

ene.field project

ene.field<sup>★</sup>

Grant agreement No: 303462

## D3.5 Position Paper on Regulations Codes & Standards

**Status: F at 04/09/2014**

(D-Draft, FD-Final Draft, F-Final)

**Dissemination level: PU**

(PU – Public, PP – Restricted to other programme participants, RE – Restricted to a group specified by the consortium, CO – Confidential)



## Index

Summary .....	5
1 Introduction .....	6
1.1 The Ene.field project – WP3 Task 3.5.....	6
1.1.1 Scope of Task 3.5.....	7
1.1.2 WP3 T3.5 – Regulations Codes & Standards task force description .....	7
1.2 Fuel cell-based microCombined Heat and Power systems .....	8
1.2.1 Solid Oxide Fuel Cell .....	9
1.2.2 Proton Exchange Membrane Fuel Cell .....	10
1.2.3 Regulations Codes & Standards matrix .....	11
1.3 Regulation Codes & Standards definitions.....	12
2 Previous projects.....	14
2.1 European Regulations Codes & Standards projects.....	14
2.1.1 HarmonHy .....	14
2.1.2 HYPER .....	15
2.1.3 HyIndoor.....	16
2.1.4 HySafe.....	16
2.1.5 HyER .....	17
2.1.6 International Regulations Codes & Standards projects .....	18
2.1.7 FC-based microCHP systems: demonstration projects .....	18
2.2 Conclusions .....	18
3 Analysis of the International and European Regulations Codes & Standards for Fuel Cell-based microCombined Heat and Power systems status.....	20
3.1 Main RC&S stakeholders .....	20
3.2 Regulations Codes & Standards for fuel cell-based microCombined Heat and Power systems.....	21
3.3 Methodology of analysis .....	22
3.3.1 Questionnaire referred to the Codes & Standards .....	22
3.3.2 Questionnaire referred to the European Union Regulations.....	23
4 Analysis of the Regulations Codes & Standards status related to fuel cell microCombined Heat and Power installation in Countries involved in the Ene.field project .....	35

4.1	Installation requirements.....	35
4.1.1	Why a national level? .....	36
4.2	Conclusions .....	36
5	Conclusions from the Position Paper .....	38
Annex I.....		41
	Glossary.....	41
Annex II.....		44
	European Regulations Codes & Standards projects.....	44
	HarmonHy .....	44
	HYPER.....	48
	HyIndoor.....	50
	HySafe.....	51
	Other projects .....	52
	Fuel Cell System Testing, Safety & Quality Assurance .....	52
	FC Eurogrid - Evaluating the performance of fuel cells in European energy supply grids ..	54
	International Regulations Codes & Standards projects .....	55
	Hydrogen and Fuel Cell Permitting Guide (USA).....	55
	Finnish Handbook of the SOFC System in Buildings (Finland).....	60
	FC-based microCHP systems: demonstration projects .....	62
	Callux (Germany).....	62
	Ene-farm (Japan) .....	64
Annex III.....		66
	Overview of the existing legislation .....	66
	Main International Standards .....	66
	IEC 62282 series .....	66
	Main European Standards.....	67
	EN 50465 .....	67
	European Regulations .....	69
	CE marking-related EU Directives .....	69
	European Union legislative acts related to microCombined Heat and Power.....	70
	Regulations Codes & Standards matrix.....	75
	Inlet fluids.....	75
	Electrical system.....	77

Heat and hot water .....	79
Construction and siting .....	81
Exhaust .....	83
Administration.....	83
People.....	84
Annex IV .....	85
Additional informations on the questionnaires proposed.....	85
Questionnaire referred to the Codes & Standards .....	85
Questionnaire referred to EU Regulations.....	95
Annex V .....	103
National legislation.....	103
Austria .....	103
Belgium.....	107
Denmark.....	110
France.....	114
Germany.....	119
Ireland .....	126
Italy.....	129
The Netherlands.....	135
Slovenia .....	139
Spain .....	140
The United Kingdom.....	146
References.....	155

## Summary

This Position Paper supplies an accurate overview of the current Regulations Codes & Standards (RC&S) framework throughout the Europe for what concerns the installation aspects referring to the Fuel Cell-based microCombined Heat and Power (FC-based microCHP) systems. Its aim is to analyze the existing scenario and, when necessary, to supply opinions and suggestions for possible future actions that can help the diffusion of this technology.

