eLY4OFF

PEM ELECTROLYSERS FOR OPERATION WITH OFFGRID RENEWABLE INSTALLATIONS

Guidelines and recommendations to overcome RCS barriers

Deliverable D6.1

GRANT AGREEMENT
700359

D6.1 Guidelines and recommendations to overcome RCS barriers

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Abstract summary

Off-grid production of hydrogen through water electrolysis and its associated applications (isolated site electrification through fuel cells, mobility, gas grid injection…) are subject to regulations, codes and standards (RCS) as any industrial application. Main relevant RCS documents related to application envisioned in ELY4OFF were identified and are presented in this deliverable.

Difficulties and barriers related to RCS that may exist for off-grid hydrogen production and utilization were identified through literature study and discussion with hydrogen stakeholders.

It appears that RCS panorama is relatively clear for equipment design but remains unclear and inhomogeneous for hydrogen applications at European level. This may lead to delays due to required administrative processes and therefore extra costs which penalize hydrogen systems implementation. Unclear regulations for on-going development of off-grid or grid connected hydrogen applications may also be barriers to hydrogen energy applications by generating extra cost and limiting competitiveness.

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Definitions

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (Agency for the Environment and Energy Management)
AFHYPAC	Association Française pour l'Hydrogène et les Piles A Combustible (French Association for Hydrogen and Fuel Cells)
ATEX	ATmosphères Explosibles (Explosive atmospheres)
BCGA	British Compressed Gases Association
CAPEX	CApital EXpenditure
CD	Committee Draft
CE	European Conformity
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
EIGA	European Industrial Gases Association
EN	European Norm
FCHEA	Fuel Cell & Hydrogen Energy Association
FD	Final Draft
FQD	Fuel Quality Directive
GHG	GreenHouse Gases
HSE	Health and Safety Executive
ICPE	Installation Classée pour la Protection de l'Environnement (Classified installation for the protection of the environment)
IEC	International Electrotechnical Commission
IED	Industrial Emissions Directive
INAGA	INstituto Aragonés de Gestión Ambiental (Environmental management institute in Aragon)
INERIS	Institut National de l'Environnement Industriel et des RISques National Institute of Industrial Environment and RISks
ISO	International Organization for Standardization
OJEU	Official Journal of the European Union
PNNL	Pacific Northwest National Laboratory
PtG	Power-to-Gas
PV	Photovoltaic
RCS	Regulations, Codes and Standards
R&D	Research and Development
RED	Renewable Energy Directive
RES	Renewable Energy Source
SAE	Society of Automotive Engineers
SC	SubCommittee
TC	Technical Committee
TR	Technical Report
TS	Technical Specification

I. Introduction

I.1 Context

This report is part of the ELY4OFF project (http://ely4off.eu/). According to the project website, the ELY4OFF goal is defined as follows:

"The strategic goal of the ELY4OFF is the design and engineering of a robust, flexible, highly efficient and cost-competitive PEMWE. This will be automatically controlled using cutting-edge operational capabilities under highly dynamic power supplies required for direct coupling to RES generation. The final design of the PEMWE will be achieved on the basis of the development, validation and demonstration of a PEMWE industrial prototype of 50 kW comprising: cylindrical stack (to be able to produce hydrogen under high pressure) consisting of industrial size elementary cells, balance of plant (BOP), power electronics, advanced communication & control system, and peripheral equipment and end applications."

In addition to these design tasks, another objective is to identify Regulations, Codes and Standards (RCS) linked to ELY4OFF hydrogen application and determine if there exist any barriers due to RCS, and if so to propose solutions to overcome them.

I.2 Methodology

As described in ELY4OFF project Grant Agreement, two different tasks are dealing with *Regulations Codes and Standards:*

- Task 2.1: EU members states RCS and end-user specifications
- Task 6.1: Alternatives and proposals to overcome RCS barriers

One deliverable related to RCS is associated to each of this task:

- D2.2 (M30): RCS analysis at EU and international level
- D6.1 (M15): Guidelines and recommendations to overcome RCS barriers

Description of D6.1 in the grant agreement was "Different possibilities will be studied, considering as a basis: inputs on RCS aspects detected in task 2.1, incentives to cover CAPEX and operational costs and/or rewards for GHG and CO2 emissions savings and exploring other options. Since off-grid RES installations with electrolysers avoid the cost of upgrading existing grids or creating new ones, economically feasible incentives will be proposed."

After discussion with ELY4OFF partners, it was agreed that providing a first RCS analysis at M15 was more relevant and helpful to the project than directly providing recommendations.

Initially, the RCS review was supposed to be done in report D2.2 which is due later than D6.1, and as D6.1 has to be based on a RCS review, it was decided to modify the content of this report. It was then decided that the content and objectives of D6.1 would be:

- Introduce and define the different types of RCS documents;
- Give an overview of relevant RCS documents in the hydrogen field;
- Give a preliminary list of identified barriers to hydrogen energy applications development and provides some recommendations to overcome them.

The approach followed to write this report was based on two steps:

- a classical bibliographic research
- interviews of hydrogen stakeholders

Thanks to this approach, it was possible to list RCS and complementary documents in the hydrogen field and also collect feedbacks from hydrogen stakeholders about what should be improved in order to develop hydrogen energy field.

All these information are organized in this report as presented in the next part.

Regarding the future content of the report D2.2, some possibilities are presented in the conclusion section of the present document and a proposed approach is presented.

I.3 Plan of the present report

This report is organized in 3 main parts.

(i) First, existing types of RCS are described in order to understand which of them are mandatory and how they are linked to each other. The issue of terming is also commented.

(ii) Second, main RCS and additional documents in the hydrogen field are listed. It allows to quickly know which documents to check for hydrogen production and uses and for having more information about RCS subject.

(iii) In a last part are presented identified barriers and solutions to overcome them. Feedbacks from interviews are given in this part.

II. Global context and definitions

The first part of this report is dedicated to the presentation of global context and issues for Regulations, Codes and Standards (RCS). First and foremost, we propose to clarify the meaning of RCS, on a general basis. Then, we identify the different documents related to RCS and explain how they are connected. Finally we highlight the issue of definitions, which is of paramount importance in a RCS context.

II.1 What are RCS?

Regulations, Codes and Standards refer to different levels of "coding". Based on the recent report issued by the standardization body CEN – CENELEC (the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC)) [1], and specifications provided by the HyApproval project [2], we clarify the meaning of Regulations, Codes and Standards in what follows.

- **Regulations**

"Regulations are the highest level of "coding", because they do not only contain descriptions of the physical and operational features of the given technology or product, but also performance standards and limit values (tolerances) to be complied with, and implicit restrictions for the use of non-standard or non-compliant items or systems. Regulations are needed to ensure that public goods such as safety, security, sustainability, health, interoperability, are not unduly compromised by the use of a given product or system over its complete life-cycle" [1].

"Authorities, e.g. local, national, or international governments, provide compelling regulations to protect the public, workers, and environment from dangers and hazards. A European Community Directive is an example of a regulation. This is a collective legislative act requiring Member States to achieve a particular result without dictating the means of achieving that result. In addition to the EC directives the European countries typically have their own national or local regulations for producing parts, e.g. pressurized equipment and equipment intended for use in explosive atmospheres. National or local regulations for the use of such equipment may also apply." [2]

Regulations are mandatory

- **Codes**

Codes (also referred to as "**codes of practice**") "usually explain the basic functions of an equipment or product for safe handling and problem-preventive maintenance in order to guarantee trouble-free operation. These codes usually share at least some basic elements that are built around the generic features and functionality of the technology, and build a common understanding among the people how to deal with this type of product or system" [1]. In that case, **the codes (of practice) are not a mandatory document, unless the codes were validated by decree** [3].

The notion "Code" can also be used differently: it then refers to a collection of rules made binding by a local or national government [3]. **In that case, the code is mandatory**. In the USA, the meaning of "Codes" is always this one. In Europe, the difference have to be clearly make between "Codes" and "Codes of practices".

- **Standards**

"A **standard** is a document that sets out requirements for a specific item, material, component, system or service, or describes in detail a particular method or procedure. **Standards facilitate international trade** by ensuring compatibility and interoperability of components, products and services. They bring benefits to businesses and consumers in terms of reducing costs, enhancing performance and improving safety [1].

Standards are developed and defined through a process of sharing knowledge and building consensus among technical experts nominated by interested parties and other stakeholders - including businesses, consumers and environmental groups, among others" [1].

"The formal definition of a standard is a "document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context"" [1].

"There are several different types of standards. Basically, standards include requirements and/or recommendations in relation to products, systems, processes or services. Standards can also be a way to describe a measurement or test method or to establish a common terminology within a specific sector" [1].

"**Standards are voluntary which means that there is no automatic legal obligation to apply them. However, laws and regulations may refer to standards and even make compliance with them compulsory**" [1]. As an example, the ATEX - Directive 2014/34/EU (related to explosion protection) states that it is mandatory under European law for all equipment for use in a potentially explosive atmosphere to conform to specific safety standards [1].

Only accredited standards can become mandatory [4]. As shown in Table 1 below, each European country has its own national standards organization, which can accredit standards [5]. Once the standard is accredited, it can be set mandatory by ministerial decree [4].

	National standards organizations	
Country	**Short Name**	**Name**
Germany	DIN	(de) Deutsches Institut für Normung e.V.
Austria	ON	(de) Österreichisches Normungsinstitut
Belgium	NBN	(fr) Institut Belge de Normalisation (nl) Belgisch Instituut voor Normalisatie
Cyprus	CYS	(en) Cyprus Organisation for Standardisation
Denmark	DS	(da) Dansk Standard
Spain	AENOR	(es) Asociación Española de Normalización y Certificación
Estonia	EVS	(en) Estonian centre for standardisation
Finland	SFS	(fi) Suomen Standardisoimisliitto r.y.
France	AFNOR	(fr) Association française de normalisation
Greece	ELOT	(en) Hellenic Organization for Standardization

Hungary	MSZT	(en) Hungarian Standards Institution
Ireland	NSAI	(en) National Standards Authority of Ireland
Iceland	IST	(en) Icelandic Standards
Italy	UNI	(it) Ente Nazionale Italiano di Unificazione
Latvia	LVS	(en) Latvian Standards Ltd
Lithuania	LST	(en) Lithuanian standards board
Luxembourg	ILNAS	(fr) Institut luxembourgeois de la normalisation, de l'accréditation, de la sécurité et qualité des produits et services
Malta	MSA	(en) Malta Standards Authority
Norway	NSF	(no) Norges Standardiseringsforbund
Netherlands	NEN	(nl) Nederlands Normalisatie-Instituut
Poland	PKN	(en) Polish Committee for Standardization
Portugal	IPQ	(pt) Instituto Português da Qualidade
Czech Republic	CSNI	(cs) Czech Standards Institute
United Kingdom	BSI	(en) British Standards Institute
Slovakia	SUTN	(en) Slovak Institute for Standardization
Slovenia	SIST	(en) Slovenian Institute for Standardization
Sweden	SIS	(en) Swedish Standards Institut
Switzerland	SNV	(de) Schweizerische Normen-Vereinigung (fr) Association suisse de normalisation
Turkey	TSE	(tr) Institut turc de normalisation

Table 1: European national standards organization [6]

Regulations, Codes and Standards are not equivalent, as regards their coverage, but also as regards the way they are designed.

"While standards are developed by standardisation organisations, through thorough development processes, involving workgroups put together by a wide range of interested parties, codes may be developed by a few or only a single company or association. Due to their more extensive development process, standards generally have a wider acceptance than codes." [2]

"Standards and codes, unlike regulations, are not legal documents, yet standards may be included or referred to in regulations and, through the regulation, may be made legally binding. In this case the standard is said to be harmonised with the regulation and becomes **a harmonised standard**." [2]. However, the use of these standards remains voluntary. Manufacturers, other economic operators, or conformity assessment bodies are free to choose another technical solution to demonstrate compliance with the mandatory legal requirements [7].

RCS are not only about constraints. They may be drivers to foster system implementation.

Following Figure 1 summarizes information given in part II.1 [8]:

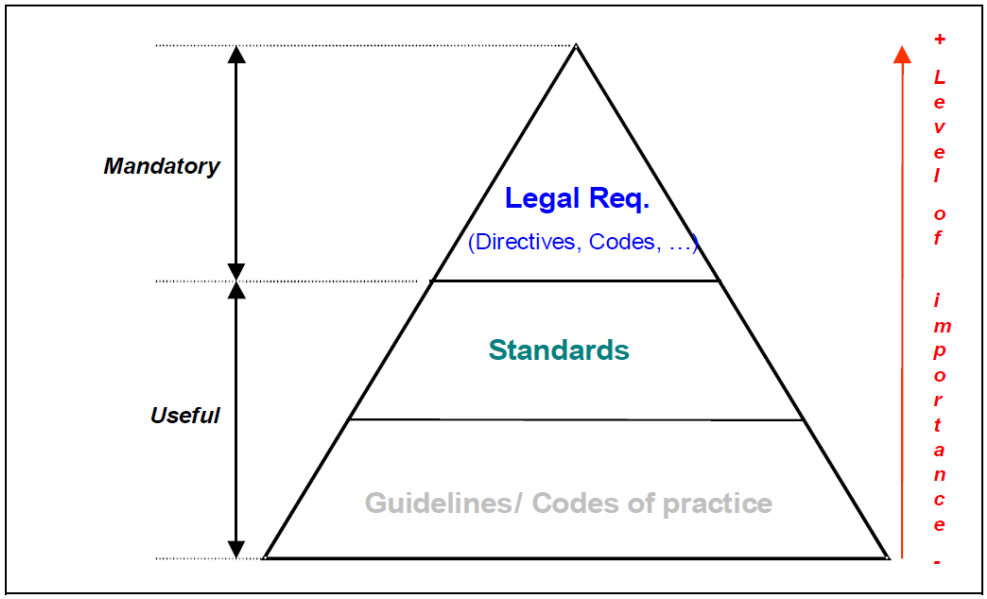


Figure 1: Recap drawing of RCS levels

II.2 RCS document types

RCS documents are subdivided in many types. Documents can be mandatory or not, established by the European Union, national governments or even company workgroups. This part aims at clarifying the different RCS documents.

II.2.1 European level

There exist several European documents, as presented below.

II.2.1.1 European Community Regulation

This mandatory document is applied in the same way in all European Union countries (general scope document), with no transposition in the national law [3]. It becomes mandatory 20 days after its publication in the Official Journal of the European Union (OJEU), or at a fixed date [3].

The "Regulation (EC) No 79/2009 of the European parliament and of the council of the 14th of January 2009 on type-approval of hydrogen-powered motor vehicles" is an example of regulation.

II.2.1.2 European Directive

European directives are addressed to recipient States to give them an objective to reach. However, each recipient State is free to choose its mean to reach this objective within the agreed period [3]. Recipient States have to transpose the directive in their national law: it consists in writing or modifying national law text in order to reach the European directive objective, and revoking laws which could be in conflict with this objective [3]. For example, in France, European directives are transposed in laws, orders or decrees [3].

The "Pressure equipment directive 2014/68/UE" is an example of directive.

II.2.1.3 Decision

As the community regulation, the decision is a mandatory document with no transposition in the national law [3]. The difference with the regulation is that the decision is not a general scope document: it is addressed to the appointed addressees, who can be private individual, legal entity or Member State [3]. Decision becomes mandatory 20 days after its publication in the Official Journal of the European Union (OJEU), or at a fixed date [3].

II.2.1.4 Opinion and Recommendation

These two documents are not mandatory [3]. As their names suggest, the opinion expresses a European Union institution opinion, whereas the recommendation is an incitation addressed to a Member State to adopt a certain behaviour [3].

