting process for building and operating a hydrogen stationary storage are officially treated on a uniform basis throughout Italy. Specific municipalities can have different requirements in terms of land use, and these need to be taken into account when applying for permission to build and operate a hydrogen stationary storage facility. Then, the local Fire Department is responsible for providing an evaluation in terms of safety and fire prevention. Depending on the location of installation, Regional authorities such as the Comitato Tecnico Regionale (CTR) and the Agenzia Regionale Protezione Ambiente (ARPA) also need to be consulted.

The local Fire Department refers to the Ministerial Decree of 23 October 2018 to establish the required safety measures.

The permitting processes for the storage of hydrogen should be simplified and streamlined. Best practices such as the appointment of One-stop-shop authorities should be the standard. Whenever possible, assessments (e.g. Risk assessment, Health and Safety, etc. and the associated authorities which are competent to issue them) should be integrated with a view to minimize duplication of effort and reduce overall administrative burden while maintaining a high level of safety and environmental protection.

3.2. Conclusions

Hydrogen is rapidly emerging as an alternative to fossil fuels but the storage technology needs further improvements in terms of infrastructure and applications which in turn depends on the energy density, storage capacity, an efficient hydrogen storing system, safety requirements and finally on low investment cost.

Since there are no specific national regulations for hydrogen storage facilities, the rules can vary greatly between different local Fire Departments and Municipalities, leading to potentially extra costs where the most severe restrictions and requirements are imposed such as unreasonably large safety distances.

Most of the significant barriers of this Decree of 2006 has been largely overcome thank to the Ministerial Decree of 23 October 2018, the new technical rule for the design, construction and operation of hydrogen refuelling stations for automotive applications, allowing for 700 bars and with a better alignment to ISO 19880.

3.3. Policy 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 since at the moment hydrogen storage is assimilated, from a legal and administrative perspective, to chemical storage of flammable and dangerous gases. In order to operationalize and codify this recommendation, it is necessary to establish the meaning of "commercial" use of hydrogen, as a means to distinguish it from industrial use, thereby giving legislation and administrative practice a realistic opportunity to differentiate between the two.

- Simplify the permitting process by decreasing the number of permits and the number of administrations involved. The permitting process for storing hydrogen on-site implies the application of a number of different permits and assessments (risk and safety assessment, environmental assessment, etc.). Often, these permits require individual applications and separate processes involving different authorities. This not only increases the amount of time necessary to fulfill requirements but leads to duplication of efforts and increased compliance costs and administrative burden on project developers.

- Shorten the duration to receive the permits. Irrespective of scale or purpose, the process of permitting hydrogen storage is long and costly. The lack of experience of both economic operators/project developers as well as permitting authorities and the lack of clarity on procedures and applicable legislation often causes delays and may even lead to divergent interpretation of associated obligations. This limits the development of a hydrogen market and stifles development and growth.

- The permitting process (simplified and streamlined, in line with the recommendation above) should be clearly established in administrative practice and made available to potential project developers, giving them clarity and certainty with respect to their obligations and necessary steps. This process should be completed in a reasonable time and maximum response times should be established and enforced in practice in order for a smooth and predictable business environment to develop.

- Incorporate H2-specific (and H2 storage-specific) rules into the existing, relevant legislation in order to avoid uncertainties and non-adapted application of rules. 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.

- Promote simplified processes for small amounts of storage and demonstration units. Subjecting demonstration projects and the storage of low volumes of hydrogen storage to the same (or similar) obligations creates disproportionate burden on small projects and slows down innovation and development. Differentiated treatment (and reduced obligations) should apply, scaling up with the quantities of hydrogen stored, in order to progressively reduce administrative burden on small projects.

4. Transport and distribution of Hydrogen

This Paper deals with the transportation on road of hydrogen in gaseous or liquid form, or absorbed by special materials, in conventional gas tanks, metallic cylinders and composite vessels.

Hydrogen is typically stored and transported either as a compressed hydrogen gas or as a cryogenic liquid. Specialised vessels are used which can be connected into bundles or gathered onto trailers for transportation. Due to the small size of its molecules, hydrogen is prone to leak more easily through certain materials, slight cracks, or poor joints of the storage tanks, compared to other common gases at equivalent pressures.

Gaseous hydrogen is transported in small to medium quantities by lorry, in compressed-gas containers. For transporting larger volumes, several pressurized-gas cylinders or tubes are bundled together on so-called CGH2 tube trailers. The large tubes are bundled together inside a protective frame. The tubes are usually made of steel with a typical pressure of 200 bar. Alternative pressurized storage systems use composite storage containers for lorry transport.

As an alternative, hydrogen can be transported in **liquid** form in lorries or by other means of transport. In comparison to pressurized-gas vessels, more hydrogen can be carried with an LH2 trailer, as the density of liquid hydrogen is higher than that of gaseous hydrogen. Over longer distances it is usually more cost-effective to transport hydrogen in liquid form, since a liquid hydrogen tank can hold substantially more hydrogen than a pressurized gas tank. LH2 can also be transported by ship or by rail, provided that suitable waterways, railway lines and loading terminals are available.

The transport of hydrogen is considered as that of any other dangerous good or flammable gas, and the rules for its transport are those defined by the European Agreement concerning the International Carriage of Dangerous Goods by Road - ADR 2017 as transposed by Decree of the Ministry of Infrastructure and Transport, 12 May 2017.

4.1. Overview and assessment of current legal framework

The European Agreement concerning international carriage of dangerous goods by road (ADR 2017) is the main reference regulation.

The Decree of the Ministry of Infrastructure and Transport, 12 May 2017 (national transposition of the European Agreement concerning the International Carriage of Dangerous Goods by Road: DIR/2016/2309/EC - ADR 2017) provides rules for transport of hydrogen, related to classification of dangerous goods for the purpose of road transport, shipping procedures (labelling, marking documentation), the use of packaging and tanks, dispositions related to construction, test and approval of packaging and tanks, use and requirements of means of transport and cases of exemption.

The regulation ADR 2017 in Part 1 'General provisions' of the Annex A contains provisions concerning the respective safety obligations of the various participants in dangerous goods transportation chain of transport and regarding Safety Advisers who are responsible for monitoring, controlling and identifying ways in which the work associated with the transport of dangerous goods is carried out as safely as possible.

In particular, national requirements for appointment, tasks, training, examination and certification of Dangerous Goods Safety Advisers (DGSA) are set out by Ministry of Infrastructure and Transport as indicated in art.11, Legislative decree n.35, 27 January 2010 (national transposition of Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods).

Though the rules for hydrogen transport are slightly different from other types of gas (for example when applying the classification code or certain shipping procedures such as labelling, marking and documentation), there are no specific types of roads or special routes for hydrogen transport, since hydrogen is considered as any other dangerous good and the rules for its transport are those defined by the ADR. The authorities competent to allocate specific routes are local Authorities (Regional and Municipalities) in agreement with the Fire Department, with the approval of the Ministry of Infrastructure and Transport.

The requirements for hydrogen transport regarding tunnels, bridges and parking, are included in ADR 2017. It contains for example restrictions to the passage of vehicles carrying dangerous goods through road tunnels.
Route possibilities using tunnels depend on the design and size of the transport container: bulk or bottled. ADR requires tunnels to be classified according to risk. The transport of dangerous goods is allowed without restrictions for category A. For example if hydrogen is transported in tanks, there are restrictions for tunnels of the categories B,C, D and E, whereas hydrogen transport in other containers is not allowed in tunnel categories D and E.