First of all, the already existing projects, dealing with RC&S activities, were evaluated and, for each of them, all the results that can be useful for the Ene.field project were highlighted.

The analysis was conducted through two steps. The former dealt with a research of the existing RC&S related to the installation aspects at an International, European and National level. The documentation collected was grouped according to topics considered relevant to this argument.

The latter consisted in a collaboration, by means of two questionnaires, with the European manufacturers involved in the Ene.field project. The questionnaires deal respectively with the status of the European Standards and the European Regulations and Directives. The aim of this kind of analysis was to get an opinion on what is satisfactory, what is necessary to modify and what has to be completely eliminated, regarding the current legislation, from the point of view of the FC-based microCHP systems manufacturers directly involved.

This work led to some relevant conclusions that can be the starting point for further discussions:

- Referring to the existing Standards both at a national and at an European level, the main result merged from the analysis conducted is the existence of a generalized situation of non-homogeneity that represents a barrier towards the diffusion of the FC-based microCHP systems throughout the Europe Countries.
- As far as the European Regulations and Directives are concerned, the most discussed issue refers to the Energy Labeling. According to the opinion of the manufacturers involved, the two currently existing methodologies, set by the European Commission for the labeling of energy-related products dealing with the space heating, penalize the cogeneration systems with respect to other technologies (e.g., such as the heat pumps). These methods are described respectively in the European Regulation no. 813/2013 and in the related Communication from the Commission available from July 2014. The main result that emerged is both these methodologies are not convincing: the former yields the same result in terms of seasonal space heating energy efficiency irrespective of the variation in efficiencies among different microCHP technologies; the latter acts as a “simplified” method assuming that the operation of a microCHP device, coupled with an hypothetical supplementary device, remains constant whatever the thermal efficiencies and the times of operation are. On the same topic, the EN 50465 standard proposed by the CENELEC contains a methodology which offers more reliable results since it takes into account the existing differences in efficiencies, operation and size related to the microCHP technologies.

## 1 Introduction

This position paper has the purpose of analyzing the current status of RC&S, and in particular in Europe, concerning the development of FC-based microCHP systems, with particular focus on their installation.

The document is structured as follows:

- **Chapter 1** offers an introduction on the entire work, and explains the scope and criteria that have been chosen.
- **Chapter 2** is a general overview of the already existing International and European projects that deal with fuel cell (and hydrogen) RC&S activity.
- **Chapter 3** analyzes the current International and European RC&S situation, and describes the most relevant standards and regulations in force. Starting from the present situation, chapter 3 presents two questionnaires respectively referring to International + European Standards and European Regulations, that have been distributed in order to evaluate the correct strategies to improve them with respect to the FC-based microCHP systems, with particular focus on installation.
- **Chapter 4** is an overview and a manual of the current National Standards situation concerning FC-based microCHP systems installation. All the European Countries involved in the Ene.field project are considered in this Chapter. The final conclusion has been drawn to define what needs to be changed at a national level.
- **Chapter 5** summarizes the conclusions that have been made on the basis of the conducted analysis.

### 1.1 The Ene.field project – WP3 Task 3.5

Ene.field (*European-wide field trials for residential fuel cell microCHP*, Joint Technology Initiatives – Collaborative Project (FCH), FCH-JU-2011-1, **Grant Agreement Number 303462**) is a European Project that foresees the installation of about 1,000 residential FC-based microCHP systems throughout 12 European Union (EU) Member States.

Both academic and industrial partners are involved in this project. Among these partners, 9 European FC-based microCHP systems manufacturers have the task of producing and then installing cogeneration devices. The objective is to evaluate their performances over a period of 3 years.

System installation and operation tests will be conducted in different European situations, in terms of domestic heating market dynamics, types of dwellings and climatic conditions. This activity will allow an important database on energy consumption and on the applicability of these devices throughout Europe. This will be an important step to be made before mass production.