To summarize about European documents, regulations and decisions are mandatory, opinions and recommendations are not. Directives have to be transposed in the national law, they give obligation of result but let each State free about the way to reach these results [3].

In the next part, national RCS and European RCS place in the national laws are presented.

II.2.2 National level

The national level is studied through French case. Every document of the Kelsen pyramid applied to France is explained. Later, the Spanish and UK pyramids are also presented as examples to illustrate that the same kinds of documents are used.

II.2.2.1 Kelsen pyramid applied to France

There exist many kinds of documents dealing with laws, which may lead to conflicts between them. During the 20th century, the Austrian jurist H. Kelsen wanted to classify legal documents, and created the Kelsen Pyramid. Texts at the top of the pyramid prevail over all the ones that are under in the pyramid and so each legal level have to be in compliance with texts situated in levels above.

Figure 2 below shows the Kelsen Pyramid applied to France [3].

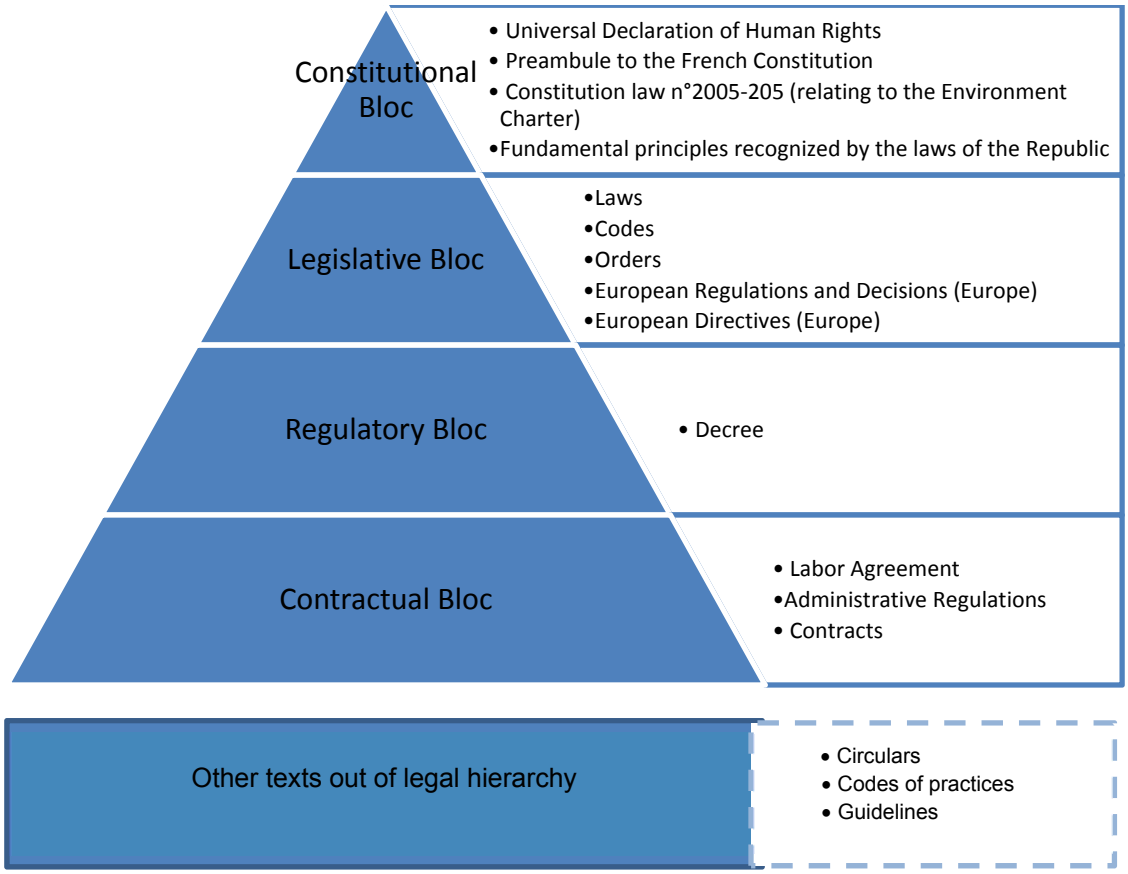


Figure 2: Kelsen Pyramid applied to France [3]

The Kelsen pyramid (Figure 2) shows different legal levels and associated texts in the French Republic. European Regulations, Decisions and Directives are in the legislative bloc, which is under the Constitutional bloc.

National RCS are presented in the following parts.

II.2.2.2Legislative Bloc

- **Laws**

Laws are mandatory documents, which are general, permanent and apply to all people of society [3]. They become mandatory once published in the official journal of the French Republic [3]. From now on, these laws are more and more European Directives transpositions [3].

The « Loi relative à la transition énergétique pour la croissance verte » (Energy transition law for the green growth) is an example of law.

- **Codes**

Codes are collections of laws and rules (Figure 3) made binding by a local or national government [3]. **Codes are mandatory** [3].

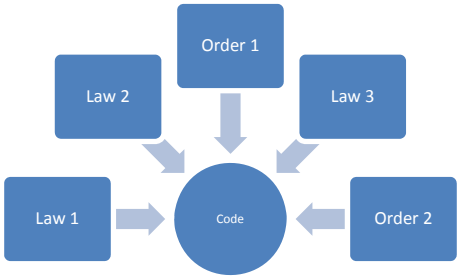


Figure 3: A code is a collection of laws and orders

The "Code de l'énergie" (Energy Code) is an example of code.

- **Orders**

An order is prescribed by a relevant authority [3]. It can be a Court decision for example [3].

The « Ordonnance n° 2016-1019 du 27 juillet 2016 relative à l'autoconsommation d'électricité » (Order related to electricity auto consumption) is an example of order.

II.2.2.3 Regulatory Bloc

This bloc is composed of texts which allow law enactment, especially by clarifying some details.

- **Decrees**

Decrees are administrative acts issued from executive power [3]. They can have a general or an individual impact [3].

The « Décret n° 2016-1821 du 21 décembre 2016 relatif aux constructions à énergie positive et à haute performance environnementale sous maîtrise d'ouvrage de l'Etat, de ses établissements publics ou des collectivités territoriales » (Decree related to zero-energy buildings) is an example of decree.

II.2.2.4 Contractual Bloc

Documents of this bloc are legal acts which create legal effect between signatories [9].

II.2.2.5 Other texts out of legal hierarchy

These texts are out of legal hierarchy but have to be taken into account in professional frameworks: if not, relevant authorities can express reproaches and sanctions.

- **Circulars**

Circulars are explicative texts of laws and decrees**. They are not source of law** [3]. Exceptionally and in case of litigation, the State Council can judge that a circular has a regulatory status [3].

The « Circulaire du 24/05/76 relative aux dépôts d'hydrogène liquide » (Circular related to liquid hydrogen storage) is an example of circular.

- **Codes of practice**

Codes of practice are usually a set of best practices for a specific product or system so as to ensure safe handling, maintenance and operation [8]. It can be validated by decree, which give them a regulatory status [3].

The "CP4 - Industrial Gas Cylinder Manifolds and Gas Distribution Pipework (excluding Acetylene)" by the BCGA (British Compressed Gases Association) is an example of codes of practice.

- **Guidelines**

A guideline or a guide is a document generally written by a given organization, whether for its own needs, or for its customers' needs. Guidelines provide guidance to appropriate behaviour so as to ensure safety of people (workers, users and general public). They may also give information about codes, standards and regulations to be complied with and about the recommended way to meet those requirements. For example, it gives information related to material properties, adequate installation, and use of equipment and safety procedures. Guidelines may be intended:

- to authorities, who have to verify the conformity with applicable regulations and standards of a system and to approve it,
- to end-users of a given system, so that they can run the system in accordance with safety and performance requirements,
- to maintenance employers, so as to give them principles to observe during maintenance and cleaning up [8].

The "Application Guideline for Use of Hydrogen Quality Specification" by SAE (Society of Automotive Engineers) is an example of guidelines.

II.2.2.6 Spanish Kelsen Pyramid

Figure 4 below shows the Spanish Kelsen Pyramid.

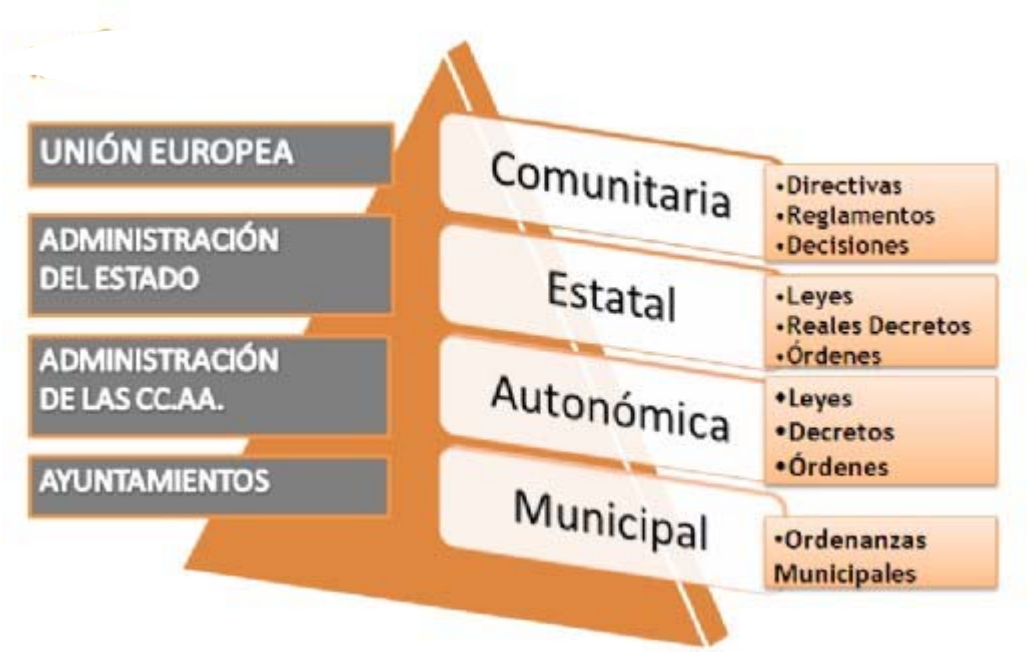


Figure 4: Spanish Kelsen Pyramid [10]

The Spanish legal hierarchy is quite similar to the French one, with the same kind of documents and the European Community place. However, through the important role of the Spanish Autonomies (Aragón, Castilla La Mancha, Cataluña etc.), it can be seen that the power is more decentralised.

II.2.2.7 United Kingdom legislation

As presented on Figure 5 below [11], there are several sources of law in UK, which are organized in the same way as in France or Spain.

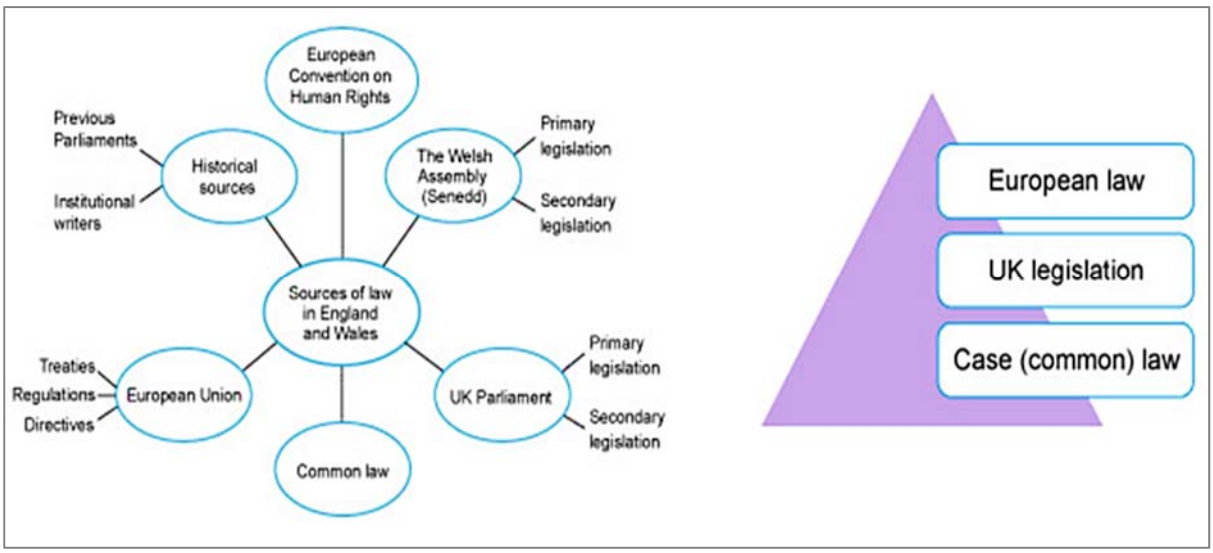


Figure 5: UK legislation [11]

Figure 6 below shows an example of this legislation through the application in UK of the European directive on the landfill of waste of 1999.

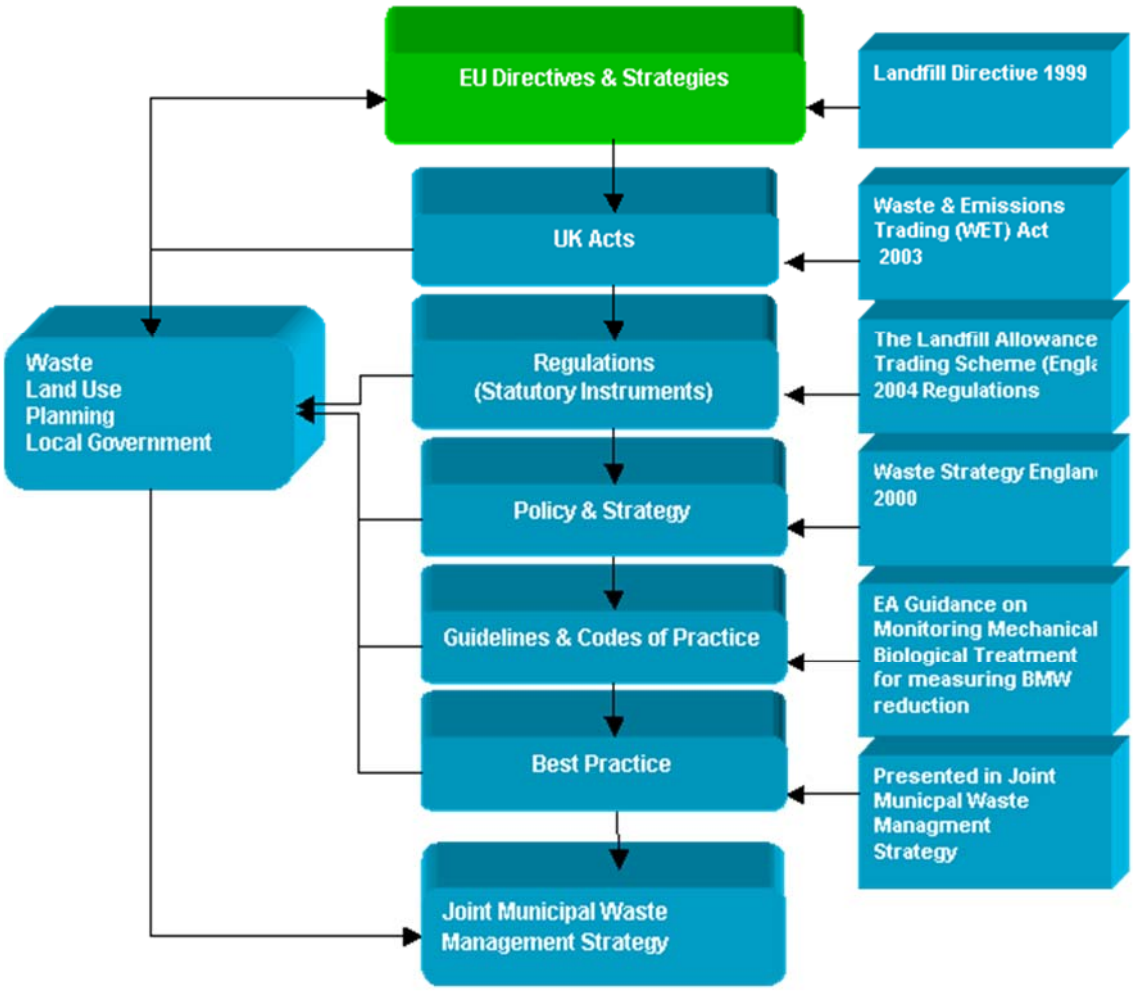


Figure 6: Application in UK of the European directive on the landfill of waste of 1999 [12]

II.2.3 Recap drawing

As shown previously, there are several kinds of documents, from several institutions and not all of them are mandatory. Figure 7 below summarizes part II.2 and gives a visual overview of how documents are linked to one another.