The main EU reference documents concerning hydrogen transport are:

- DIR/2016/2309/EC ADR European Agreement concerning the international carriage of dangerous goods by roads.
- DIR 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods.
- DIR 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the trans-European road network
- Safety data Sheet SDS Eiga067A

4.2. Conclusions

Hydrogen transport is satisfactorily regulated, mainly by national transposition of ADR 2017, that is revised every 2 years to align with technical progress and regarding road planning (specific requirements when hydrogen is transported), restriction of road transport, requirements regarding tunnels, bridges, and parking as well as the permitting process/requirements for on the one hand the drivers/transporting company and on the other hand the equipment (trailer).

How successful research and development is in bringing down the cost of transportation and storage methods will affect both the viability of hydrogen as an energy carrier and whether centralised or localised production prevails.

4.3. Policy Recommendations

Since hydrogen is considered as any other flammable gas or dangerous good, for its transportation the ADR applies, and there are not many recommendations to provide since it defines the main requirements for hydrogen transport on road.

For tunnels, it is preferable to have different restrictions during the day, related to the traffic. For bridges and parking garages, some efforts could be made to provide clearer and harmonized prescriptions.

Regarding quantity and pressure limitation, it is not possible to increase the pressure/quantity; delivery containers are certified for specific pressures, where the standard pressure is 200 or 300 bars.

5. Hydrogen as a fuel, and refuelling infrastructure for mobility purposes

Hydrogen has emerged as a possible transportation fuel for addressing long-term, sustainable energy supply, security, and environmental problems. Yet, there are a number of barriers that need to be overcome if hydrogen vehicles are ever to penetrate transportation markets, not least of which is the development of an aligned vehicle–infrastructure system. Hydrogen vehicles and refuelling infrastructure are complementary and must both successfully penetrate transportation markets for either to be successful.

Moreover, hydrogen as a fuel cannot become an economically viable option unless its cost is comparable to that of conventional fuels. The cost of hydrogen conditioning (compression, liquefaction), of auxiliary equipment and the overall cost of hydrogen storage are key issues.

5.1. Overview and assessment of current legal framework

Hydrogen is defined as Alternative Fuel by Legislative Decree no. 257, national transposition of AFID Directive.

As far as alternative and sustainable mobility is concerned, Legislative Decree no. 257 (16th December 2016), implementing EU Directive 2014/94/EU (Alternative Fuels Infrastructure Directive - AFID) establishes a National Strategic Framework (Quadro Strategico Nazionale (QSN)), for the development of a network of refuelling / recharging points for alternative fuels, in order to progressively reduce dependence on oil in the transport sector, including hydrogen in the list of alternative fuels. One goal is to create an adequate number of refuelling stations by the end of 2025.

International standards define hydrogen quality

For a long time there wasn’t any European Technical Committee of CEN and / or CENELEC that dealt exclusively with hydrogen, even if the topic was partially part of the aim of numerous Technical Committees of both CEN and CENELEC. In 2016 the CEN / CLC / JTC6 "Hydrogen in Energy Systems" has been issued, with the purpose of working on all transversal topics concerning hydrogen (e.g. guarantee of origin, safety, social acceptability), and the study of aspects not already covered by other Technical Committees Europeans. The CEN / CLC / JTC6 establishes the liaison with the European and International Technical Committees with the main aim of not to duplicate the regulatory study concerning hydrogen and to favour the interaction and the information exchange. CEN / CLCJ / TC6 does not deal with the issues that are already part of the mandate of other CEN Technical Committees (e.g. H2-CH4 mixtures), but deals with what concerns the management of interfaces (electrical interface and gas interface).

Similarly in Italy, the Regulation concerning hydrogen technologies is being followed by the UNI-CEI / CT056 "Hydrogen" Joint Committee set up in 2017 to directly follow the CEN / CLC / JTC6 "Hydrogen in Energy Systems" as a national interface.

The UNI-CEI / CT056 "Hydrogen" has, among its competences, to follow at national level the ISO / CT197; this role is carried out directly by the UNI-CEI / CT056 / GL1 working group "ISO / CT197 Interface". Until 2017 the national role of interface of ISO / TC 197 was carried out by the Technical Committee CT 286 of Comitato Termotecnico Italiano.

In Italy there is no certification system of hydrogen as a Guarantee of Origin (GO) scheme, but through the UNI-CEI CT056 the developments of the CEN / CLC / TC6 / WG2 "Guarantiee Origine" in Europe are closely monitored. Currently the activity of WG2 is temporary waiting for CEN decisions, considering that the issue of the guarantee of origin could evolve towards a definition, in the same legislation, of the guarantee of origin of hydrogen and electricity and / or other renewable sources.

Regulatory and technical issues continue to be a barrier to the deployment of hydrogen

Hydrogen Refuelling Stations (HRS) play a key role in the infrastructure of hydrogen-powered vehicles. Unlike traditional stations where fuel is delivered by tankers, in the case of hydrogen it is also possible to supply it by pipelines or locate its production on site at the filling station. Apart from the many possible configurations for the construction of filling stations in most cases these will comprise: a hydrogen generator (only for stations where production takes place on site); a hydrogen purification system to meet the requirements for fuel cell vehicles (in case of the production of hydrogen by other means than electrolysis); tanks for gaseous or liquid hydrogen storage; a compressor to bring the fuel to a high pressure (350 bar, 700 bar) at which it is supplied to the vehicle tank ; safety components (relief valves, venting chimneys, hydrogen sensors, fence-off safety measures); mechanical equipment (such as underground pipelines, valves) and electrical equipment (e.g. control panels, high voltage lines, meters).

At present, according to the Ministerial Decree of 23 October 2018, art. 5, it is forbidden to build HRS in urban areas, or in areas where the allowed building rate is >3 m^3/m^2 (urban expansion areas) and in public green or park areas. In particular, Annex 1 of the decree foresees technical regulations for design, construction and exercise of Hydrogen refuelling stations for mobility purposes.

This Decree has substituted the one of 2006, overcoming most of the significant barriers of old Decree introducing an innovative approach where the perspective analysis has been supported by the risk analysis. The new Decree allows the filling pressure at 700 bars and it is aligned to ISO 19880.

Even if the permitting process for a hydrogen refuelling station is officially treated on a uniform basis throughout Italy, specific municipalities can have different requirements, and these need to be taken into account when applying for permission to build and operate a HRS. Especially, the local Fire Department is responsible for providing an evaluation in terms of safety and fire prevention. Depending on the location of installation, Regional authorities such as the Comitato Tecnico Regionale (CTR) and the Agenzia Regionale Protezione Ambiente (ARPA) also need to be consulted.

Technical Annex to the Decree of 2018 (Titles II and IIII) provides rules for external safety distances related to HRS equipment for the supply, compression, storage and dispensing of hydrogen. The safety distances concern both compressor (active system) and dispenser (passive system). The local Fire Department refers to this Decree to establish the required safety measures.

The relevant Directives, which affect the permitting requirements for HRS, are the SEA[11] and EIA Directives, (including Directive 2014/52/EU) on the assessment of the effects of certain public and private projects on the environment[12] as well as Directive 2012/18/EU (Seveso Directive)[13], Directive 2010/75/EU on industrial emissions[14] and the ATEX Directive (Directive 2014/34/EU)[15]. These Directives have been designed to regulate large scale, chemical, emission emitting industrial processes but end up applying also to small scale, non-emitting processes.

Given the highly complex regulatory landscape, as well as the relatively long “distance” between the text of the Directives, originally establishing these obligations, the national acts transposing them in national law and administrative guidance documents/requirements (where they exist), implementing the obligations at an operational level, it is highly difficult to re-establish the link between the operational requirements (at national level) and the sources of the obligations established by EU law.