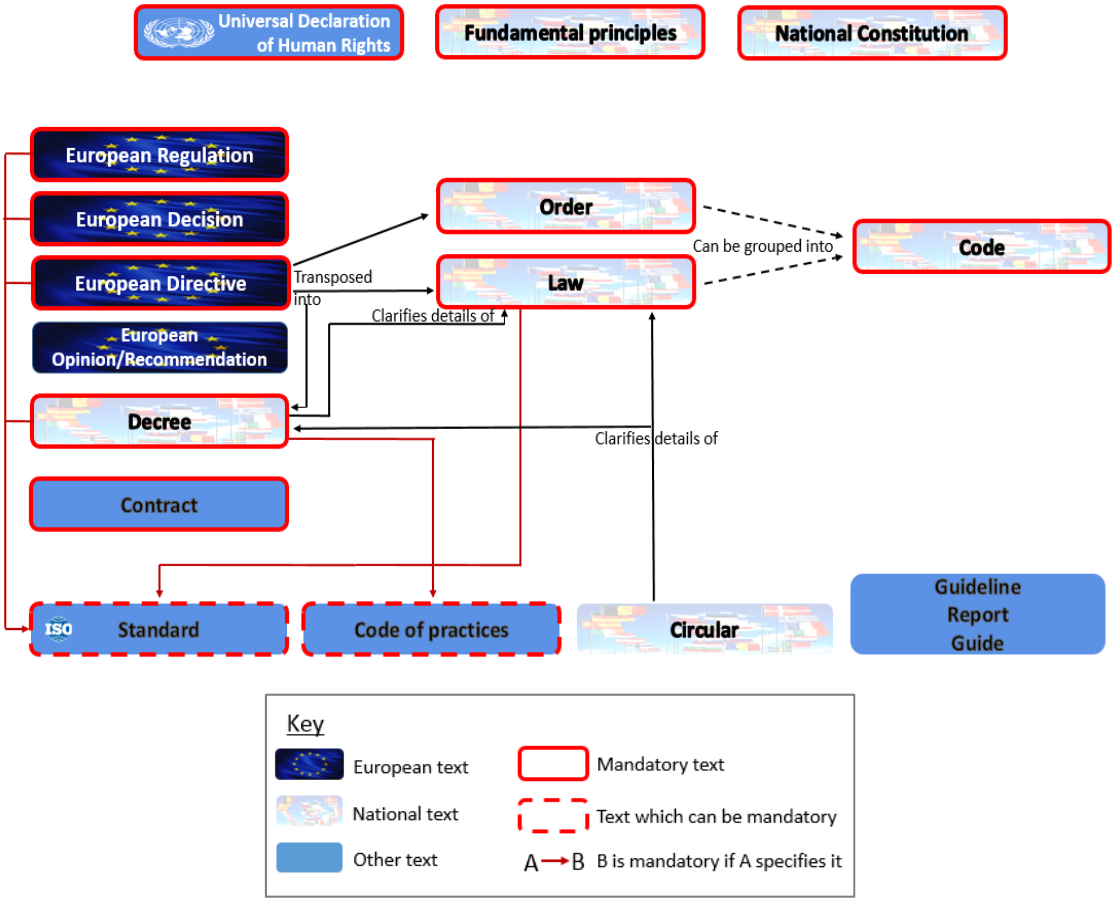


Figure 7: Law hierarchy and RCS

II.3 The issue of terming and definitions

In a context of RCS, exactness is critical. The starting point is being specific about what is dealt with. As a result, words and terms must be used with caution in order not to give rise to confusion.

The issue of terming and definitions then arises. Indeed, depending on how the concepts are defined, they will be subjected to different kinds of RCS. This issue is exemplified in the field of hydrogen in what follows.

The CEN / CENELEC - Sector Forum Energy Management / Working Group Hydrogen raised this issue of definitions. They pointed out that “if Power-to-Gas plants are treated as energy consumers, they are subject to taxes and fees, which increases the cost of the hydrogen produced” [1].

On the opposite, possible leverages can be illustrated by the case of biogas in Germany. Indeed, “in Germany, with the aim of promoting both the feeding in of both hydrogen and synthetic methane to the grid, both of these gases were included in the definition of biogas in section 3 para.10c of the Energy Act (EnWG)” [1]. “This classification is subject to the condition that they primarily originate from renewable energy sources. In practice this means that the injection of renewable hydrogen and synthetic methane is granted privileged connection, privileged injection, elimination of feed-in fees and fixed payment for avoided grid costs”. The definition of biogas is a driver for hydrogen in this context.

The issue of definitions can be further illustrated with another example. As stated in [1], “in 2010, the Industrial Emissions Directive (IED) was issued. IED defines the obligations of large industrial facilities to avoid or minimise polluting emissions in the atmosphere, water and soil, as well as waste from industrial and agricultural installations. The permitting process of Power-to-Gas (PtG) plants is delayed as even small installations are treated as producers of chemicals on an industrial scale. The existing directive, IED, refers to "large industrial production" without specifying the size, or capacity of such production. In this context, it is questionable whether small electrolysers used for local production of hydrogen, e.g. in refuelling stations should be considered as production on an industrial scale and submitted to the same regulatory requirements as large reforming plants”. Knowing if the directive applies or not, would make it possible to simplify the permitting process in some cases.

Overall, it is highly recommended to pay attention to the use of terms and the definition of concepts, when dealing with RCS issues.

III. Resource overview

This part gives an overview of documents linked to hydrogen production and applications. These documents are RCS, but also project references, codes of practice, guides, etc. The objective is to identify the most relevant RCS documents in the hydrogen field, and to provide additional references also addressing this subject. This should help the reader find information more effectively and get benefit from these references. Several previous projects which focused on hydrogen RCS and provided useful information are also identified.

III.1 CE (European Conformity) marking

CE marking is mandatory for the European markets, and hydrogen equipment have to comply with several directives to be certified.

CE marking was created to inform that a product is in conformity with the Community requirements. It has to be applied to the product before its commercialization on the European market. Then, it gives it the right to move freely on the whole European Union territory. In order to be allowed to affix CE marking, machines' designers have to respect several European directives. [13]

Figure 8: CE marking

Regarding the hydrogen field, the main directives are following:

- **Machinery directive 2006/42/EC**
- **Equipment and protective systems intended for use in Potentially Explosive Atmospheres 2014/34/UE**
- **Pressure equipment directive 2014/68/UE**
- **Low Voltage Directive (LVD) 2014/35/UE**
- **Electromagnetic compatibility directive 2014/30/EU**

Machinery, Low Voltage and Electromagnetic compatibility directives are validated by self-certification, which means that the designer can certify that the product is in conformity with laws. Pressure equipment directive has to be certified by a third party. Regarding Equipment and protective systems intended for use in Potentially Explosive Atmospheres, certification can be self-certification or third party certification, depending on the ATEX level of the zone.

Additional documents listed in Table 1 below can be checked for more information about CE marking.

Bibliographic reference	Author	Provided Information
[8]	HySafe, an international association for hydrogen safety	Description of European Directives to follow
[14]	European Commission	Six steps to affix a CE marking to your product

Table 2: Additional documents about CE marking

III.2 Industrial Emission Directive (IED)

The **"Industrial Emission Directive" 2010/75/UE** commits European Member States to control and reduce the impact of industrial emissions on the environment [15]. As it is a European Directive, each European Member State has to define the way to fulfil the directive obligations.

In France, it means that hydrogen installations are concerned by the "Installation Classée pour la Protection de l'Environnement (ICPE)", regulation depending on the quantity of hydrogen on site [16], as presented in the table below.

<table>
<tr><th colspan="5">Hydrogen</th></tr>
<tr><td colspan="5">After June 2015</td></tr>
<tr><td>ICPE section</td><td colspan="2">Fabrication : 3420
Fabrication of inorganic chemical products</td><td colspan="2">4715 : Hydrogen (number CAS 133-74-0)</td></tr>
<tr><td rowspan="4">Threshold</td><td rowspan="4">In industrial quantities</td><td rowspan="4">A</td><td>x ≥ 1t</td><td>A</td></tr>
<tr><td>1t > x ≥ 100kg</td><td>DC</td></tr>
<tr><td>Low threshold</td><td>5 t</td></tr>
<tr><td>High threshold</td><td>50 t</td></tr>
</table>

Table 3: Hydrogen production rate level of the ICPE regulation [17]

Note: A "Authorization", D "Declaration", C "Subject to periodic checks"

In the UK, there is no lower limit, and all hydrogen installations require an Environmental Permit, which is provided by the Environmental Agency.

In Spain, the production of hydrogen requires an "Autorización ambiental integrada" (Integrated Environmental Authorization), delivered by a regional institute (for example INAGA (INstituto Aragonés de Gestión Ambiental)).

III.3 Main Standards in ELY4OFF framework

In order to give a quick overview of the main international standards and European regulations in the ELY4OFF framework, Figure 9 is provided below.

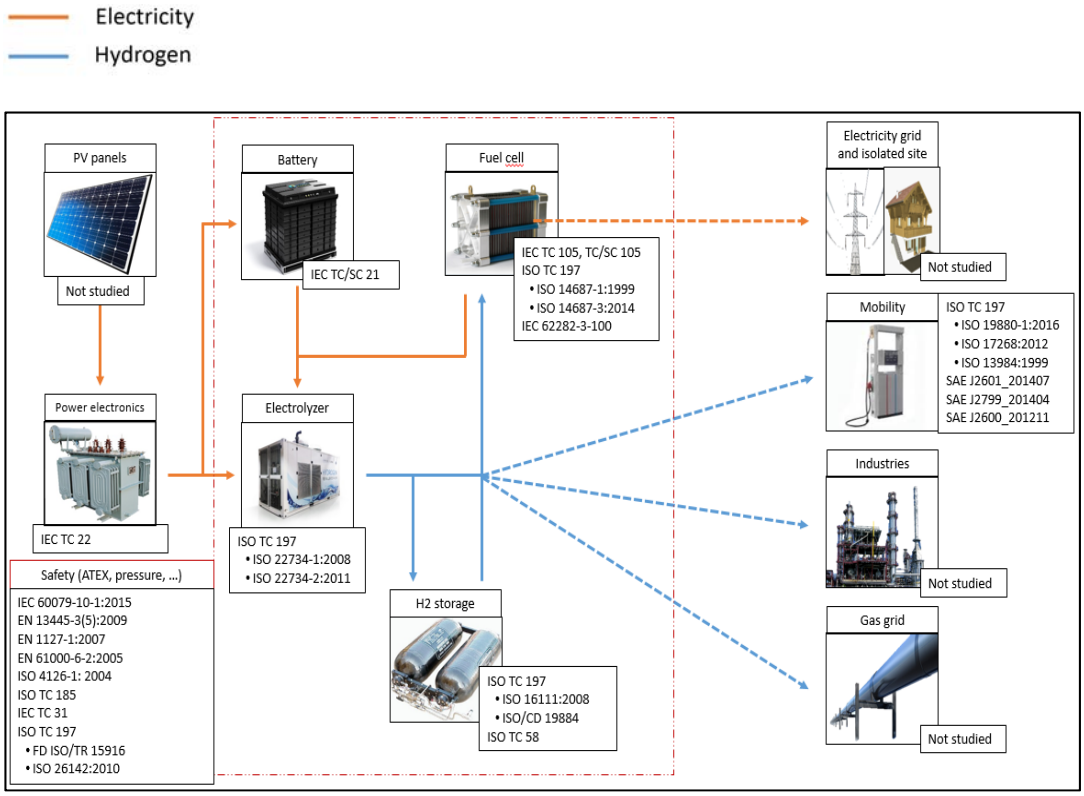


Figure 9: Main standards and technical committee in the ELY4OFF framework

On the figure above, mobility is the only hydrogen application with described RCS as for now it was identified as one of the most relevant within ELY4OFF project. Other hydrogen uses are only mentioned to give an overview of the different possible hydrogen applications.

These standards are detailed from Table 4 to Table 10 below.

Power Electronics		
Reference	**Title**	**Publication date**
IEC TC 22	Power electronic systems and equipment	Active TC

Table 4: Power Electronics RCS

Battery		
Reference	**Title**	**Publication date**
IEC/TC SC 21	Secondary cells and batteries containing alkaline or other non-acid electrolytes	Active TC

Table 5: Battery RCS

Electrolyser		
Reference	**Title**	**Publication date**
ISO TC 197	Hydrogen technologies	Active TC
ISO 22734-1:2008	Hydrogen generators using water electrolysis process -- Part 1: Industrial and commercial applications	2008
ISO 22734-2:2011	Hydrogen generators using water electrolysis process -- Part 2: Residential applications	2011

Table 6: Electrolyser RCS

Hydrogen Storage		
Reference	**Title**	**Publication date**
ISO TC 197	Hydrogen technologies	Active TC
ISO 16111:2008	Transportable gas storage devices -- Hydrogen absorbed in reversible metal hydride	2008
ISO/CD 19884	Gaseous hydrogen - Cylinders and tubes for stationary storage	Unknown
ISO TC 58	Gas cylinders	Active TC

Table 7: Hydrogen storage RCS

Fuel Cell		
Reference	**Title**	**Publication date**
IEC TC 105	Fuel cell technologies	Active TC
ISO TC 197	Hydrogen technologies	Active TC
ISO 14687-1:1999	Hydrogen fuel -- Product specification -- Part 1: All applications except proton exchange membrane (PEM) fuel cell for road vehicles	1999
ISO 14687-3:2014	Hydrogen fuel -- Product specification -- Part 3: Proton exchange membrane (PEM) fuel cell applications for stationary appliances	2014
IEC 62282-3-100	Stationary fuel cell power systems - Safety	2012

Table 8: Fuel cell RCS

Mobility		
Reference	**Title**	**Publication date**
ISO TC 197	Hydrogen technologies	Active TC
ISO 19880-1:2016	Gaseous hydrogen -- Fuelling stations -- Part 1: General requirements	2016
ISO 17268:2012	Gaseous hydrogen land vehicle refuelling connection devices	2012
ISO 13984:1999	Liquid hydrogen -- Land vehicle fuelling system interface	1999
SAE J2601_201407	Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles	2014
SAE J2799_201404	Hydrogen Surface Vehicle to Station Communications Hardware and Software	2014
SAE J2600_201211	Compressed Hydrogen Surface Vehicle Fueling Connection Devices	2012

Table 9: Mobility RCS

Safety (ATEX, Pressure, …)		
Reference	**Title**	**Publication date**
IEC 60079-10-1:2015	Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres	2015
EN 13445-3(5):2009	Unfired pressure vessels	2009
EN 1127-1:2007	Explosion prevention and protection	2007
EN 61000-6-2:2005	Immunity for industrial environment	2005
ISO 4126-1: 2004	Safety devices for protection against excessive pressure	2004
ISO TC 185	Safety devices for protection against excessive pressure	Active TC
IEC TC 31	Equipment for explosive atmospheres	Active TC

ISO TC 197	Hydrogen technologies	Active TC
ISO/TR 15916:2015	Basic considerations for the safety of hydrogen systems	2015
ISO 26142:2010	Hydrogen detection apparatus -- Stationary applications	2010

Table 10: Safety RCS

These standards are the main standards to be consulted for installations of the same kind as the ELY4OFF installation. In addition to Figure 9, a RCS list is available in Appendix 3.

Furthermore, the following website could complete these data by presenting an overview of relevant standards all around the world and by technologies: http://www.fuelcellstandards.com/home.html

In France, it is also worth mentioning the important standard **NF M58-003:2013** « Installation des systèmes mettant en œuvre l'hydrogène » (installation of hydrogen-using systems) which describes the requirements for a safe hydrogen installation.

III.4 Key documents

During the literature work carried out for this report, some documents were identified as key references. They provide many relevant information about hydrogen RCS. Table 11 below lists these key documents related to RCS in the hydrogen field.

Reference	Author	Publication date
Sector Forum Energy Management / Working Group Hydrogen – Final Report [1]	CEN-CENELEC	2016
Handbook for Hydrogen Refuelling Station Approval [2]	HyApproval Project	June 4, 2008
Approval requirements in five EU countries and the USA [27]	HyApproval Project	December 4, 2007
Installation permitting guidance for hydrogen and fuel cell stationary applications: UK version (RR715) [28]	Health and Safety Laboratory	2009
Standards, codes and regulations of Hydrogen Refueling Stations and Hydrogen Fuel Cell Vehicles – Final Degree Project [29]	P.Huertas Gaja M.del Mar Llompart	Unknown

Table 11: Key documents about RCS in hydrogen field

For example, the figure provided in Appendix 2 comes from the CEN-CENELEC Final Report and shows a mapping of the International and European standardization activities in the hydrogen field.

The following websites provide an overview of relevant standards all around the world and by technologies and so can also be listed as key references:

http://www.fuelcellstandards.com/home.html and https://h2tools.org/content/codes-and-standards.

III.5 Additional documents

III.5.1 European Projects

In Table 12 are provided the main projects (mostly European projects) related to hydrogen and dealing with RCS information. Please refer to appendix 5 for additional details about these projects and link to useful documents published within the frame of these projects.

Acronym	Title	Website
H2trust	Development of H2 safety expert groups and due diligence tools for public awareness and trust in hydrogen technologies and applications	http://h2trust.eu/
KnowHy	Improving the knowledge in hydrogen and fuel cell technology for technicians and workers	http://knowhy.eu/
Hyperproject	Installation permitting guidance for hydrogen and fuel cells stationary applications	http://www.hyperproject.uk/
HyApproval	Handbook for approval of hydrogen refuelling stations	http://www.hyapproval.org/
HySafe	Safety of hydrogen as an energy carrier	http://hysafe.org/
CHIC	Clean hydrogen in European cities	http://chic-project.eu/
HyResponse	European hydrogen emergency response training program for first responders	http://www.hyresponse.eu/
HyDelivery	Optimisation of transport solutions for compressed hydrogen	http://www.deliverhy.eu/
Hyindoor	Pre normative research on the in-door use of fuel cells and hydrogen systems	www.HyIndoor.eu
HyLIFT	Clean efficiency power for materials handling	http://www.hylift-europe.eu/
HyQ	Hydrogen fuel quality for transportation and other energy applications	http://www.fch.europa.eu/project/hydrogen-fuel-quality-transportation-and-other-energy-applications/
HyLaw	Identification of legal rules and administrative processes applicable to fuel cell and hydrogen technologies' deployment, identification of legal barriers and advocacy towards their removal.	http://www.fch.europa.eu/project/identification-legal-rules-and-administrative-processes-applicable-fuel-cell-and-hydrogen/
CertifHy	Development of a European framework for the generation of guarantees of origin for green H2	http://www.certifhy.eu/

Table 12: Main projects related to hydrogen and giving RCS information

Note: The HyLaw project objective is to focus on hydrogen RCS, but the project does not have a website yet as it began on January the 1st 2017 (http://www.fch.europa.eu/project/identification-legal-rules-and-administrative-processes-applicable-fuel-cell-and-hydrogen).

A list of European projects about hydrogen is available on the following website:

- http://www.fch.europa.eu/fchju-projects

III.5.2 Guides and Codes of practice

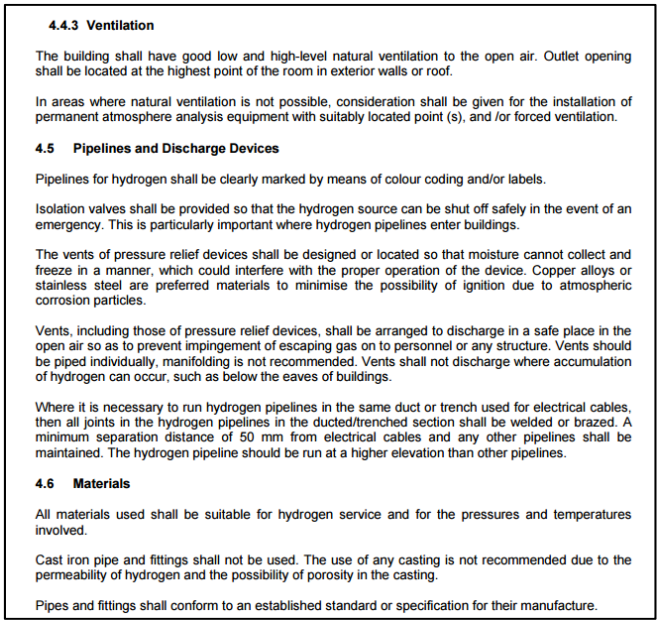
In Table 13 is provided a list of the main guides related to hydrogen field. Guides are classified by emitting country.

Country	Document	Title	Author and reference
Europe	IGC Doc 15/06/E	Gaseous Hydrogen Stations	EIGA [30]
	Doc 06/02/E	Safety in storage, handling and distribution of liquid hydrogen	
	IGC 23/00	Safety training of employees	
	IGC 75/07	Determination of safety distances	
	IGC 121/04	Hydrogen transportation pipelines	
	IGC 122/00	Environmental impacts of hydrogen plants	
	IGC 134/05	Potentially explosive atmosphere - EU directive 1999/92/EC	
	IGC 137/06	Environmental aspects of decommissioning	
	EUR 27641 EN	Working Group Hydrogen – Final Report	CEN CENELEC [1]
France	Réf. 8506	Guide d'information sur la sécurité des véhicules à hydrogène et des stations-service de distribution d'hydrogène	ADEME [31]
	Réf. 8505	Guide d'information sur les risques et les mesures de sécurité liés à la production décentralisée d'hydrogène	
	DRA-14-141532-06227C	Benchmark Stations-service hydrogène	INERIS [32]
	DRA-15-149420-06399C	Etude comparative des réglementations, guides et normes concernant les électrolyseurs et le stockage d'hydrogène	
	DRA-09-101596-02693A	Points réglementaire et normatif sur l'hydrogène en 2009	
	/	L'hydrogène en France en 2015	AFHYPAC [33] [34]
	/	L'hydrogène en France en 2016	
Spain	None	None	None
United Kingdom	RR715	Installation permitting guidance for hydrogen and fuel cell stationary applications: UK version	HSE [28]

	CP 4	Industrial Gas Cylinder Manifolds and Gas Distribution Pipework (excluding Acetylene)	BCGA [35]
	CP 33	The Bulk Storage of Gaseous Hydrogen at Users' Premises	
	CP 43	The safe filling of gas cylinders	

Table 13: Main guides related to hydrogen and giving RCS information

For example, the document IGC Doc 15/06/E gives general and safety information about hydrogen refuelling stations (Figure 10).



4.4.3 Ventilation

The building shall have good low and high-level natural ventilation to the open air. Outlet opening shall be located at the highest point of the room in exterior walls or roof.

In areas where natural ventilation is not possible, consideration shall be given for the installation of permanent atmosphere analysis equipment with suitably located point (s), and /or forced ventilation.

4.5 Pipelines and Discharge Devices

Pipelines for hydrogen shall be clearly marked by means of colour coding and/or labels.

Isolation valves shall be provided so that the hydrogen source can be shut off safely in the event of an emergency. This is particularly important where hydrogen pipelines enter buildings.

The vents of pressure relief devices shall be designed or located so that moisture cannot collect and freeze in a manner, which could interfere with the proper operation of the device. Copper alloys or stainless steel are preferred materials to minimise the possibility of ignition due to atmospheric corrosion particles.

Vents, including those of pressure relief devices, shall be arranged to discharge in a safe place in the open air so as to prevent impingement of escaping gas on to personnel or any structure. Vents should be piped individually, manifolding is not recommended. Vents shall not discharge where accumulation of hydrogen can occur, such as below the eaves of buildings.

Where it is necessary to run hydrogen pipelines in the same duct or trench used for electrical cables, then all joints in the hydrogen pipelines in the ducted/trenched section shall be welded or brazed. A minimum separation distance of 50 mm from electrical cables and any other pipelines shall be maintained. The hydrogen pipeline should be run at a higher elevation than other pipelines.

4.6 Materials

All materials used shall be suitable for hydrogen service and for the pressures and temperatures involved.

Cast iron pipe and fittings shall not be used. The use of any casting is not recommended due to the permeability of hydrogen and the possibility of porosity in the casting.

Pipes and fittings shall conform to an established standard or specification for their manufacture.

Figure 10: Example of information provided by guides (here from IGC Doc 15/06/E)

III.5.3 Notes, Workshops and Reports

Table 14 below gives the main notes, workshops and reports about RCS in the hydrogen field.

Title and reference	Type of document	Author	Publication date
Regulatory matrix [36]	Note	FCHEA	2015
Inventory of Safety-related Codes and Standards for Energy Storage Systems [37]	Report	Pacific Northwest National Laboratory (PNNL)	2014
International Standardization Efforts on Hydrogen Technologies [38]	Workshop	A. Tchouvelev	2013
Introducing Hydrogen as an energy carrier [18]	Report	European Commission	2006

Table 14: Workshops and Reports about RCS in hydrogen field

As an example, Figure 11 below comes from the document called “Introducing Hydrogen as an energy carrier” written by the European Commission.

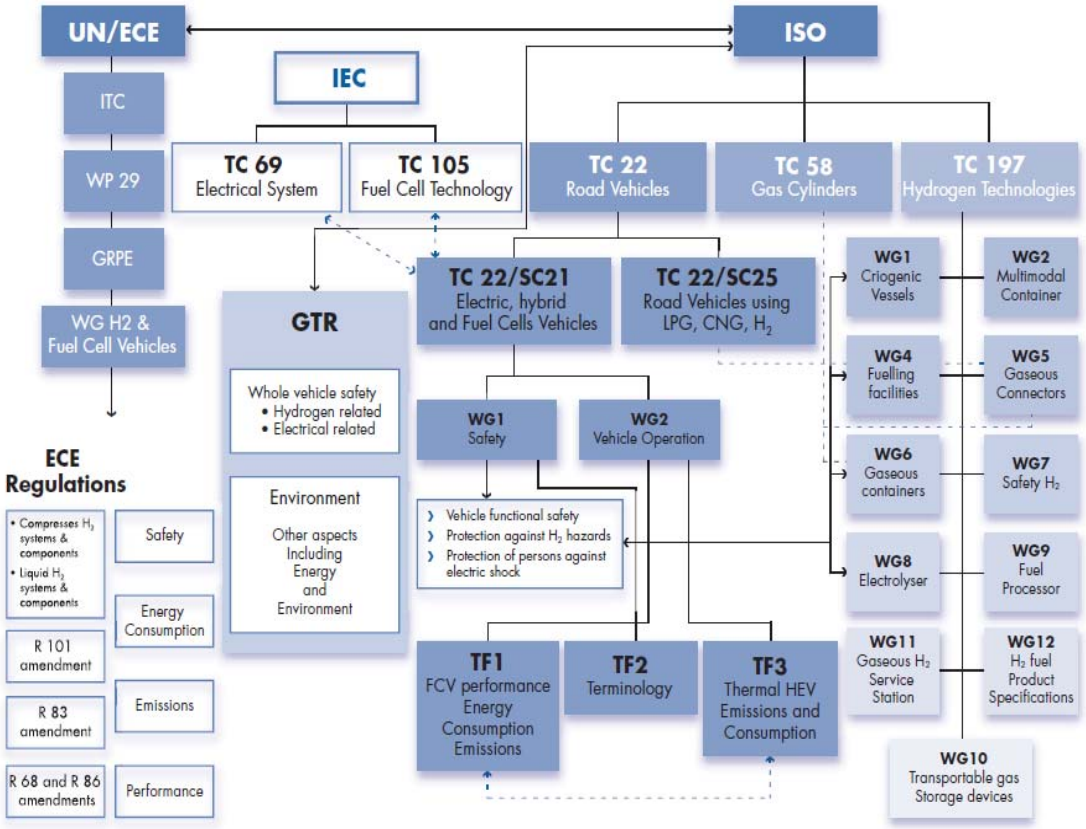


Figure 11: International standardisation and regulatory bodies in the field of hydrogen and fuel cells and their linkages [18]

IV. Recommendations

IV.1 General recommendations

In this section, based on the literature review and analysis of references, common types of actions generally proposed to develop and favour an innovative technology and its associated applications are presented. Although most of the literature work focused on RCS documents, a generic approach for economic policies to support innovation is also presented.

(i) Focus on the major RCS, not address them all

Focus on legally binding RCS (constraints) + possible drivers (standards may be drivers to foster system implementation);

Depending on the project status, focus on generic RCS;

(ii) Develop the EC regulatory framework

As pointed out by [2] for the hydrogen refuelling stations case, "the regulatory framework is still mostly determined at national level. As a result, due to the absence of specific requirements and regulation, there is significant variability with regards to the technical and regulatory references that will be invoked, as well as to how exactly they will be applied (as these did not specifically consider hydrogen refuelling stations when created)" [2].

As a result, we could pass on the key recommendation from the HyApproval project to develop an EC regulatory framework for hydrogen systems "based on the proven combination of Essential requirements, Harmonized standards, and Notified bodies." [2]. According to the HyApproval project, "this could be most efficiently achieved through the development of an EC Regulation (as opposed to an EC Directive)[1]" [2].

(iii) Economic policies to support new energy pathways

New energy pathways, that are not competitive yet, can (and should) benefit from public support, if they can provide additional social welfare.

Public support can be categorized into direct and indirect subventions, but also into supply or demand policies [19].

In general, supply policies, also called **technology-push**, aim at developing the products portfolio; while **demand-pull** policies correspond to Keynesian policies that act on demand in order to re-launch employment and production. In the case of new energy technologies, demand-pull policies target the learning-by-doing effect. Traditionally, R&D support is categorized as a technology-push measure. Public support for R&D is crucial since a major risk of under-investment exists in comparison to what the public interest would be. Indeed, financial risks underlie R&D investment, risks that some companies are unwilling to take.