5.2. Conclusions

Establishing hydrogen as a fuel for transportation requires a detailed analysis of the entire supply chain. This includes how hydrogen is to be produced, its large-scale storage that takes the seasonal intermittency of renewable power generation into account, its transportation and distribution from a central production plant to fuelling stations as well as the fuelling stations themselves.

Hydrogen is recognized as alternative fuel in the National Decree n.257 of 16 December 2016, which implements the EU Directive 2014/94/EU, by which Italy is committed to develop an adequate network of refuelling stations by 31 December 2025. A plan for the deployment of hydrogen technologies has been developed, but the targets for hydrogen technologies appear ambitious regarding the lack of financial coverage considered essential for their achievement.

The lack of implementing regulations of the Ministerial Decree 31 August 2006 causing a major obstacle in the diffusion of HRS in Italy has been overcome thank to a new Decree of 2018, allowing for 700 bars and better alignment to ISO 19880. The local Fire Department refers to this Decree to establish the required safety measures and it is responsible for providing an evaluation in terms of safety and fire prevention. Each municipality may apply different rules for installing a hydrogen refuelling station, and these need to be taken into account when applying for permission to build and operate a HRS.

From a land-use perspective, HRS do not differ significantly from conventional refuelling stations (in general) and those using compressed natural gas (CNG) in particular. However, the lack of specific rules regarding HRS raise the risk that legislation applicable to (industrial) hydrogen production (see category 1) or hydrogen storage (see category 2) would be

[11] According to Directive 2001/42 on the assessment of the effects of certain plans and programs on the environment.

[12] In line with the EIA Directive, Production and Storage of Hydrogen falls within the projects listed in Annex II (6a and 6c -production of chemicals; and storage facilities for chemical product), for which Member States shall determine whether the project shall be made subject to an assessment or not.

[13] Annex I, Part 1, establishes Hydrogen as a dangerous substance (therefore within scope) and lists the quantity of hydrogen for the application of lower-tier requirements (≥ 5t) and upper-tier requirements (≥ 50t).

[14] Directive 2014/52/EU harmonizes and defines principles for the environmental impact assessment of projects which may have a large environmental impact

[15] The Directive describes the rules and regulations for all actors in the value chain, with respect to ensuring that only safe equipment for use in potentially explosive atmospheres are sold and applied

strictly interpreted and applied *mutatis mutandis* to HRS thus limiting considerably the zones where some HRSs (especially those with on-site production or with high storage capacity) can be located.

5.3. Policy Recommendations

- Develop approval guidelines for HRS

  Without clear regulations, local authorities are left to interpret which requirements would apply and which would not when considering permitting an HRS on a case-by-case basis. This causes delays and extra costs for both operators and for authorities and carries regulatory risks for the HRS operator. The approval guidelines for HRS should present the step-by-step processes that should be followed by the HRS operator to obtain all necessary permits and approvals.

- Streamline existing regulation (at EU and national level) to consider the specificities of hydrogen distribution for mobility purposes.

  The rules on (industrial) production and storage of hydrogen are not designed for hydrogen refuelling stations, they reflect the traditional view that hydrogen production and storage is a large scale, industrial, chemical process. Although it may not be evident, given that permitting is under the competence of local or regional authorities, based on national legislation, the permitting requirements applicable to HRSs draw heavily on obligations established at EU level. Permitting requirements applicable to HRS at national level should be identified and developed.

- Establish reasonable safety distances, which enable the co-location of hydrogen refuelling alongside conventional fuels.

  To allow the commercial deployment of HRSs it is necessary to design specific administrative rules, procedures and methodologies which standardize, to a certain extent, the safety rules applicable to HRSs, and bring them up-to-date with the latest technology status and best practice. Safety distances applicable for hydrogen storage at HRS should be determined on the basis of risk assessments. They should take into account the amount of hydrogen stored and be reduced by means, which decrease risks (e.g. where fire-walls are used or when hydrogen is stored underground).

- Establish, endorse and promote a widely acceptable standard laying down safety requirements for HRS (including safety distances).

  The regulatory gap for safety requirements specific to HRS has several major consequences:

  - HRS operators face uncertainty during permitting: there is no standardized approach by the administration for the interpretation of the applicable regulation, which can lead to non–uniform interpretation by different authorities,
  - Unreasonably high requirements: Authorities which wish to exercise a high degree of precaution in the face of limited experience with hydrogen technologies interpret general regulations by imposing the “maximum” level of prescribed safety measures, often overly restrictive
  - Duplication of efforts, without added safety benefits: every new HRS project is treated on a case by case basis which increases the necessity of individual (case–by–case) modeling, calculation, planning, etc. Designs, which have been deemed safe already, could be replicated at lower administrative and economic cost, without the need to repeat the entire administrative process of planning (including safety studies) and permitting.
  - Discouragement of HRS with on-site production: despite the opportunities for localized, renewable hydrogen these offer, the authorization procedure for HRS with on–site production is cumbersome and, in some cases, prohibitive.

  To avoid uncertainty and unreasonable burden resulting from the application of excessive requirements, the safety requirements, which apply to HRS, should be standardized. The resulting standard should be endorsed by competent authorities and used as reference for the permitting and operation of Hydrogen refuelling stations. Simplified procedures, which avoid superfluous requirements should be implemented for HRS designs which have already been permitted / installed (i.e. deemed safe).

- Support development of a guarantee of origin system for green hydrogen at European level

  A Guarantee of origin system for green (renewable) hydrogen should be established (e.g. CertifHy project). The lack of a Certification system for hydrogen as green fuel and of a Guarantee of Origin for electricity produced by hydrogen limits the possibility for final customers to buy low-carbon hydrogen in full transparency.

6. Towards zero emissions in road, rail and waterborne transport

The European Directive for the development of an alternative fuels infrastructure for transport (the previously cited DAFI: 2014/94/EU) lays the political ground towards a progressive transition towards zero or low-emission transport in the EU. Italy has adopted this directive as Legislative Decree n. 257 of 16 December 2016, which includes a national plan for hydrogen mobility, largely prepared by the platform of Italian stakeholders MobilitàH2IT[16]. According to a report by the European Environmental Agency, Italy is among the European countries with the highest number of premature deaths caused by air pollution[17]. This is largely due to the transport sector, both in terms of its volume as because of its capillary nature, with vehicles and vessels of all sizes emitting combustion-related pollutants from sea harbours to urban centres and mountain villages.

Electric mobility is therefore benefiting from tremendous interest, thanks to the locally-zero emissions of electric drivetrains, but also with a view to emancipation from fossil fuels. Purely battery-powered vehicles and vessels are already a common sight on public roads and waterways, but a significant leap is required to create the infrastructure and capacity necessary for an all-electric transport fleet. Hydrogen has the potential to perfectly complement the bottlenecks of the electric grid and battery performance in this respect, as it generates 100% electrical transport (through fuel cells emitting only water vapour), but allows to store large amounts of energy on board without progressive extra weight and can refuel within a few minutes, comparable to current practice with conventional fuels.

This characteristic makes hydrogen especially interesting for heavy-duty vehicles and ships, which need significant amounts of energy stored on board for service autonomy. Already there are numerous fuel cell bus (FCB) fleets being demonstrated in Europe: notably in London and Hamburg, but also in Bolzano, Milan and San Remo. Switzerland and Norway recently announced the purchase of 1000 trucks each for retail transport, to be operational by 2023[18]. Also trains are eminently suitable for hydrogen propulsion, as the example of Germany shows, launching the first two of 14 contracted hydrogen-powered trains in September 2018 in Lower Saxony, with the aim to substitute diesel-powered locomotives on non-electrified lines.