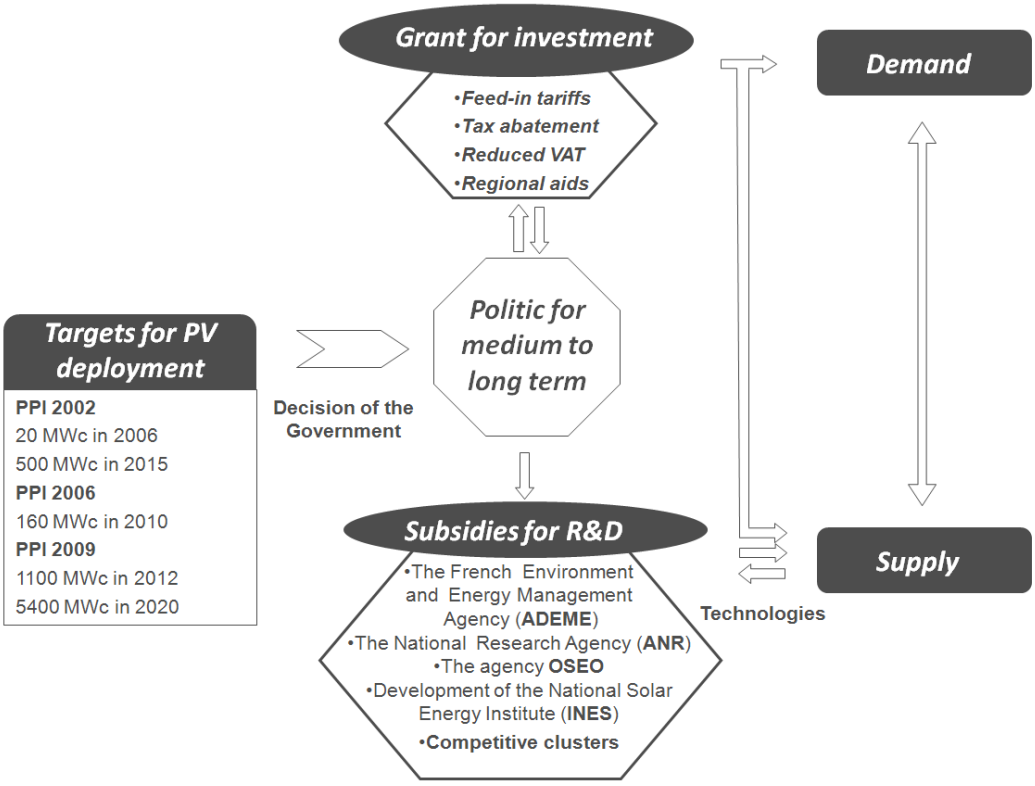
Technology-push measures are most often accompanied by demand-pull ones in order to drive the consumers to adopt the developed innovations. Such measures gather feed-in tariffs, tax abatement, value added tax (VAT) rate reduction and/or regional aids. **The aim is to incite consumers to adopt technologies that are beneficial for the global social welfare, despite their higher costs compared to competing technologies.**

Technology-push policies usually tend to prevail during the first innovation phases, while demand-pull measures are predominant at the end when the technology becomes more mature. Overall both effects may coexist, as suggested by models with the so-called two-factor learning curve. The two factors are cumulative experience ("learning by doing" and accumulated knowledge ("learning by searching").

[1] **A "regulation" is a binding legislative act.** It must be applied in its entirety across the EU. For example, when the EU wanted to make sure that there are common safeguards on goods imported from outside the EU, the Council adopted a regulation [5].
A "directive" is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals. One example is the EU consumer rights directive, which strengthens rights for consumers across the EU, for example by eliminating hidden charges and costs on the internet, and extending the period under which consumers can withdraw from a sales contract [5].

R&D subsidies are supposed to act on the supply side by helping cost reduction whereas grants for investment are supposed to act on demand by increasing it. Finally, supply and demand are acting on each other since a decrease in prices would lead to an increase of new system purchases (change of the supply and demand economic equilibrium along the curves); whereas an increase of demand (and therefore of the system production) would lead to a decrease of costs (and hopefully prices) according to the learning effect model (supply curve shift). It is a step-by-step approach, since it is very difficult to link the level of the supports and their effects. The "virtuous cycle" between R&D, market growth and price reduction has been illustrated for PV in Japan in [19]. However, it is very difficult to claim to which extent R&D played a role and to which extent it was boosting the demand.

To illustrate the statement we make, next figure depicts the public support to photovoltaics, in the French context.



French support system for PV [19]

A distinction is proposed between:

"i/ Market incentives: they correspond to the strategies targeting the market.

They include the **price-driven approaches**:

- Feed-in tariffs: price-driven strategies that guarantee a fixed price;
- Investment subsidies: grants aiming at boosting the demand;
- Loans: low interest loans aiming at increasing installed capacity;
- Tax reductions;

and the **capacity-driven approaches**:

- Tradable Green Certificates: a number of certificates is released, their price being derived according to supply and demand balance.

The latest usually apply on “green” energy in general, making no difference between the kind of technology (wind, photovoltaics, etc.). The market incentives are usually used by States to reach their objectives of installed capacity.

ii/ Technologies and R&D incentives: they correspond to R&D subsidies and demonstration programs (focused development of installations aiming at promoting the new energy pathway and thus stimulate the market).”

So, as it was done in other energy sectors (such as renewable energy development, and especially photovoltaics), public support should be implemented at the first deployment stages in order to drive costs down and bring hydrogen technologies into the market.

Applied to the hydrogen pathways, the following incentives could be considered:

- Special tariff for Power-to-Gas pathways (either through direct blending of hydrogen and natural gas, or after a methanation step). This could be achieved by including hydrogen in the biogas category (which is related to the issue of definitions);
- Investment subsidies to develop the hydrogen infrastructure deployment;
- Implementation of low-interest loans for the purchase of fuel cell electric vehicles;
- Tax exemption for the power supplied to electrolysers, especially in case of power supply pathways (i.e. when power is stored as hydrogen, then rendered as power);
- Green certificates for Power-to-Gas pathways: this issue is tightly related to the goal of the Certifhy project (see sections III.5.1 and 0) that aimed at establishing criteria to define green hydrogen and low-carbon hydrogen;
- R&D subsidies for hydrogen technologies, in order to further reduce costs and improve efficiencies and durability of the equipment.

A number of these options were suggested recently by a French ministerial mission [20], such as subsidizing the deployment of hydrogen refueling stations and CSPE tax exemption for the power consumed by electrolysers (CSPE is the French contribution to the public service for power supply; it contributes namely to subsidizing the development of renewables such as wind power and photovoltaics). Furthermore, the document [21] from the hydrogen council (a new international partnership between 13 industrial companies to develop hydrogen) lists barriers to the development of this field and propose some recommendations.

IV.2 Feedback from hydrogen stakeholders

IV.2.1 Methodology

The objective of this part is to understand if, from the point of view of hydrogen technology actors, there are any barriers, due to RCS or others topics, for the development of hydrogen sector.

In order to get a feedback from the field, several stakeholders of hydrogen were identified and interviewed.

IV.2.2 Interviewed actors

Hydrogen stakeholders from different following types of companies and institutes (Table 15) were interviewed regarding their feelings on the difficulties that they faced when initiating a hydrogen project and their recommendations on how to develop the hydrogen energy sector.

Hydrogen stakeholder	Partner of ELY4OFF project
Energy system provider for isolated site 1	No
Energy system provider for isolated site 2	
Electrolyser manufacturer 1	
Electrolyser manufacturer 2	
French Association of hydrogen	
Hydrogen consulting company	
National standardization institute	
National electricity producer	
FHA – Hydrogen Foundation in Aragon	Yes
ITM – Electrolyser designer	
CEA 1 – French Research Institute	

Table 15: Stakeholders interviewed

We would like to thank them once more for their time and their help in identifying reference documents presented before in this report. Feedback analysis and synthesis from these interviews is summarized in part IV.2.3

IV.2.3 Synthesis of hydrogen expert feedback

In this section main ideas, comments and remarks from the discussion with hydrogen stakeholders about barriers for the hydrogen field development are presented. As said previously, discussions were not limited to RCS barriers. This explains why others barriers are presented and why this section leads to recommendations of several types (RCS, economics and psychology/communication).

IV.2.3.1 RCS

RCS can be separated into two parts: (i) RCS for equipment design and manufacturing, and (ii) RCS for application, i.e. when hydrogen equipment are installed and in operation in a specific environment (country, use, constraints…). Based on the discussion with hydrogen stakeholders, it was clearly identified that design and operation RCS in the hydrogen energy field do not induce the same level of difficulties.

- **Design RCS**

According to stakeholders, design RCS are sufficiently clear and designers of fuel cell, electrolyser and hydrogen storage devices have all the required information to know how to build and certify their products with the CE marking. These RCS are mostly presented in the section III.3.

CE marking allows to sell the products in all Europe without difficulties, and also in some countries with lowest requirements. However, it does not allow to reach the American and Canadian markets for example which require complying with other regulations and standards.

However, one of the stakeholders pointed out that the standard ISO 22734-1:2008 on electrolysis system for industrial applications is a bit old. Since 2008, electrolysis systems have been improved and are now working at higher pressure: it leads to a rise of the membrane crossover phenomena, and this point is not well covered in ISO 22734-1:2008. Furthermore, this standard is very generic and best suited to laboratory applications and constraints, and not so much to stationary applications for energy storage. However, it keeps being the standard the most focused on electrolysis and consequently manufacturers continue to refer to it.

Regarding CE marking, the only comment could be that the way of certification (self-certification possible or not) in the directive 2014/68/UE about pressure equipment is not clear enough.

- **Applications RCS and administrative processes**

According to hydrogen stakeholders, most of the difficulties occur when hydrogen equipment has to be installed, commissioned and operated, for a hydrogen refuelling station for example. There are many “grey” areas, where regulations and recommendations are not clear enough and may vary from one European country to another. This may lead to delays in filling and obtaining exploitation permits in some cases.

Furthermore, administrative processes and laws are not harmonized between European countries, which leads to difficulties for industrials. Indeed, industrials may fear to build installation nowadays which will not be legal anymore in the future due to new or evolving RCS. Time required to get permit licence and authorization is different between countries: it takes for example more time in Spain and France than in Germany, due to the precautionary principle, as in these 2 countries hydrogen is less integrated and known in society. This problem requires communication in order to favour hydrogen technologies acceptance at public level, political level and administrative level (see later).

These difficulties (grey areas, lack of harmonization, administrative delays and uncertainty) can be damaging for hydrogen energy sectors as they slow down project realization and generate extra costs.

- **Industrial Emission Directive**

Water electrolysis processes are subject to the European IED, due to hydrogen production (“in industrial quantities” in France for example) and stored hydrogen on-site, although it can be considered as a clean way of hydrogen production if the electricity comes from renewable energies. This directive is applied in different ways in each European country (cf. section III.2), but always leads to extra time and extra cost.

- **Tax due to electricity consumption**

To produce hydrogen, electrolysis systems require electricity. When coupled to the electric grid, the consumed electricity is submitted to several taxes. In France one of them is the CSPE, which has as objective (between others) to finance feed-in tariffs of RES electricity production. According to stakeholders, these taxes are brakes to the development of green hydrogen productions as it increases the hydrogen cost.

IV.2.3.2 Economics

On the economic point of view, stakeholders mention that there is a lack of incentives to encourage the hydrogen development. In order to make hydrogen energy attractive, the oil price should be at least four times higher and with the guarantee that it will not highly fluctuate over time. Again according to stakeholders, innovation and environmental aspects are often not sufficient to convince investors about hydrogen compared with cheaper fossil fuel solutions.

One of the reason of the high cost of hydrogen systems is that, due to the flammable character of hydrogen, it is still difficult to find components satisfying the 3 following criteria: functionality, security, low price.

The rarity of these components and the time spent to find and qualify them lead to hydrogen cost raising. However, roll-out of hydrogen technologies and applications should lead to decrease of cost in the future.

IV.2.3.3 Psychology and communication

It has been pointed out by stakeholders that psychology and social acceptance of a new technology is a critical point for the development of a new innovative field. Although hydrogen is a very active sector, it seems that in Europe there is a lack of communication about hydrogen and outreach effort for large public and students of any age. Indeed, people do not think about hydrogen as a solution for energy storage when looking for a solution to their energetic problems.

It is necessary to reassure about the fact that using hydrogen is safe, and to highlight its ecological benefits if produced from RES. In addition, it is often forgotten to mention that to produce their own fuel would be beneficial for countries economy, reducing dependence to fossil fuels and improving their trade balance.

IV.2.4 Recommendations established with hydrogen expert feedback

In accordance with hydrogen expert feedbacks, the following recommendations could be highlighted.

Recommendation n°	Type	Content
Recommendation 1	RCS	RCS on the side on operation should be clarified and harmonized between European countries. As an example, there does not exist RCS about hydrogen injection in the gas grid.
Recommendation 2	Economic	Hydrogen should be encouraged with economic incentives (like tax exemption for the power consumed by electrolysers), in order to be more competitive with fossil fuel energies, which could be justified by the environmental benefit of this field (if produced with renewable or low-carbon energies).
Recommendation 3	Psychology and communication	Promote hydrogen in schools, universities and to general public in order to raise awareness about this technology. Integrate hydrogen technologies in everyday life to raise awareness about hydrogen among the general public. Highlight its ecological benefits and its possible influence on trade balance.

Recommendation 4	RCS	In France, adjust the IED application through the ICPE regulation in order to facilitate authorization request for electrolysis system. These requests are long and costly which affect an efficient realization of hydrogen projects.
Recommendation 5	RCS	Clarify the CE self-certification conditions in the directive 2014/68/UE about pressure equipment.
Recommendation 6	RCS	Update ISO 22734-1:2008 to take into account recent evolution of electrolysis system and better take into account stationary use for energy storage.
Recommendation 7	RCS	Facilitate administrative procedures for demonstrators in hydrogen fields, which could then allow to define easier standards to be followed by industries.
Recommendation 8	RCS	Adapt administrative processes depending on the type of hydrogen production and implied hydrogen quantity.

Table 16: Recommendations inspired with the hydrogen stakeholder feedbacks

In the next section are presented several recommendations gathered from the bibliographic work.

IV.3 Specific recommendations for the hydrogen development

In this section are presented recommendations, to favour the development of hydrogen fields. These recommendations were proposed in several reference documents, and are summarized in the Table 17 below.

Reference	Main recommendations	Publication date
CEN – CENELEC Sector Forum Energy Management / Working Group Hydrogen [1]	1. RCS: provide a European harmonized legal status for injection of H2 to the natural gas grid 2. RCS: Give the possibility to certify “green hydrogen”	2016
How hydrogen empowers the energy transition [21]	1. Road map: Hydrogen sector needs investments before the consumer demand increases, but potential investors are discouraged by the lack of emission reduction targets or incentives for specific sectors 2. Economic: set preferential financial incentives up 3. RCS: Redefined industry standards as they have been set for specific applications and remain limited overall	01/2017
H2 Trust – D4.1: FCH safety issues, industry best practices and recommendations [22]	1. R&D: Creation of a European database on accident for monitoring safety aspects, increase the funding of large demo project … 2. RCS: need to improve harmonization, foster industry collaboration in safety RCS, revision	10/2014

	and simplification of safety standards, strengthening RCS about production, transportation and storage 3. Communication: improve communications and training for professionals, regulators and public safety officials and general public	
Rapport Filière hydrogène-énergie [20]	1. Economic: in economic studies, include hydrogen environmental gain compared with fossil fuel use 2. Technic: improve knowledge on hydrogen production without CO_2 emissions 3. Economic: provide subsidies for the establishment of hydrogen refueling stations 4. Experimental: Experiment the hydrogen use in an airport for the whole machine fleet 5. Communication: promote demonstrations of transport fueled by with hydrogen (bus, taxi …)	09/2015
Fuel Cells and Hydrogen 2 Joint Undertaking – 2016 Annual work plan and budget [23]	1. Technical: increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs. 2. Experimental: demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems 3. Environmental: reduce the use of the EU defined “Critical raw materials” (platinum)	12/2015
Short term and long term opportunities to leverage synergies between the electricity and transport sectors through power-to-hydrogen [24]	1. Economic: create a feed-in-tariff for the injection of green or low-carbon hydrogen into the natural gas grid, and exempt electricity used to produce green or low carbon hydrogen injected into the natural gas grid from grid fees and energy taxes 2. Economic: accountability of green or low-carbon hydrogen towards EU targets, especially with regard to the EU Renewable Energies Directive (RED) and the EU Fuel Quality Directive (FQD)	02/2016

Electrical Energy Storage [25]	1. RCS: achieve the conditions for all necessary cooperation between the energy markets in electricity and gas, including use of infrastructure 2. RCS: the regulatory regime may need to differentiate between private consumer-owned storage and storage directly connected to the regulated grid 3. Economic: recommendation to the government and public authorities with a role in research to adjust their research policies and investments to the desired targets for storage development	
Energy Storage: which market designs and regulatory incentives are needed? [26]	1. Economic: EU member states should stimulate and invest more in R&D activities and product development	2015

Table 17: Main recommendations for hydrogen development from several documents

V. Conclusion

As explained previously, the work presented in this report will be continued in a future ELY4OFF report (D2.2). Based on the literature work, RCS analysis, discussions with hydrogen stakeholders and preliminary recommendations identifications that were carried out during the first 15 months of the project, the following tasks of specific interest were identified:

(i) **Literature study**: continue hydrogen related RCS literature analysis in order to list more accurately all RCS linked to this field;

(ii) **Guide**: propose a methodology guide presenting RCS to follow and administrative actions to do depending on the type of application and the lifecycle phase of a project;

(iii) **Specific case studies**: focus on 1 or 2 off-grid hydrogen production cases in Europe, to find out all the RCS to take into account and detail the administrative process to follow to achieve the hydrogen installation;

(iv) **Recommendations and incentives**: for off-grid installations, find hurdles points of the development of this field and presents a list of detailed recommendations in order to overcome these barriers.

Following discussions with ELY4OFF partners, and considering the time allocated to this task, it is proposed to focus on detailing recommendations and incentives for off-grid hydrogen production (task (iv) presented in the previous paragraph).

The work to be carried out will build upon general recommendations already identified in part IV of this report and on on-going demonstration projects and experience in Europe. For the most promising off-grid hydrogen markets to be identified in WP 6, the work to be carried out will contribute to identify the most relevant and efficient incentives and recommendations (at RCS level, economic level and communication level) to foster the deployment of hydrogen technologies.

Although further discussions with partners will clarify it, a proposed content of D2.2 could be:

1) Identification of most promising markets applications
2) Identification of main barriers and difficulties for each application
3) Incentives and recommendations for each application

Through their strong expertise in hydrogen energy field, partners of ELY4OFF project will all contribute to the construction of this report by sharing their experience, analyzing difficulties associated to each market and suggesting incentives and recommendations to overcome them.

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Appendix

Appendix 1: International standardization and regulatory bodies

Appendix 2: Mapping of the standardization activities in the area of hydrogen: general outlook of the possible issues [1]

Appendix 3: Standards relating to hydrogen systems (from [1])

Appendix 4: Reference list for regulations, standards and codes of practice applicable to a European hydrogen refuelling station [2]

Appendix 5: Details on projects about hydrogen

Appendix 1: International standardization and regulatory bodies

"CEN and CENELEC, the European counterparts to the international standardisation organisations ISO and IEC, have adopted international standards and harmonised these with a range of the European directives. In addition to the European and international standardisation bodies there are national bodies such as the US National Fire Protection Association, NFPA." "Depending on the national and local regulations the European and International standards may be sufficient for approving a HRS. Otherwise standards from national or local standardisation organisations or appropriate codes have to be applied." "the EC regulations and the European (CEN, CENELEC) and International (ISO, IEC) standards will be discussed together with the most commonly used codes (EIGA, NFPA, etc…) and national standards." [2]

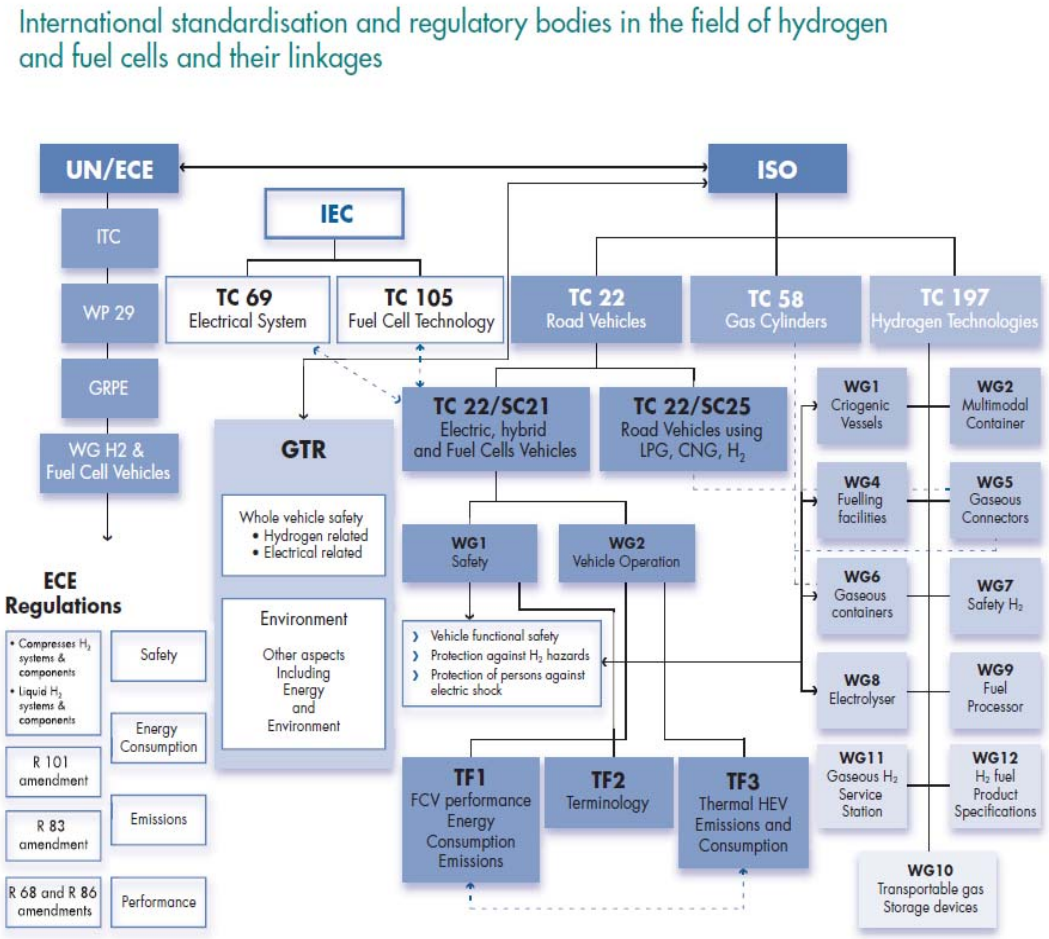

Figure from [18]

Appendix 2: Mapping of the standardization activities in the area of hydrogen: general outlook of the possible issues [1]

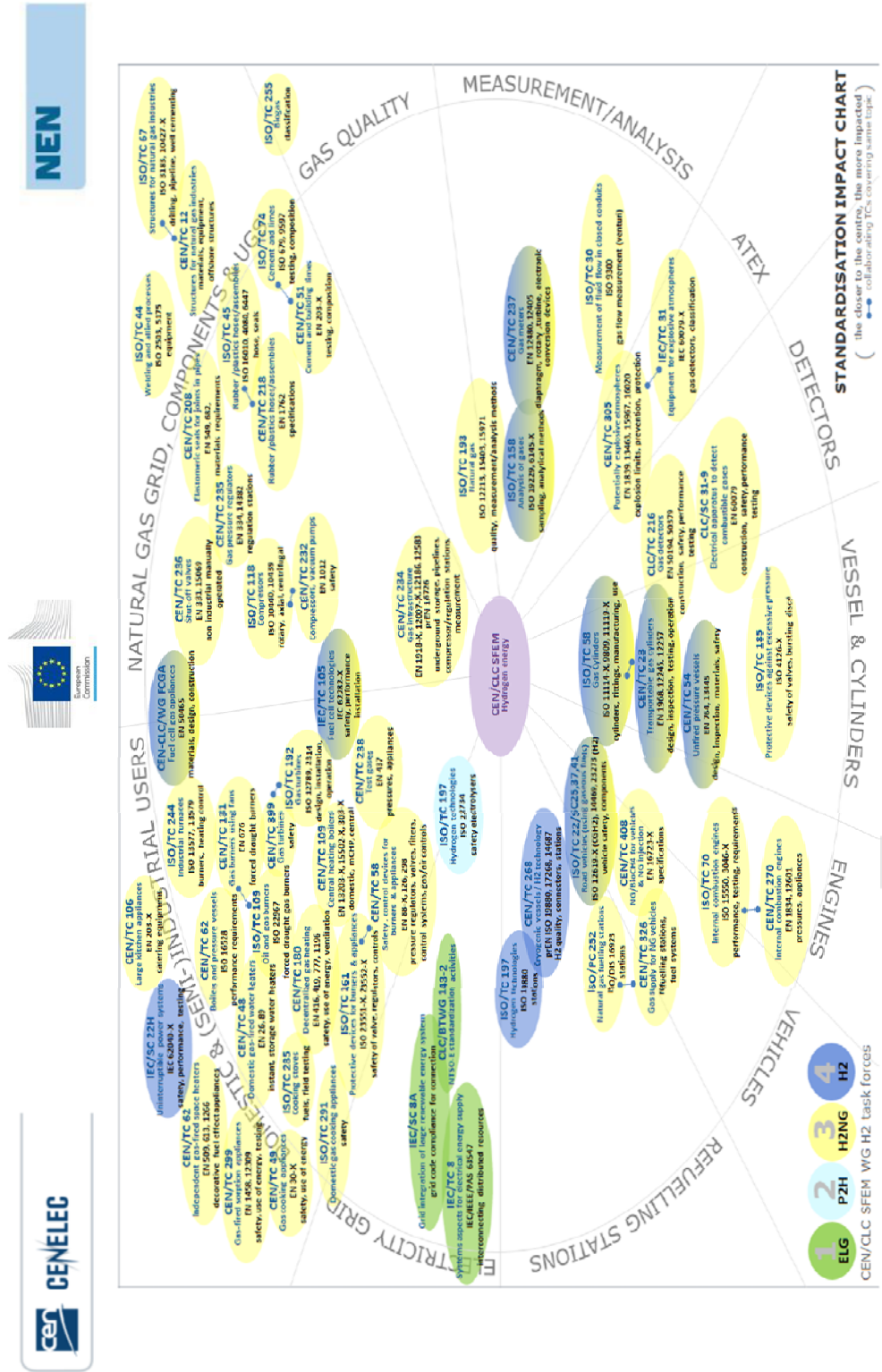

Figure 2 Mapping of international and European standardization activities in the area of hydrogen and H2NG.

Appendix 3: Standards relating to hydrogen systems (from [1])

CEN/TC 58 Safety and control devices for burners and appliances burning gaseous or liquid fuels

CEN/TC 69 Industrial valves

- EN ISO 15848-1 *2015 - Industrial valves — Measurement, test and qualification procedures for fugitive emissions —Part 1: Classification system and qualification procedures for type testing of valves*
- EN ISO 15848-2: *2015 -(EN 16325:2013 prA1:2015): Industrial valves — Measurement, test and qualification procedures for fugitive emissions — Part 2: Production acceptance test of valves*

CEN/TC 192 Fire and Rescue Service Equipment

CEN/TC 185 Fasteners

- EN ISO 15330: 1999 Fasteners - Preloading test for the detection of hydrogen embrittlement - Parallel bearing surface method

CEN/TC 234 Gas Infrastructure

- EN 1594:2-2013 *Gas infrastructure - Pipelines for maximum operating pressure over 16 bar - Functional requirements*
- EN 1775:2007 *Gas supply - Gas pipework for buildings - Maximum operating pressure less than or equal to 5 bar - Functional recommendations*
- EN 1918-1:1998 (*prEN 1918-1:2014) Gas supply systems - Underground gas storage - Part 1: Functional recommendations for storage in aquifers*
- EN 1918-2:1998 *(prEN 1918-2:2014) Gas supply systems - Underground gas storage - Part 2: Functional recommendations for storage in oil and gas fields*
- EN 1918-3: 1998 *(prEN 1918-3:2014) Gas supply systems - Underground gas storage - Part 3: Functional recommendations for storage in solution-mined salt cavities*
- EN 1918-4:1998 (*prEN 1918-4:2014) Gas supply systems - Underground gas storage - Part 4: Functional recommendations for storage in rock caverns*
- EN 1918-5:1998 *(prEN 1918-5:2014) Gas supply systems - Underground gas storage - Part 5:Functional recommendations for surface facilities*
- EN 12007 series *Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar*
- EN 15001-1:2009 *Gas Infrastructure - Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations - Part 1: Detailed functional requirements for design, materials, construction, inspection and testing*
- EN 16348: 2013 - *Gas infrastructure - Safety Management System (SMS) for gas transmission infrastructure and Pipeline Integrity Management System (PIMS) for gas transmission pipelines – Functional requirements*
- EN 16726 (*prEN 16726:2014) Gas infrastructure - Quality of gas - Group H*

CEN/TC 238 Test gases, test pressures and categories of appliances

- EN 437:2003 + A1:2009 Test gases - test pressures - appliance categories.