As regards waterborne transport, there is high potential given the urgent needs to abate pollution especially in ports and on inland waterways and the large capacity for fuel processing, storage and distribution in port environments. Environmentally speaking, it is also important to consider that, in the case of spillage accidents at sea, the massive leakage of hydrogen will not cause environmental problems as is the case with conventional fossil fuels. Though there are several projects of vessels powered by hydrogen[19] (including the *Energy Observer*, the French catamaran currently sailing around the world, and *Hepic*, the hydrogen-powered ferry by Alilaguna for the Municipality of Venice), maritime implementation is currently impeded by a gap in regulations, codes and standards as regards the bunkering and on-board use of hydrogen as a fuel.

Speaking of mobility, the first application that springs to mind is passenger cars. Hyundai, Toyota and Honda have already added series-produced models of hydrogen-powered fuel cell electric vehicles (FCEV) to their portfolio of cars, and Mercedes, Audi and Renault/Nissan have got their market versions lined up. Having demonstrated the performance and reliability of these vehicles on the road, it is now crucial to establish a minimum network of hydrogen refuelling stations (HRS) to guarantee coverage of at least the main corridors of trans-European transport (so-called TEN-T corridors). Only in this way will the commercial take-up of zero-emission FCEVs be possible, automatically followed by a progressive decrease in the cost both of the hydrogen produced and distributed and of the vehicles themselves.

6.1. Overview and assessment of current legal framework

Road transport – no recognition of hydrogen vehicles

Hydrogen vehicles are actually *fuelled electric vehicles*, using compressed (or liquefied) gas as a fuel but generating fully electric propulsion, and are uniquely classified as hydrogen vehicles according to Commission Regulation (EU) n.406/2010 of 26 April 2010, which implements Regulation (EC) N.79/2009 on type–approval of hydrogen–powered vehicles. This Regulation has not been completely adopted in Italy at this stage, so that there is currently no specific regulation for hydrogen vehicles. Applicable at this time are the Decrees of the Italian Ministry of infrastructure and transport of 28 April

[16] https://www.mobilitah2.it/

[17] Air quality in Europe. European Environmental Agency. 2015 Report

[18] https://www.openaccessgovernment.org/hydrogen-trucks/52230/

[19] FellowSHIP, FCShip, META-PHU, Nemo H2, FELICITAS, SF-Breeze, Pa-X-ell, US SSFC, MC-WAP, ZemShips, RiverCell

2008 (national transposition of Directive 2007/46/EC) and 29 May 2017 (transposition of Directive 2014/45/EC) which describe, respectively, the administrative provisions and general technical requirements for the approval of all new vehicles falling within the scope of the European Directive, among which hydrogen-powered fuel cell vehicles (FCEV), and the periodic roadworthiness tests for motor vehicles and trailers. Both of these imply an individual, case-by-case type-approval for homologation, registration and use of FCEVs.

The lack of specific regulation for service, maintenance and technical inspections for hydrogen vehicles effectively impedes sector development. Currently the only applicable, hydrogen-specific technical regulation is given by Decree 23 October 2018 of the Ministry of Interior, which is aligned to the filling pressure of 700 bar as in other countries. Possible restrictions related to hydrogen-powered transport are only considered in terms of hydrogen as dangerous good, which is regulated by Legislative decree n.35, 27 January 2010 (national transposition of European Directive 2008/68/EC) and subsequent modifications (the latest being Decree 12 May 2017 adopting EC Directive 2016/2309).

Due to the lack of recognition of hydrogen-powered FCEVs, also incentives and restrictions that could be applicable are not considered. Incentives for battery electric vehicles should be applicable, but are not explicitely transferrable to FCEVs. It is clear that an adequate Regulatory framework and support measures such as waiving/reduction of parking fees or road tax, preferential road lanes and exemption from access restrictions are low-cost policy measures that can radically incentivise the penetration of zero-emission hydrogen vehicles.

Road transport – Bolzano as a leading European example, the rest of Italy far behind

Despite the difficult situation described above, the city of Bolzano has successfully implemented a conspicuous infrastructure of hydrogen-powered vehicles, with a fleet 11 FCEV passenger cars managed by the local municipality, 12 fuel cell buses and 2 police cars running on hydrogen. With the only publicly accessible hydrogen refuelling station in Italy, providing 400 kg/day of 100% renewable hydrogen generated from local hydropower, Bolzano is a remarakble example of sustainable hydrogen mobility. By contrast, however, this further underlines the severe lack of implementation in the rest of the country, where similar cases could be easily replicated thanks to the widespread availability of renewable power, local public transport fleets and logistically strategic locations.

Rail transport – high potential to be explored

The recent availability of hydrogen-powered trains opens a large field of easy-to-implement, high-impact application of zero-emission transport. Non-electrified railway lines are abundant in Italy, across all Regions, and the well-defined fleets and refuelling depots this implies, provides an excellent opportunity for migrating a significant part of transport from polluting, diesel-fuelled to zero-emission electric, without necessity for major infrastructural investments. The applicable regulations are currently those already mentioned, in particular Decree 23 October 2018. However, the safety implications of this Directive are possibly less of an obstacle than for road transport, since the infrastructure for railway transport is more apt to industrial scale and can therefore be made to more easily comply with this regulation.

Maritime and waterborne transport – severe barriers due to international regulation gaps

With 8000 km of coastline, many industrial ports and its pivotal position in the Mediterranean, Italy has the opportunity to drive the development of zero-emission shipping and become a leading example in the adoption and implementation of hydrogen-powered vessels. Venice already advocates the urgency of cleaning its local transport, and identified fuel cell-electric propulsion as a viable solution also for in-land water mobility. The successful demonstration of the "vaporetto" *Hepic*, aimed for transport of up to 25 passengers across the world-famous canals, unfortunately could not be followed up by commercial implementation (despite the local public transport company Alilaguna driving the project) because of a severe gap in international regulation as regards waterborne hydrogen-fuelled transport.

The International Code of Safety for Ships using Gases or other Low-Flash-Point Fuels, better known as the IGF Code, entered into force on 1 January 2017, and is a mandatory instrument applicable to all ships using gases and other low flashpoint fuels. However, presently, it only contains detailed requirements for natural gas (LNG or CNG) as fuel, and only for use in internal combustion engines, boilers and gas turbines. A phase 2 development of the IGF Code is currently allowing the further development of technical provisions for ethyl/methyl alcohols as fuel and fuel cells. Requirements for fuel cells will constitute a new part E of the IGF Code, which should also regulate the use of hydrogen.

Until these additions and amendments are finally approved and enter into force, applications making use of other gases such as hydrogen, including use of fuel cells, within the frame of the IGF Code Part A, are required to follow the *alternative design method* in accordance with SOLAS Regulation II-1/55, which is extremely complicated and lengthy, and not suitable for commercial deployment, limiting the potential for decarbonisation of the maritime sector.

The Commitment by the International Maritime Organization (IMO) to reduce CO2 emissions (50% reduction by 2050) and the rules on other pollutants such as Sulphur (0.1%-0.5% limits) clearly requires the maritime sector to look at hydrogen and fuel cells to power the world shipping industry of the future. Current difficulties in increasing the penetration of hydrogen-propelled vessels are born from a lack of experience and the absence of specific rules, and need to be solved working in strong cooperation with IMO.

Adequate hydrogen refuelling infrastructure should be planned

As hydrogen is adopted as an alternative, zero-emission fuel, it will become necessary to also regulate for equipment maintenance, technical reviews and authorization mandates related with refuelling of captive fleets in depots, train stations and depots, docking in the harbours of the nation and fuelling protocols. The same recommendations for land Hydrogen Refuelling Stations (HRS) as well as hydrogen storage and refuelling procedures should be taken into consideration for waterborne environments where an independent system of regulations and authorities exists, which lags behind those for the land-based applications.

The refuelling infrastructure for large depots such as for rail and maritime, may still need a different approach than that given to land-based HRS due to the large amount of fuel that this kind of vehicles/vessels require. In the long term, this may also come to apply for aviation. This is a major issue that should be treated soon after the urgent measures needed to facilitate the more market ready applications such as cars, buses and trucks.

6.2. Conclusions

Hydrogen propulsion shows the change in the direction and future trends in the transport sector, on road, rail and on water. This does bring about a major change of mindset and a paradigm shift. The use of hydrogen as fuel for propulsion or as an element of hybridisation with other technologies such as batteries or natural gas appears to be a necessity in the future, given the need to deeply decarbonize the sector, reducing pollutant emissions, and the inability of other fuels to deliver sufficiently on such targets.

Currently the main obstacle in the penetration of hydrogen-powered vehicles (fuel cell electric vehicles, FCEV) in Italy is the lack of recognition of this class of vehicles. Though there is a European regulation on the matter, in Italy an individual, case-by-case type-approval for homologation, registration and use of FCEVs is necessary. Together with non-updated regulations in Italy on retail hydrogen storage and distribution, this results in complicated, lengthy and costly administrative procedures for the implementation of both FCEVs and hydrogen refuelling stations, which discourage the adoption of hydrogen vehicles as zero-emission alternative.

Rail and maritime transport provide massive potential for improvement in environmental performance through transition to hydrogen fuelling. The scale, location and industrial orientation of their infrastructure makes a feasible use of hydrogen possible. Especially for waterborne transport however, the comprehensive gap in specific regulations, and the fact that straightforward adoption of homologation requirements from land-based applications is not considered in the maritime world, is an urgent bottleneck to be resolved.

6.3. Policy Recommendations

We ask to the decision-makers to promote and help the decarbonisation of the transport sector, whether on road, rail or water, promoting and aiding to the introduction of break-through technologies such as fuel cells and hydrogen, which have already demonstrated their performance and reliability in numerous demonstration projects and pre-commercial applications.

Of primary importance is to support the generation of captive fleets, such as buses, taxis, trucks and even trains running on hydrogen. These fleets greatly facilitate overcoming the challenge of making hydrogen refuelling a commercially viable enterprise, as the infrastructure can be made to operate continuously at design capacity. Leveraging on the experience and economic feedback from these applications will generate the interest and opportunity to distribute the infrastructure more widely.

Incentives for battery electric vehicles should be transferred to FCEVs, since support measures such as waiving/reduction of parking fees or road tax, preferential road lanes and exemption from access restrictions are low-cost policy measures that can radically encourage the penetration of zero-emission hydrogen vehicles. The case of Bolzano should be looked at for best-practice example, which can be readily replicated across key hubs in the Italian network.

Decision-makers are invited to play an active and positive role in the international maritime committees to help establish rules supporting the implementation of hydrogen technology, where applicable taking advantage of validated guidelines and requirements from land-based applications.

7. Electricity grid issues for electrolysers

This Paper concerns the hydrogen production via an electricity grid connected electrolysis unit to supply for example transport fuel hydrogen on-site at a refuelling station or for industrial purposes.

Hydrogen production via electrolysis requires open and fair access to the electricity grid in order to utilize electrons from, most typically the distribution network, or on a more frequent basis, electrons from a renewable source fed in part to the electrolyser and the balance to a grid connection. The regulatory framework covering the European electricity grid and transmission/distribution networks has transitioned to a liberalized market system and opened the electricity sector to market competition over the past 20+ years; it has removed market and legal barriers to network access and ensured the inclusion of electrolyser, hydrogen and fuel cell technologies in the electricity sector. In particular, the generation side and the sales side have been liberalized, but the transmission and distribution activity has remained under concession, and for each area of interest there is only one DSO with obligation to connect third parties who request it (including electrolysers).

The main EU Legislation framework impacting grid access in general and thereby electrolyser access has been introduced via three ‘energy packages’:

- The first, Directive 96/92/EC (concerning common rules for the internal market in electricity, promoted the independence of the transmission system operator, and laid down the rules relating to the organisation and functioning of, and access to, the wholesale electricity market);
- The second, Directive 2003/54/EC (concerning common rules for the internal market in electricity (Electricity Directive)), focused on the concepts of unbundling and third-party network access); and
- The third comprised two Directives (Directive 2009/72/EC and Directive 2009/73/EC) and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) to further open up the gas and electricity markets in the European Union with the separation of companies' generation and sale operations from their transmission networks (and thereby independent distribution networks). It also provided for the establishment of a National Regulatory Authority (NRA) for each Member State and for the Agency for the Cooperation of Energy Regulators (ACER) which provides a forum for NRAs to work together.

Whilst these energy legislation packages collectively provided for competition, operational transparency, open access to the electricity network and security of supply, they have recently been complemented by Commission Regulation 2016/1388 for establishing a network code on demand connection – giving the legal basis for regulatory authorities to ensure that objective and non-discriminatory technical rules would establish minimum technical design and operational requirements for the connection to the grid system. It entered into force on 7th September 2016 as binding and directly applicable in all Member States.

In the context of the Power to Gas aspects of a grid connected electrolyser and when operated to generate hydrogen (to be transported / stored in the existing gas infrastructure), the covering legal framework includes Directive 2009/73/EC which establishes common rules for the transmission, distribution, supply and storage of natural gas and sets rules relating to the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisation for transmission, distribution, supply and storage of natural gas and the operation of gas network systems.

7.1. Overview and assessment of current legal framework

Connection of the electrolyser to the electricity grid

The connection of an electrolyser to the e-grid under the EC access regulatory framework should be quite straightforward and the connection should be made at the local level (where the electrolyser is to be located) via the (low voltage) Distribution Network Operator (DNO).
In Italy, the connection to the electric grid is operated by any of the commercial / public electricity companies as DNO’s where the power required is less than 10MW. If the power required is greater than 10 MW the connection can only be operated by Terna (National Electric Grid Operator - TSO).
Under the EC legal framework (the three ‘energy packages’ referenced above) that have provided for competition within and open access to electricity networks, there should, in principle, be no significant difference in connecting an electrolyser to the e-grid as for any other industrial or similar load. There are, though, differences in some jurisdictions according to load thresholds and whether both a DNO and the TSO need to provide approvals (for higher power loads) for the load connection.

The situation in Italy, as across all the member states, shows that there are no significant differences between connecting an electrolyser or connecting other installations of a similar load demand, also considering the procedural steps to follow. Moreover, there is an opening of the ancillary services market also to the demand side and, consequently, also to the electrolysers, for which there will be no specific criteria given the technological neutrality of the participation requirements.

Power to Gas plants and energy storage facilities

A Power to Gas facility would typically include an electrolyser directly connected to the e-grid or directly connected to a renewable energy system (wind, solar) to draw electricity for electrolyser operation (installed examples have a power consumption for the electrolyser of around 3-400 kW) to generate hydrogen. The hydrogen can be temporarily stored and then supplied to fuel cells, ICE turbines or other power-electric generation system, or injected into the gas grid.). Power to Gas is a relatively recent technology approach and has limited legal recognition and may be constrained within the current EC legal context.

The Power to Gas process chain is increasingly recognized as having a significant role to play in decarbonizing and sustaining energy independence in European and wider energy systems. As indicated above, the Power to Gas process links the power grid with the gas grid by converting surplus power into a grid compatible gas via a process involving hydrogen production by water electrolysis and hydrogen conversion to methane (CH4) via methanation to create substitute natural gas (SNG), which can be injected into the existing gas grid or gas storage systems, used as CNG motor fuel, or utilised in natural gas facilities. The alternative is for direct injection of hydrogen into the gas grid.