CEN/TC 268 Cryogenic vessels and specific hydrogen technologies applications

CEN/TC 408 Project Committee - Natural gas and biomethane for use in transport and biomethane for injection in the natural gas grid

CEN/CLC JWG 2

- EN 16325: 2013 (under development A1:2015)- *Guarantees of Origin related to energy - Guarantees of Origin for Electricity*

ISO/TC 22 on Road Vehicles

ISO/TC 58 Gas Cylinders (and CEN/TC 23)

- EN 12245:2009+A1:2011 *(under development) Transportable gas cylinders - Fully wrapped composite cylinders*
- EN ISO 11114-4 2005 *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement*
- ISO 9809-1:2010 Gas cylinders -- Refillable seamless steel gas cylinders -- Design, construction and testing
- ISO 1114-1 (work in progress) Transportable gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 4: Test methods for selecting steels resistant to hydrogen embrittlement
- ISO 11119-1 *2012 Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 1: Hoop wrapped fibre reinforced composite gas cylinders and tubes up to 450 l*
- ISO 11119-2 *2012/Amd 1:2014 Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 2: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners*
- ISO 11119-3 GG*as cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450L with non-load-sharing metallic or non-metallic liners*
- ISO 11119-4 (ISO/DIS 11119-4) *Gas cylinders -- Refillable composite gas cylinders -- Design, construction and testing -- Part 4: Fully wrapped fibre reinforced composite gas cylinders up to 150 l with load-sharing welded metallic liners*
- ISO 11439 I*:2013 Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*
- ISO 11515 *:2013 Gas cylinders — Refillable composite reinforced tubes of water capacity between 450 L and 3000 L — Design, construction and testing*
- ISO 17519 (*ISO/DIS 17519:2015) Gas cylinders -- Refillable permanently mounted composite tubes for transportation*

ISO/TC 158 Analysis of Gases

ISO/TC 193 Natural Gas

- EN ISO 6974:2012 Natural gas — Determination of composition and associated uncertainty by gas chromatography
- ISO/TR 16922:2013 Natural gas – Odorization
- EN ISO 13734*:2013- Natural gas - Organic components used as odorants - Requirements and test methods*

ISO/TC 197 Hydrogen Technologies

- ISO 13984:*1999 Liquid hydrogen -- Land vehicle fuelling system interface*
- ISO 13985:*2006 Liquid hydrogen -- Land vehicle fuel tanks*
- ISO 14687 (currently in preliminary stage, target date 2018) ISO 14687-2*:2012 Hydrogen fuel — Product specification — Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*
- ISO/TS 15869:*2009 Gaseous hydrogen and hydrogen blends -- Land vehicle fuel tanks*
- ISO/TR 15916:2004 *(under revision) Basic considerations for the safety of hydrogen systems*
- ISO/TR 15916:*2004 Basic considerations for the safety of hydrogen systems*
- ISO 17268:*2012 (under revision in preparatory stage) Gaseous hydrogen land vehicle refuelling connection devices*
- ISO 19880-1 *(ISO/DTR 19880-1) Gaseous hydrogen -- Fueling stations -- Part 1: General requirements*
- ISO 19880-*2 (ISO/CD 19880-2) Gaseous hydrogen -- Fueling stations -- Part 2: Dispensers*
- ISO 19880-8
- ISO 19881 *(ISO/CD 19881) Gaseous Hydrogen -- Land Vehicle Fuel Tanks*
- ISO 19882 *(ISO/AWI 19882) Gaseous hydrogen -- Land vehicle fuel tanks -- Thermally activated pressure relief devices*
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- ISO 22734-1*: 2008 Hydrogen generators using water electrolysis process — Part 1: Industrial and commercial applications*
- ISO 22734-2: *2011 Hydrogen generators using water electrolysis process — Part 2: Residential applications*
- ISO 26142:*2010 Hydrogen detection apparatus —Stationary applications*

ISO/PC 252 Natural gas fuelling stations for vehicles

IEC/TC 31 Equipment for explosive atmospheres

- EN IEC 60079-10-1:2015 *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*
- EN IEC 60079-29-1:2007 *Gas detectors – Performance requirements of detectors for flammable gases*

IEC/TC 105 on Fuel Cell Technologies

- IEC 62282-3: *2013 Fuel cell technologies – Part 3-201: Stationary fuel cell power systems – Performance test methods for small fuel cell power systems*

Other organizations

- ASME B31.8:2014 *Gas Transmission and Distribution Piping Systems*
- ASME B31.G:1991 Manual for determining the remaining strength of corroded pipelines
- DNV-RP-F101: 2015 Corroded pipelines

- SAE J2600:2012. Compressed Hydrogen Surface Vehicle Fueling Connection Devices
- SAE J2601:2014 Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles

Mandates and regulation

- UN Model Regulations on the Transport of Dangerous Goods
- UNECE European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)
- UNECE UN Vehicle Regulations R110 CNG and LNG vehicles
- UNECE UN Vehicle Regulations R134Hydrogen and Fuel Cell Vehicle Safety

- EU Directive 94/9/EC ATmosphères Explosibles (ATEX)
- EU Directive 2009/28/EC Renewable Energy Directive (RED)
- EU Directive 2009/30/EC Fuel Quality Directive (FQD)
- EU Directive 2009/142/EC the Gas Appliance Directive (GAD)
- EU Directive 2009/137/EC The Measuring Instruments Directive (MID)
- EU Directive 2010/35/EU Transportable Pressure Equipment Directive (TPED)
- EU Directive 2010/75/EU Industrial Emissions Directive (IED)
- EU Directive 2012/27/EU Energy Efficiency Directive (EED)
- EU Directive 2014/94/EU on the deployment of Alternative Fuels Infrastructure (AFID)
- EU Mandate M/400 to CEN "Gas quality" (SA/CEN/08/06.002)
- EU Mandate M/475 to CEN for standards for biomethane for use in transport and injection in natural gas pipelines
- EU Mandate M/533 COMMISSION IMPLEMENTING DECISION C(2015) 1330 of 12.3.2015 on a standardization request addressed to the European standardization organisations, in accordance with Regulation (EU) No 1025/2012 of the European Parliament and of the Council, to draft European standards for alternative fuels infrastructure

Germany

- BImSchG, BImSch Bundesimmisionsschutzgesetz (German law on biofuel quotas)
- BioKraftQuotenG Bundesimmisionschutzverordnung (German air pollution control laws)
- Energy Act (EnWG)

Appendix 4: Reference list for regulations, standards and codes of practice applicable to a European hydrogen refuelling station [2]

European Directives

67/548/EEC

- *Title:* Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances

- *Relevance to:* Dangerous substances

- *Status:* Published. Amended seven times and latest by the Council Directive 92/32/EEC of 30 April 1992.

- *Application:* The directive deals with the notification of substances, exchange of information on notified substances, and the assessment of the potential risk to the public and the environment of notified substances, as well as the classification, packaging and labelling. It is not applicable for the carriage of substances.

73/23/EEC – Low Voltage Directive, LVD

- *Title:* Council Directive 73/23/EEC of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits.

- *Relevance to:* General safety, Equipment certification and conformity

- *Status:* Published

- *Application:* Applies to electrical equipment designed for use with a voltage

rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current. **It is not applicable to electrical equipment used in an explosive atmosphere.** The directive's scope includes the protection against hazards from electrical equipment and correct marking of electrical equipment and packaging thereof.

80/779/EEC

- *Title:* Council Directive 80/779/EEC of 15 July 1980 on air quality limit values and guide values for sulphur dioxide and suspended particulates

- *Relevance to:* Environmental protection, Sulphur dioxide

- *Status:* Published

- *Application:* Fix limit and guide values for sulphur dioxide and suspended particulates in the atmosphere and the conditions for their application in order to improve the protection of human health and the environment.

89/336/EEC – Electromagnetic Compatibility Directive, EMC

- *Title:* Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility

- *Relevance to:* General safety, Equipment certification and conformity

- *Status:* Published

- *Application:* Applies to apparatus liable to cause electromagnetic disturbance or where the performance of this apparatus is liable to be affected by such disturbances. Apparatus includes all electrical and electronic appliances together with equipment and installations containing electrical and/or electronic components. The directive's scope includes the protection against electromagnetic disturbance from electrical apparatus and certification of such equipment.

89/391/EEC

- *Title:* Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers in the workplace

- *Relevance to:* Safety of workers at work, General

- *Status:* Published

- *Application:* To introduce measures to encourage improvements in the safety and health of workers in the workplace. It contains general principles relating to the prevention of occupational risks, the protection of safety and health, the elimination of risk and accident factors, the informing, consultation, balanced participation in accordance with national laws and/or practices and training of workers and their representatives, as well as general guidelines for the implementation of said principles. It shall apply to all sectors of activity, both public and private. A worker is any person employed by an employer, including trainees and apprentices but excluding domestic servants.

89/654/EEC

- *Title:* Council Directive 89/654/EEC of 30 November 1989 concerning the minimum safety and health requirements for the workplace (first individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

- *Relevance to:* Safety of workers in the workplace, HSE

- *Status:* Published

- *Application:* Protection of workers from risks to their safety and health at the workplace. It shall apply to all sectors of activity, both public and private. A worker is any person employed by an employer, including trainees and apprentices but excluding domestic servants.

89/655/EEC

- *Title:* Council Directive 89/655/EEC of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers in the workplace (second individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

- *Relevance to:* Safety of workers in the workplace, Work equipment

- *Status:* Published

- *Application:* Protection of workers from risks to their safety and health due to the use of work equipment in the workplace. It shall apply to all sectors of activity, both public and private. A worker is any person employed by an employer, including trainees and apprentices but excluding domestic servants.

91/271/EEC

- *Title:* Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment

- *Relevance to:* Environmental protection, Waste water

- *Status:* Published

- *Application:* Concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors.

93/68/EEC – CE Marking Directive

- *Title:* Council Directive 93/68/EEC of 22 July 1993 amending Directives – among others – EMC and LVD. The initial Machinery Directive, directive 89/392/EEC, was also amended, but this was later amended by the directive 98/37/EC.

- *Relevance to:* General safety, Equipment certification

- *Status:* Published

- *Application:* Added two Annexes to the LVD regarding CE conformity marking and international production control. Amendments to Annex I of the EMC regarding CE conformity marking.

94/9/EC – ATEX Product Directive (also known as ATEX 95 and ATEX 100)

- *Title:* Directive 94/9/EC of the European Parliament and of the Council of 23 March 1994 on the approximation of the laws of Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

- *Relevance to:* Equipment certification, Explosive atmosphere

- *Status:* Published

- *Application:* Applies to equipment and protective systems intended for use in potentially explosive atmospheres. Such equipment and systems also include safety devices, controlling devices and regulating devices intended for use outside potentially explosive atmospheres but

required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion.

94/55/EC – ADR

- *Title:* Council Directive 94/55/EC of 21 November 1994 on the approximation of the laws of the Member States with regard to the transport of dangerous goods by road

- *Relevance to:* Hydrogen supply, Transportation

- *Status:* Published

- *Application:* Not directly applicable to a HRS but to a possible way of fuel supply.

96/49/EC – RID

- *Title:* Council Directive 96/49/EC of 23 July 1996 on the approximation of the laws of the Member States with regard to the transport of dangerous goods by rail

- *Relevance to:* Hydrogen supply, Transportation

- *Status:* Published

- *Application:* Not directly applicable to a HRS but to a possible way of fuel supply.

97/23/EC – Pressure Equipment Directive, PED

- *Title:* Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment.

- *Relevance to:* Pressure equipment, Fixed

- *Status:* Published

- *Application:* Applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure PS greater than 0.05 MPa (0.5 bar). Pressure equipment includes vessels, piping, safety accessories and pressure accessories. Where applicable, pressure equipment also includes elements attached to pressurised parts such as flanges, nozzles, couplings, support, lifting lugs, etc.

98/24/EC

- *Title:* Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

- *Relevance to:* Safety of workers at work, Chemical agents

- *Status:* Published

- *Application:* Protection of workers from risks to their safety and health arising, or likely to arise, from the effects of chemical agents that are present at the workplace or as a result of any work activity involving chemical agents. It shall apply to all sectors of activity, both public and private. A worker is any person employed by an employer, including trainees and apprentices but excluding domestic servants.

98/37/EC – Machinery Directive, MD

- *Title:* Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery.

- *Relevance to:* General safety, Equipment certification and conformity

- *Status:* Published

- *Application:* Applies to machinery and lays down the essential health and safety requirements therefore. It shall also apply to safety components placed on the market separately. Machinery is an assembly of linked parts or components, at least one of which moves, joined together for a specific application. Safety component should fulfil a safety function when in use and the failure or malfunctioning of which endangers the safety or health of exposed persons.

1999/36/EC – Transportable Pressure Equipment Directive, TPED

- *Title:* Council Directive 1999/36/EC of 29 April 1999 on transportable pressure equipment

- *Relevance to:* Pressure equipment, Transportable

- *Status:* Published

- *Application:* Enhance safety with regards to transportable pressure equipment approved for inland transport of dangerous goods by road and by rail and to ensure the free movement of such equipment within the EU, including placing on the market and repeated putting into service and repeated use aspects. The term “transportable pressure equipment” shall include receptacles and tanks used for the transport of Class 2 substances in accordance with the Annexes to the RID and ADR treaties. Class 2 substances include gases, compressed, liquefied or dissolved under pressure. The ADR and RID treaties are covering the transport of dangerous goods by road and rail respectively. *However ADR shall not apply to substances of Class 2 in tanks or tank containers of a total capacity exceeding 3000 litres or deeply refrigerated liquefied gases.*

1999/92/EC – ATEX User Directive (also known as ATEX 137)

- *Title:* Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres. (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

- *Relevance to:* Safety of workers at work, Explosive atmosphere

- *Status:* Published

- *Application:* The ATEX user directive is an individual amendment of the council directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work. It is focusing specifically on workers potentially at risk from explosive atmospheres. The directive shall apply to all sectors of activity, both public and private, and the term “worker” shall include any person employed by an employer, including

trainees and apprentices but excluding domestic servants.

ISO standards, drafts, reports and specifications

ISO 11114-1

- *Title:* Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents – Part 1: Metallic materials

- *Relevance to:* Hydrogen supply, gaseous transport

- *Status:* Published standard

- *Application:* Guidance in the selection and evaluation of compatibility between metallic gas cylinder and valve materials, and the gas content. Seamless and welded gas cylinders used to contain compressed, liquefied and dissolved gases, are considered.

ISO 11114-4

- *Title:* Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents – Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement

- *Relevance to:* Hydrogen supply, gaseous transport

- *Status:* Published standard

- *Application:* Applies to seamless steel gas cylinders and specifies test methods and the evaluation of results from these tests in order to qualify steels suitable for use in the manufacture of gas cylinders (up to 3 000 l) for hydrogen and other embrittling gases.

ISO 13984:1999

- *Title:* Liquid hydrogen – Land vehicle fuelling system interface

- *Relevance to:* Dispensing facilities, Liquid hydrogen

- *Status:* Published standard

- *Application:* Applies to the design and installation of liquid hydrogen fueling and dispensing systems, and specifies the characteristics of liquid hydrogen refuelling and dispensing systems on land vehicles of all types in order to reduce the risk of fire and explosion during the refuelling procedure and in order to provide a reasonable level of protection from loss of life and property.

- *Corresponding standards:* SAE J2783 (under development)

ISO 13985:2006

- *Title:* Liquid hydrogen – Land vehicle fuel tanks

- *Relevance to:* On-board hydrogen storage, Liquid hydrogen

- *Status:* Published standard

- *Application:* specifies the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles as well as the testing methods required to ensure that a reasonable level of protection from loss of life and property resulting from fire and explosion is provided.

ISO/DIS 15869

- *Title:* Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks

- *Relevance to:* On-board hydrogen storage, Gaseous hydrogen

- *Status:* Under development

- *Application:* This International Standard specifies the requirements for lightweight refillable fuel tanks intended for the onboard storage of high pressure compressed gaseous hydrogen or hydrogen blends on land vehicles. This International Standard is not intended as a specification for fuel tanks used for solid or liquid hydride hydrogen storage applications.

ISO/TR 15916:2004

- *Title:* Basic considerations for the safety of hydrogen systems

- *Relevance to:* General safety

- *Status:* Published standard

- *Application:* Providing guidelines for the use of hydrogen in its gaseous and liquid forms. It identifies the basic safety concerns and risks, and describes the properties of hydrogen that are relevant to safety.

ISO 16110-1

- *Title:* Hydrogen generators using fuel processing technologies – Part 1: Safety

- *Relevance to:* Hydrogen supply, fossil fuels

- *Status:* Under development

- *Application:* Applies to hydrogen generation systems with a capacity less than 400 m3/h at 0 °C and 101,325 kPa, which convert fossil or biomass fuel to a hydrogen rich stream of composition and conditions suitable for, for example, a hydrogen compression, storage and delivery system.

ISO/CD 16110-2

- *Title:* Hydrogen generators using fuel processing technologies – Part 2: Procedures to determine efficiency

- *Relevance to:* Hydrogen supply, fossil fuels

- *Status:* Under development

- *Application:* covers operational and environmental aspects of the performance of hydrogen generators described in ISO 16110-1.

ISO 17268:2006

- *Title:* Compressed hydrogen surface vehicle refuelling connection devices.

- *Relevance to:* Dispensing facilities, Compressed gas

- *Status:* Published standard

- *Application:* Applies to design, safety and operation verification of Compressed Hydrogen Surface Vehicle, CHSV, refuelling connection devices. Applies to nozzles and receptacles which (1) prevent hydrogen fueled vehicles from being refuelled by dispenser stations with working pressures higher than the vehicle; (2) allow hydrogen vehicles to be refuelled by dispenser stations with working pressures equal to or lower than the vehicle fuel system working pressure; (3) prevent hydrogen fuelled vehicles from being refuelled by other compressed gases dispensing stations; and (4) prevent other gaseous fuelled vehicles from being refuelled by hydrogen dispensing stations.