European electricity grids and transmission/distribution networks have been liberalized and opened to market competition over the past 20+ years. This allows network access for the connection of electrolysers for hydrogen generation, but the process chain for Power to Gas is more complex, with the inclusion of energy storage, energy generation systems and/or injection of hydrogen into a gas grid. Directive 2009/73/EC) and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) provides for access to gas and electricity markets and clear procedures applicable to granting authorisation for transmission, distribution, supply and storage of natural gas and the operation of systems.

However, there is no clear and unequivocal legal position for Power to Gas facilities, leading to mixed approaches to recognition (or not) under current regulatory frameworks of Power to Gas plant, e-grid connection and their operation, and this represents a regulatory gap and a barrier to technology deployment.

In Italy, there are no specific laws nor regulations for Power to Gas plants; their legal status is the same as any other industrial plant. Moreover, there is a lack of a clear legal definition and coverage with the result of an uncertain and difficult identification of specific burdens and supporting policies for these plants.

Power to Gas plants in the electricity balancing market

Electricity grid balancing, or load balancing, is an ancillary service required by the transmission or distribution system operator (TSO / DSO) to enable the integrity and stability of the transmission or distribution system, as well as the power quality (frequency and voltage), to be maintained within set network limits and which would typically be part of regulated (mandatory) network requirement.

Balancing services are needed when the grid load is greater or less than foreseen at the time of market-clearing; outages have occurred (planned or unforeseen) and increasingly, when renewable energy generation is greater or less than foreseen at the time of market-clearing. An electrolyser based Power to Gas plant can potentially provide a balancing service to ‘switch-on’ the electrolyser when the network has excess power (using electricity to generate hydrogen); and to generate power (using stored hydrogen or SNG) when the grid has less power than needed to maintain load/frequency. This would necessarily exclude Primary Reserve provision (typically for large scale generators) and mainly cover Secondary Reserve provision.

From the European point of view, the electricity Directives (Directive 2009/72/EC and Directive 2009/73/EC) and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009)) have provided the network access and regulatory framework for the operation of P2G plant in ancillary services. In practice, grid operators (DSO and TSO level) use dynamic and often complex contracting and payment mechanisms for ancillary services which may lock-in, or lock-out, plant and technology options such as Power to Gas.

In the context of ancillary services, Commission Regulation (EU) 2017/2195 of 23 November 2017 is relevant, in establishing a guideline on electricity balancing (GLEB), the common market for procurement and exchange of FCR (FCR Cooperation) aims at the integration of balancing markets in order to foster, but not limit to, effective competition, non-discrimination, transparency, new entrants and increase liquidity while preventing undue distortions. These objectives must be met in consideration of secure grid operation and security of supply.

In Italy, electrolysers are not expressly indicated among the devices for grid balancing at the DNO or any grid level.

7.2. Conclusions

Considering the connection of electrolysers to the electricity grid, there are no specific needed recommendations, being similar to any other installations of a similar load demand. This is an example of a best practice in provision of technology accessibility.

Power to Gas technology offers considerable energy independence and sustainability benefits in enhancing the use of renewables (and addressing intermittency) alongside electricity and gas grid operation, but the lack of legal recognition and formative regulatory framework is a barrier and constraining wider its deployment.

The combination of electric grid and gas grid systems is an acknowledged complicating factor. Further, as the permitted amount of H2 in the gas grid is limited by country specific standards and regulations to between 0.1% to 12 vol.%, this adds restrictions to avoid gas quality thresholds. Methanation of hydrogen (produced via electrolysis) to generate SNG is an alternative pathway. The use of gas grid networks for energy storage is however broadly recognized as an energy asset.

It is essential that the operational framework for Power to Gas will be clarified within a legal definition, for the combination of electrolyser plant and related energy storage facilities, in both energy consumption and energy generation 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. A clear basis for tailored support mechanisms for Power to Gas operation and services should also be covered.

7.3. Policy Recommendations

- Clarify the operational framework and establish a legal basis for Power to Gas plants and related energy storage facilities.
- Clarify the operational framework for electrolysers to participate in ancillary services and the legal basis to do so.
- Promote dedicated support mechanisms for Power to Gas to foster the deployment of several units throughout Italy.

8. Gas grid issues

This Paper concerns the injection of hydrogen (H_2) into the gas grid, whether for Power to Gas (P2G), energy storage, or other purposes, at two levels:

- at the Transmission Service Operator (TSO) level, where the TSO is typically responsible for managing and maintaining the national high pressure, long distance, gas grid ‘trunking’ network and provides the network interface with any international gas grid connections and local distribution network connections;
- at the Distribution Service Operator (DSO), level, where the DSO is typically responsible for managing and maintaining the local, regional, low pressure gas grid network and provides the network interface with those seeking to establish gas injection facilities and those seeking gas offtake facilities. It is at the DSO level that Power to Gas plants will be expected to be located and Power to Gas facilities to be operated, with hydrogen (as a blend with natural gas) to be transported within the DSO network for the foreseeable future.

It is increasingly recognized that the injection of hydrogen from renewable sources in the natural gas network would effectively increase the transport and storage capacities of the existing gas network infrastructure for indirect electricity transport, for energy storage and for meeting decarbonisation targets.

The Power to Gas process chain links the electric power grid with the gas grid by converting (surplus) electric power into hydrogen and direct injection of H_2 into the gas grid at either the Transmission level (TSO) or Distribution level (DSO). The alternative is to create a grid compatible gas via a process of H_2 conversion to methane (CH_4) via methanation to create synthetic natural gas (SNG), which can be injected into the existing gas grid (or into gas storage systems, used as CNG motor fuel, or utilised in natural gas facilities). In all instances, the main limitation at present is typically the composition of hydrogen allowed in the natural gas streams entering and carried through the national gas grid networks.

8.1. Overview and assessment of current legal framework

European national gas grids and transmission/distribution networks have been liberalized and opened to market competition over the past 20+ years. Directive 2009/73/EC and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) provide for access to gas (and electricity) markets and define clear procedures applicable to granting authorisation for transmission, distribution, supply and storage of natural gas and, in principle, for allowing network access for hydrogen injection. The process chain for P2G is more legally complex though and there is no clear and unequivocal legal position for Power-to-Gas, leading to a diversity of approaches in the recognition of a P2G plant and as to hydrogen injection at legally acceptable levels.

The TSO has the right and the obligation to set operating standards to ensure safe and efficient network operation, to provide non-discriminatory network access permission levels (for supply points and DSO connection) which need to be in line with a wider national legal framework relating to gas quality, management of injection and extraction points, safety requirements and payment / tariff terms.

The DSO gas network is obliged to meet technical and safety requirements with regard to both operational infrastructure (pipelines, compression, valves and junctions) configured for a specific gas quality, and the flow of the gas to major users (such as major commercial or industrial sites) within local distribution grids.

At present it is not possible to inject hydrogen into the gas grid; there is currently no legal basis (law or regulation) for injection of hydrogen into the gas grid. The regulatory Authority for the electricity, gas and water markets is likely to have future responsibility on injection of hydrogen as well.

Gas injection composition levels for TSO and DSO networks are also set by mandated limits within regulatory frameworks for operation, safety or other conventions, and 100% hydrogen is not allowed in any instance. Moreover, the Italian regulations have not set any defined limit yet. The only regulation is the Gas Grid Code of *Snam Rete Gas*, where provisions concerning the qualitative characteristics of the gas injected into the grid include the allowed presence of hydrogen, but only with reference to bio–methane fed to the grid. In this case the maximum allowed concentration of hydrogen is 0.5% by volume; the possibility to increase the concentration up to 1 % is under discussion. There is no regulation on Payment Issues, related to the injection of hydrogen into gas network as for example connection costs, feed–in tariffs or remunerations.

Injecting hydrogen into the gas grid is still a relatively new approach and Power-to-Gas activities are mainly at the proof of concept / demonstration stage. As such, there is no clear framework for managing the safety aspects of a H_2 injection facility at the DSO level and its operation, and these are not yet in place. Safety is a critical issue for gas handling in general and for hydrogen and hydrogen mixtures in particular. These are covered comprehensively by the EIA[20], SEA[21], IED[22] and SEVESO[23] Directives, and – particular to Italy – the Ministerial Decree of 23 October 2018 ("Technical rule of fire prevention for design, construction and operation of hydrogen distribution facilities for automotive applications "), though the latter refers primarily to hydrogen refuelling stations. The authority responsible for the interpretation and monitoring of safety measures is the Fire Department.

Any hydrogen injection facility is expected to be connected to a local distribution network via a DSO for use within a DSO network. In Italy, the applicable regulation is the ATEX Directive 2014/34/EU as transposed by Legislative Decree n.85, 16 May 2016.

8.2. Conclusions

Considering the Italian situation, the current position is considered a barrier in most contexts: regulatory, economic, operational and structural.

A review of the current regulation is expected and some working groups at international level are studying how to regulate this matter.

Moreover, there are no reported incentives granted to hydrogen facility operators at the DSO level, which are typically based on conventional natural gas flows in national gas grid networks. Although there have been adjustments made to accommodate for bio-methane/bio-gas injection into gas grids, no formal basis has been established for hydrogen facilities and hydrogen injection which has created a substantial barrier to the business case for Power-to-Gas and overlooks the value of related de-carbonisation and sustainability benefits.

8.3. Policy Recommendations

- Review relevant technical and gas quality issues for increased injection and use of hydrogen in the 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 the gas grids.

- Establish a coordinated review of payments/tariffs/incentives to identify a coherent basis for modified tariff and payment arrangements for hydrogen production sites and gas grid connection and injection facilities.

- Review the safety requirements and corresponding legal frameworks for safety compliance to allow increased hydrogen flows in gas networks.

[20] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment

[21] Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment

[22] Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control

[23] Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances

9. Residential stationary FC (Micro-CHP)

Residential stationary fuel cells (also known as Fuel Cell micro-CHPs, Fuel Cell micro-cogenerators) are a highly efficient technology that uses hydrogen, biogas, natural gas or other gaseous hydrocarbons to produce heat and electricity for a single household up to small residential or commercial buildings. Stationary fuel cells are a distributed generation technology, i.e. they produce power and heat at the site of the consumers and for the purpose of immediate energy supply. The produced electricity can be used to cover the customers' own demand or can be injected into the electricity grid and sold.

Micro-CHP is defined by the Energy Efficiency Directive as a cogeneration unit with a maximum capacity below 50 kW, however the fuel cell units with a maximum capacity up to 5kW are sufficient for single homes or small residential or commercial buildings. The European market for stationary fuel cells can be divided into three different market segments: residential, commercial and industrial. One of the most mature clusters of fuel cells comprises integrated micro-CHPs in the power range of 0.3 to 1.5 kWel to supply heat and electricity to 1/2-family dwellings or single flats in apartment buildings. In terms of commercial buildings, the products are in a medium power range of 5 to 400 kWel. In terms of industrial applications for prime power or CHP, the products are beyond 400 kWel.

Stationary fuel cells run on gas and need to be connected either to the gas grid or to a stand-alone gas tank.

Micro-CHPs represent a next-generation solution for replacing traditional gas boilers in much of the built environment, where extensive energy saving renovation and renewable energy solutions are not feasible. This can contribute significantly to the EU policy aim of decarbonising energy consumption of both heat and electricity in the home. Fuel cell micro-CHPs in particular represent a highly efficient alternative for new buildings.

The roll-out of micro-CHP in households and small businesses gives consumers the opportunity to produce their own heat and electricity and become active participants in the energy sector (so called prosumer). Consumers are empowered to produce their own, reliable and low carbon electricity, which can be dispatched at times of low production of intermittent renewable energy sources or peak electricity demand (e.g. for electric heating) to balance the grids.

The major benefits of stationary fuel cells are: extremely high electrical efficiencies, with a substantial CO2 savings in the building sector and various industrial applications; nearly fully removal of local emissions of pollutants like NOx and SOx as well as particulates, a particular advantage for urban population centres where local emissions tend to become a drain on the standard of living and governments are already putting regulatory limits in place; effective, complementary and enabling role in a power mix that is increasingly dominated by intermittent renewables; support to distributed generation with benefits of a less centralised energy system.

The active engagement of EU institutions in energy and climate policymaking is also reflected at national level, with most Member States currently assessing objectives and choices to support their energy and climate transition. This very dynamic political environment can present both opportunities and barriers to emerging technologies like fuel cell micro-CHP. Existing and emerging barriers at the national level are impeding the early market introduction of FC micro-CHP in the short to medium term.

Member States are currently implementing energy efficiency legislation at system, building and product levels, which should open market opportunities for FC micro-CHP. However, in many European countries as Italy, implementation is either lagging behind, not ambitious or not comprehensive enough to drive FC micro-CHP deployment.

Even after the successful completion of the Ene.field project, which demonstrated more than 1000 stationary fuel systems for residential and commercial applications, the number of installed FC micro-CHP units across Europe is still very limited, about 2000, mainly in Germany.

Fuel cell micro-CHP is currently a product at an early market stage where volumes are low and hence product cost is high. The weaknesses of standard market processes in increasing volumes for such an innovative product against an established market product are well known. Only a supportive policy framework can accelerate the transition to mass commercialisation of fuel cell micro-CHP, which will bring important benefits to consumers and the energy system at large.

The policy context is crucial if fuel cell micro-CHPs are to achieve a swift transition into commercialisation: a coherent, steady and predictable policy framework should reward the European heating sector's contribution to a more efficient, reliable and cleaner energy system, through advanced products and new business models.

9.1. Overview and assessment of current legal framework

Several legal and administrative processes are necessary to get the approval for the installation of a FC Micro-CHP.

The installation requirements for connection of residential stationary fuel cells to the electrical systems of the buildings and to the natural gas networks

There is no common EU framework for installation of FC micro-CHP units in the buildings or for their connection to the gas grids. Among the European countries the qualification requirements for installers entitled to connect stationary fuel cells to the electrical systems of the buildings are similar. In general, the installation can be performed by professionals with an appropriate qualification for work with electric devices.

The connections to the gas grids must also be done by trained and qualified installers. In some countries, the works can be provided only by the distribution network operator, in others the gas professionals must be approved by the gas network operator.

Typically, the requirements for connection of FC micro-CHP units to the gas grid are stipulated by the distribution grid operators. There are various regulations and standards at national level related to gas grid connection. No harmonised EU framework in regards to applicable standards and codes is in place.

Almost all countries do not consider any structural barriers or regulatory gaps associated with the gas grid connection requirements and procedures, nor with qualification requirements for professionals performing the connections of stationary fuel cells to the electrical systems of buildings or to gas networks. In all countries, there is a broad expertise with heating appliances working on gas and therefore no significant operational barriers are identified.

In Italy, the connection to the building electricity system and the installation/exchange of the energy meter is in charge of the local electricity distributor (i.e. ENEL). The electricians must be certified according to Ministerial Decree No.37/2008. The technical requirements and administrative procedures for connection of FC micro-CHP units to the gas grids are set out by the gas network operators. Usually, the connection requirements are more general and address all types of heating appliances or cogenerators working on gas. If the gas connection is already available, there are no specific requirements. If the connection is not available yet, a connection request and an agreement with the gas operator are required. The gas operator is entitled to do the installation of the gas meter. Other connections have to be performed by a plumber certified in accordance with Ministerial Decree No. 37/2008. The connection requirements do not represent any kind of legal or operational barriers to the commercialization of stationary fuel cells.