- *Corresponding standards:* SEA J2600 (published standard)

ISO/TS 20012

- *Title:* Gaseous Hydrogen – Service Stations

- *Relevance to:* General safety

- *Status:* Under development

- *Application:* Applies to non-residential, pure hydrogen refuelling stations, and will address separation distances.

ISO/DIS 22734-1

- *Title:* Hydrogen generators using water electrolysis process – Part 1: Industrial and commercial applications

- *Relevance to:* Hydrogen supply, electrolysis

- *Status:* Under development (Draft International Standard)

- *Application:* This standard defines the construction, safety and performance requirements of integrated, packaged hydrogen gas generation appliances using electrochemical reactions to electrolyse water to produce hydrogen and oxygen gas.

ISO/CD 22734-2

- *Title:* Hydrogen generators using water electrolysis process – Part 2: Residential applications

- *Relevance to:* Hydrogen supply, electrolysis

- *Status:* Under development

- *Application:* As part 1, for residential applications

ISO 26142

- *Title:* Hydrogen detector

- *Relevance to:* General safety

- *Status:* Under development

- *Application:* Defines the performance requirements and test methods of stationary hydrogen detection apparatus that is designed to measure and monitor hydrogen concentrations.

CEN standards

EN 1127-1:1997

- *Title:* Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology

- *Relevance to:* Protection systems

- *Status:* Published standard

EN 1252-1:1998

- *Title:* Cryogenic vessels – Materials – Part 1: Toughness requirements for temperatures below – 80 C

- *Relevance to:* On-board hydrogen storage, Liquid hydrogen

- *Status:* Published standard

EN 1626:1999

- *Title:* Cryogenic vessels – Valves for cryogenic service

- *Relevance to:* On-board hydrogen storage, Liquid hydrogen

- *Status:* Published standard

EN 1797

- *Title:* Cryogenic vessels – Gas/material compatibility

- *Relevance to:* On-board hydrogen storage, Liquid hydrogen

- *Status:* Published standard

EN 1839:2003

- *Title:* Determination of explosion limits of gases and vapours

- *Relevance to:* Risk assessment

- *Status:* Published standard

EN 4126-1, 2, 3, 4, 5, 6, 7

- *Title:* Safety devices for protection against excessive pressure

- *Relevance to:* Non-electrical equipment

- *Status:* Published standard

EN 13160-1:2003

- *Title:* Leak detection systems – Part 1: General principles

- *Relevance to:* Detection systems

- *Status:* Published standard

EN 13237:2003

- *Title:* Potentially explosive atmospheres – Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres

- *Relevance to:* Protective systems

- *Status:* Published standard

EN 13463:2001

- *Title:* Non-electrical equipment for potentially explosive atmospheres – Part 1: Basic method and requirements

- *Relevance to:* Non-electrical equipment and installations

- *Status:* Published standard

EN 13648-1, 2, 3

- *Title:* Cryogenic vessels – Safety devices for protection against excessive pressure

- *Relevance to:* Non-electrical equipment, Liquid hydrogen

- *Status:* Published standard

EN 13673-1:2003

- *Title:* Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours – Part 1: Determination of the maximum explosion pressure

- *Relevance to:* Risk assessment

- *Status:* Published standard

EN 13673-2:2005

- *Title:* Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours – Part 2: Determination of the maximum rate of explosion pressure rise

- *Relevance to:* Risk assessment

- *Status:* Published standard

EN 14522:2005

- *Title:* Determination of the auto ignition temperature of gases and vapours

- *Relevance to:* Risk assessment

- *Status:* Published standard

IEC standards

IEC 60079-0

- *Title:* Electrical apparatus for explosive gas atmospheres - Part 0: General requirements

- *Relevance to:* Electrical equipment and installations

- *Status:* Published standard

- *Application:* Specification of general requirements for construction, testing and marking of electrical apparatus and components intended for use in explosive gas atmospheres. Electrical apparatus complying with this standard is intended for use in hazardous areas in which explosive gas atmospheres, caused by mixtures of air and gases, vapours or mists, exist under normal atmospheric conditions.

- *Corresponding standards:* EN 60079-0 by CENELEC (published standard)

IEC 60079-10

- *Title:* Electrical apparatus for explosive gas atmospheres – Part 10 : Classification of hazardous areas

- *Relevance to:* Electrical equipment and installations

- *Status:* Published standard

- *Application:* Classification of hazardous areas where flammable gas or vapour risks may arise, in order to permit the proper selection and installation of apparatus for use in such hazardous areas.

- *Corresponding standards:* EN 60079-10 by CENELEC (published standard)

IEC 60079-14

- *Title:* Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)

- *Relevance to:* Electrical equipment and installations

- *Status:* Published standard

- *Application:* Specification of requirements for the design, selection and erection of electrical installations in explosive gas atmospheres. These requirements are in addition to the requirements for installations in nonhazardous areas. Applies to all electrical equipment and installations in hazardous areas, and at all voltages.

- *Corresponding standards:* EN 60079-14 by CENELEC (published standard)

IEC 60079-17

- *Title:* Electrical apparatus for explosive gas atmospheres - Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)

- *Relevance to:* Electrical equipment and installations

- *Status:* Published standard

- *Application:* Intended to be applied by users, and covers factors directly related to the inspection and maintenance of electrical installations within hazardous areas only.

- *Corresponding standards:* EN 60079-17 by CENELEC (published standard)

IEC 60079-19

- *Title:* Electrical apparatus for explosive gas atmospheres - Part 19: Equipment repair, overhaul and reclamation

- *Relevance to:* Electrical equipment and installations

- *Status:* Published standard

- *Application:* Gives instructions, principally of a technical nature, on the repair, overhaul, reclamation and modification of a certified equipment designed for use in explosive atmospheres.

- *Corresponding standards:* EN 60079-18 by CENELEC (published standard)

CENELEC standards

EN 60079 – Part 1, 10, 14, 17, 19

- *Title:* Electrical apparatus for explosive gas atmospheres

- *See corresponding IEC standards*

EIGA standards

IGC 06/02

- *Title:* Safety in storage, handling and distribution of liquid hydrogen

- *Relevance to:* Hydrogen storage, Liquid hydrogen

- *Status:* Published code of practice

- *Application:* Describes certain rules and precautions related to liquid hydrogen. The code includes (1) features for layout and design, e.g. safety distances and suitable mechanical and electrical equipment, (2) notices, instructions and customer information in order to facilitate control of an emergency, (3) testing, operations and maintenance of equipment and (4) training and protection of personnel.

IGC 15/06

- *Title:* Gaseous hydrogen stations

- *Relevance to:* Hydrogen storage, Gaseous hydrogen

- *Status:* Published code of practice

- *Application:* The code shall serve as guidance for designers and operators of gaseous hydrogen stations and reflect the best practices currently available. It includes issues such as safety of personnel, operations instructions, protection, and emergency situations.

IGC 23/00

- *Title:* Safety training of employees

- *Relevance to:* Safety of workers at work, General

- *Status:* Published code of practice

- *Application:* Serve as a guideline for training programs for employees dealing with industrial gases such as hydrogen. The guideline includes a safety training checklist and information about the hazards related to the various gases.

IGC 75/07

- *Title:* Determination of safety distances

- *Relevance to:* General safety, Risk management and mitigation

- *Status:* Published code of practice, Revision of IGC 75/01

- *Application:* Establishing the basic principles for calculating appropriate safety distances for the industrial gas industry. It is intended to be an aid to writing and revising codes and practices, which involve specifying separation distances for safe equipment layout. It applies to equipment required for the storage and processing of industrial, medical and speciality gases.

IGC 121/04

- *Title:* Hydrogen transportation pipelines

- *Relevance to:* Dispensing facilities, Compressed gas

- *Status:* Published code of practice

- *Application:* Contains a summary of current industrial practices related to metallic transmission and distribution piping systems carrying pure hydrogen and hydrogen mixtures.

IGC 122/00

- *Title:* Environmental impacts of hydrogen plants

- *Relevance to:* Environmental protection, Operation

- *Status:* Published code of practice

- *Application:* Concentrates on the environmental impacts of hydrogen and carbon monoxide production, and shall provide a guideline for identifying and reducing the environmental impacts of such facilities. This document is relevant for sites which produce hydrogen by electrolysis or chemical processes and covers principal impacts and impacts due to compression, desulphurising, reforming, maintenance and storage.

IGC 134/05

- *Title:* Potentially explosive atmosphere – EU directive 1999/92/EC

- *Relevance to:* Safety of workers at work, Explosive atmosphere

- *Status:* Published code of practice

- *Application:* To facilitate and harmonize the interpretation and implementation of the required assessments and specifically the classification of areas where explosive atmosphere may occur according to the ATEX user directive

IGC 137/06

- *Title:* Environmental aspects of decommissioning

- *Relevance to:* Environmental protection, Decommissioning

- *Status:* Published code of practice

- *Application:* Providing guidance to the identification and management of environmental risks associated with decommissioning.

NFPA standards

NFPA 50A – Superseded by NFPA 55

- *Title:* Standard for Gaseous Hydrogen Systems at Consumer Sites

- *Relevance to:* Hydrogen storage, Gaseous hydrogen

- *Status:* Published standard

- *Application:* Present requirements for designing systems including container locations, safety devices, marking, piping, venting, and other components.

NFPA 50B – Superseded by NFPA 55

- *Title:* Standard for Liquefied Hydrogen Systems at Consumer Sites

- *Relevance to:* Hydrogen storage, Liquid hydrogen

- *Status:* Published standard

- *Application:* Present requirements for designing systems including container locations, safety devices, marking, piping, venting, and other components.

NFPA 52

- *Title:* Vehicular Fuel Systems Code, 2006 Edition

- *Relevance to:* Hydrogen fuelled engines

- *Status:* Published standard

- *Application:* Presents the latest fire safety rules for hydrogen as well as CNG and LNG fuel systems on all vehicle types plus their respective compression, storage, and dispensing systems.

NFPA 55

- *Title:* Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks

- *Relevance to:* Hydrogen storage, Gaseous and Liquid hydrogen

- *Status:* Published standard

- *Application:* Present requirements for designing systems including container locations, safety devices, marking, piping, venting, and other components. Incorporates the standards NFPA 50A and NFPA 50B.

NFPA 221

- *Title:* Standard for High challenge Fire Walls, Fire Walls, and Fire Barrier Walls

- *Relevance to:* General safety

- *Status:* Published standard

- *Application:* Addressing the requirements for fire walls and fire barriers.

Other standards and codes

CGA G-5.4

- *Title:* Hydrogen Piping at Consumer Locations

- *Relevance to:* Hydrogen supply, Pipeline interface

- *Status:* Published standard

- *Application:* Serve as a guide for materials and components selection to assist in installing a safe and effective hydrogen supply system at a customer's site.

CGA G-5.5

- *Title:* Hydrogen Vent System

- *Relevance to:* General safety

- *Status:* Published standard

- *Application:* Presents design guidelines for hydrogen vent systems for gaseous and liquid hydrogen installations at consumer sites, and provides recommendations for their safe operation. Intended to be a useful reference for personnel who design, install, and maintain hydrogen vent systems.

CGA H-3

- *Title:* Cryogenic Hydrogen Storage

- *Relevance to:* Hydrogen storage, Liquid hydrogen

- *Status:* Published standard

- *Application:* Contains the suggested minimum design and performance requirements for shop-fabricated, vacuum-insulated cryogenic tanks (vertical and horizontal) intended for aboveground storage of liquid hydrogen.

ASME B31.3

- *Title:* Process piping

- *Relevance to:* Hydrogen supply, Pipeline interface

- *Status:* Published standard

- *Application:* Contains requirements for piping covering materials and components, design, fabrication, assembly, erection, examination, inspection, and testing. This Code applies to piping for all fluids including cryogenic fluids.

ASME B31.12

- *Title:* Hydrogen piping and pipelines

- *Relevance to:* Hydrogen supply, Pipeline interface

- *Status:* Under development

- *Application:* Contains requirements specific to hydrogen service in power, process, transportation, distribution, commercial, and residential applications.

Appendix 5: Details on projects about hydrogen

H2TRUST

Start date: June 1, 2013

End date: December 1, 2014

Project description: http://www.fch.europa.eu/project/development-h2-safety-expert-groups-and-due-diligence-tools-public-awareness-and-trust-hydro/

Documents linked to RCS:

- H2TRUST_D4.1_FINAL.pdf

KnowHy

Start date: September 1, 2014

End date: August 31, 2017

Project description:

http://www.fch.europa.eu/project/improving-knowledge-hydrogen-and-fuel-cell-technology-technicians-and-workers/

HYPER

Start date: November 1, 2006

End date: February, 2009

Project description: http://www.hyperproject.uk/

Documents linked to RCS:

- Part 3 of the online guide: General and higher level requirements

HyApproval

Start date: October 2005

End date: September 2007

Project description: http://www.hyapproval.org/

Documents linked to RCS:

- HyApproval Deliverable 2.2 Final version of Handbook for hydrogen refuelling station approval - V2.1
- APPENDIX II "Approval requirements in five EU countries and the USA"

HySafe

Project description: http://hysafe.org/

Documents linked to RCS:

- WP16 Contribution to standards and legal requirements

Hydrogen Tools

Project description: https://h2tools.org/

Documents linked to RCS:

- Use https://h2tools.org/content/hydrogenfuel-cell-codes-standards to find RCS.

CHIC

Start date: April 1, 2010

End date: December 31, 2016

Project description: http://www.fch.europa.eu/project/clean-hydrogen-european-cities

Documents linked to RCS:

- D.4.3b CHIC report Certification of buses & H2 infrastructure final

HyResponse

Start date: June 1, 2013

End date: September 30, 2016

Project description: http://www.fch.europa.eu/project/european-hydrogen-emergency-response-training-programme-first-responders

Documents linked to RCS:

- D7.2 RCS recommendations for international standardisation bodies

DeliverHy

Start date: January 1, 2012

End date: December 31, 2013

Project description: http://www.fch.europa.eu/project/optimisation-transport-solutions-compressed-hydrogen

Documents linked to RCS:

- Final report on RCS including preliminary action plan

HYIndoor

Start date: January 2, 2012

End date: January 1, 2014

Project description: http://www.fch.europa.eu/project/pre-normative-research-door-use-fuel-cells-and-hydrogen-systems

Documents linked to RCS:

- D6.1. RCS Recommendations-final

HyLIFT

Start date: January 1, 2013

End date: December 31, 2017

Project description: http://www.fch.europa.eu/project/hylift-europe-%E2%80%93-large-scale-demonstration-fuel-cell-powered-material-handling-vehicles

Documents linked to RCS:

- D3-1 HyLIFT-DEMO report Proposal 10_en (ID 2849503)

HyQ

Start date: March 1, 2011

End date: February 28, 2014

Project description: http://www.fch.europa.eu/project/hydrogen-fuel-quality-transportation-and-other-energy-applications

Documents linked to RCS:

- Deliverable D5 1 1 Interim report of the cooperation with standardisation organisations with a particular focus on European contribution

CertifHy

Start date: November 1, 2011

End date: October 31, 2016

Project description: http://www.fch.europa.eu/project/developing-european-framework-generation-guarantees-origin-green-hydrogen

Documents linked to RCS:

- D2.1 Briefing Paper on the regulatory context
- D4.2 Specification of rules and obligations of the GO scheme (requirements, methodologies, certification process and registration of GO)