The connection to the electricity grid, with the possibility of electricity injection

There is no common EU framework for connection of stationary fuel cells to the electricity grids. In general, the connection procedures among European countries require the conclusion of connection (injection) agreements with the local/ regional electricity network operator.

Residential stationary fuel cells are capable of powering single households up to small buildings without any connection to the electricity grid. In case they are connected to the electricity grid, the entire amount of produced electricity or only the excess quantities may be injected into the grid and sold.

Practical experience is quite insufficient and therefore issues related to a greater number of stationary fuel cells systems exporting electricity to the public grids cannot be foreseen or estimated today.

In Italy, the connection requirements are more general for all types of power generating units and are not specified for FC micro-CHP systems. For the connection of FC micro-CHP system to the electricity grid a connection agreement is required with the local grid operator (i.e. ENEL) and an operational agreement with the local Custom Agency (*Agenzia delle Dogane*) and with the grid operator (i.e. Terna). Various forms must be filled in. For the connection to the local distribution network a documentation according to the Integrated text of active connections (*Testo integrato delle connessioni attive*) has to be provided, as well as information according to the System for data management of production plants and their units (*Sistema Gaudi*). The notification of the *Officina elettrica* is required (tax authority payment) for FC micro-CHP > 1kW, being the FC micro-CHP fuelled by a non-renewable source as methane.

The time needed for signing a grid connection agreement is about two months. Although this is not seen as a significant operational or economic barrier to the market entry of stationary fuel cells, there is a need to simplify the administrative procedures and to reduce and adapt the required technical documentation and preliminary studies. In general, the connection requirements for FC micro-CHP systems do not differ from those for conventional heating technologies and,, therefore, no substantial legal or operational barriers are considered.

Any required additional equipment, in particular for metering and protection devices, should be installed by the local operator of the distribution network.

The professionals entitled to do the connection work at low voltage level must be adequately trained and certified. For the installation of the energy exchange meter the installers have to be employees of the local distribution grid operator. For other connections, the electrician must be certified according to Ministerial Decree No. 37/2008.

The existing financial support mechanisms for the market roll out of residential stationary fuel cells,

Although the widespread deployment of residential FC micro-CHP systems is expected in the next few years in Europe, they are still in a market entry phase.

Ene.field and now PACE are the largest European projects aimed at ensuring the European FC micro-CHP sector makes the next step to mass market commercialisation through implementing innovations in products, which reduce unit cost, increase stack lifetime and improve the electrical efficiency of all units.

The FC micro-CHP systems must compete with well-established technologies and therefore a non-discriminatory and technology-open policy and legal frameworks at EU and national level are needed in order to go beyond the market roll-out phase. Residential stationary fuel cells working on natural gas have to be treated in the same way as any other high-efficiency micro-cogeneration unit. In case FC micro-CHP systems operate on green gases, including hydrogen, they should get the same preferential treatment as power units generating electricity from renewable sources.

The overview of national policies and funding schemes reveals significant differences in commitment and support for FC micro-CHP systems among the European countries.

Most of these do not provide any support mechanisms for FC micro-CHP systems. The existing support measures in the rest of the countries are very fragmented and unlikely to contribute substantially to the mass deployment of residential stationary fuel cells. The most commonly used support measures available for all types of cogeneration units are feed-in tariffs, CAPEX support and incentives for electricity self-production.

An overarching support policy and legal framework is crucial for the large-scale deployment of FC micro-CHP systems. The serious economic barriers and regulatory gaps can be overcome through systematic long-term support approaches including not only direct financial support but also the recognition of fuel cells in the energy efficiency policy mechanisms.

In Italy, Green Certificates (*Certificati Verdi*) are not provided for FC micro-CHP fed with natural gas, unless the cogeneration is driven by renewable energy, e.g. by biogas from biomass or waste. In this case Green certificates can be obtained. White Certificates (*Certificati Bianchi*) are provided for FC, but the advantages are related to the plant size (they are beneficial for big-size plants and not for small-size plants). White Certificates or TEE Energy Efficiency Certificates are one of the most relevant tools to promote energy efficiency in Italy. It is an effective mechanism, mostly based on measured energy savings. It acts both as an energy efficiency obligation scheme and as an incentive due to the existence of a certificate trading market. The energy savings can be achieved through energy efficiency actions among the end-users and are assessed using tons of oil equivalent (toe) as measurement unit. Almost every project including an improved efficiency in the final consumption of energy is eligible under the scheme – from boilers to lighting systems, from solar thermal to cogeneration, with the exception of projects aimed at increasing efficiency in electricity generation. If the project is approved, the owner/operator will receive a number of White certificates corresponding to the recognised savings. Other technologies benefit directly from tax incentives (PV systems). Some technologies benefit from specific feed-in tariff, feed-in premium, quota obligation and certification schemes.

Considering fiscal detraction, under the *Legge di Stabilità 2018* an ecobonus for micro cogenerators has been included; in particular, FC can be eligible for the purchase and the installation of micro-cogenerator in replacing of existing plants with a primary energy saving (pes) ≥ 20%. It is possible to deduct 65% of the total costs, with a maximum deduction of 100.000€.

9.2. Conclusions

Despite the undeniable advantages of the FC micro-CHP systems (high energy efficiency, smart grid capability, less or almost zero pollutants, NOx, SOx, particulate, CO) their presence on the market is limited so far. Only a supportive policy and legal framework can accelerate the transition of the micro-CHP sector from emerging technology to full-scale commercialisation.

Fuel cell micro-CHP systems have to be recognised as one of the key technologies capable of delivering greenhouse gas and pollutant emission reductions, energy savings, integration of renewable energy sources and smart grid solutions.

Two of the key obstacles in this respect are the cumbersome administrative procedure to install FC micro-CHP at domestic level, and the lack of a long-term support approach including not only direct financial support but also the recognition of fuel cells in the energy efficiency policy mechanisms.

Simplified grid connection procedures and guaranteed access to the grid for electricity produced from high-efficiency micro-CHP systems as well as supportive measures for the produced electricity can further contribute to successfully overcome the roll-out phase.

In addition, FC micro-CHP systems have to be accepted as an eligible technology in the national public procurement rules for purchase of products with high-efficiency performance in the government buildings. The public sector constitutes an important driver to stimulate market transformation towards high-efficiency technologies. Buildings owned by public bodies account for a considerable share of the building stock and have high visibility in public life.

Clear legislation in this regard can pave the way to establish Italy as a leading country in the development of zero-emission micro-CHP. A clear and ambitious legislation will finally promote that the national companies in this sector will increase their sales with the result of further cost reductions and increased market share.

9.3. Policy Recommendations

- Implement at national level the Energy Efficiency Directive (EED) in order to realize the potential of fuel cell micro-CHP. Clarifying eligibility of micro-CHP, along with other energy saving end user technologies, as part of the Energy Savings Obligation, defined under Article 7 of the Energy Efficiency Directive, would ensure recognition of fuel cell micro-CHP benefits.

- Simplify grid connection procedures, both for gas and electricity grid, for fuel cell micro-CHP.

- Promote dedicated support mechanisms for fuel cell micro-CHP to foster the deployment of several units throughout Italy.

- Implement at national level a clean air directive to reduce the impact of conventional boilers and heating systems on the quality of the air. The directive should set very strong limitations in terms of emissions of SOx, NOx, CO, particulates and of other species armful for the environment and for the health.