The main objective of Ene.field, through these operation tests, is to highlight, by means of an adequate collection of data, the potential of FC-based microCHP systems in terms of costs and

environmental impact. Field demonstrations will be conducted which will attempt to establish the right incentives to encourage the adoption of this technology considering the possibility of economic support from governments and the creation of new market channels.

In the framework of the Ene.field project, the activity of the WP3 Task 3.5 working group concerns the current European and International situation, in terms of RC&S, pertaining to household applications for fuel cell appliances.

### 1.1.1 Scope of Task 3.5

The main aims of the RC&S working group can be summarized as follows:

- To obtain input from a group of 9 main EU manufacturers, which will be used in analysis and discussions in relevant standardization bodies (e.g., International Electrotechnical Commission (IEC)/Technical Committee (TC) 105 Fuel Cells, International Organization for Standardization (ISO)/TC 197 Hydrogen Technologies, European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC) that are active on fuel cell topics);
- To obtain input from a group of 9 main EU manufacturers, which will be considered for analysis and discussions with regulatory bodies at a EU level.

The Working Group work has been divided into two different activities:

1. Prior to the installation of the systems (M1 - M15), an analysis of RC&S concerning FC-based microCHP systems will be conducted and the main output will be released as a position paper.
2. After installation of the systems, the activity will restart (M49 - M51) and an appendix to this paper could be created using the gained “experience” to further analyse and possibly influence the RC&S situation throughout the European Union.

**Deliverables:** Month 15 (position paper) and month 51 (lessons learnt appendix).

#### 1.1.1.1 Focus: installation requirements

EU manufacturers have pointed out that the most important RC&S macro-objective, with reference to FC-based microCHP systems, is their **installation**.

For this reason, the chapters that deal with International and European standardization will be focused entirely on this aspect.

### 1.1.2 WP3 T3.5 – Regulations Codes & Standards task force description

In the framework of the Ene.field project, the activity of the WP3 Task 3.5 working group concerns the current European and International legislative situation, in terms of RC&S, pertaining to household applications for fuel cell appliances.

The task leader is the Politecnico di Torino (IT), which is supported by the European FC-based microCHP systems manufacturers involved in Ene.field, who have the duty of supplying input. The manufacturers involved in the project are:

- BaxiInnotech
- Bosch
- Ceres Power
- DanthermPower
- Elcore
- Hexis
- RBZ
- SOFCPower
- Vaillant

The activities of this task also foresee the contribution of the National Standard Organizations of the European Countries involved in the Ene.field project.

## 1.2 Fuel cell-based microCombined Heat and Power systems

At the moment, FC-based microCHP technology is increasingly attracting attention, especially in the residential sector, due to its potential. In fact, these systems can satisfy both electrical and thermal demands (in different percentages, depending on the thermo-technical plants and status of the buildings), from a single source of fuel, and it is also possible to tune the levels of the produced heat and power according to the building's needs.

The fuel cell systems that will be deployed throughout Europe also include other components that allow them to operate correctly (balance of plant). In particular, these systems have to supply air and clean fuel to the stack, convert the power generated in an AC form in order to send it to the grid, remove the surplus heat and recover it for FC-based microCHP systems utilization and to remove the exhaust products produced by the electrochemical reactions that occur in the cells.

As far as the Ene.field project is concerned, two types of fuel cell technologies are considered in the installations:

- Proton Exchange Membrane Fuel Cell (PEMFC), at both low and high temperatures;
- Solid Oxide Fuel Cell (SOFC), at both high and intermediate temperatures.

The next two subsections show a layout example of FC-based microCHP systems based on the fuel cell typologies mentioned above.

### 1.2.1 Solid Oxide Fuel Cell

Figure 1 shows a schematic representation of an SOFC-based microCHP system. The core is defined by the dotted rectangle. In this configuration, an Internal steam-Reforming (IR) is considered. The choice of separating the reformer from the SOFC stack has been made purely for explicative purposes, but the reforming reactions can take place directly on the cell anode (depending on the fraction of direct reforming indicated by the individual manufacturers).

The fuel stream (natural gas from the distribution network) directed towards the SOFC stack has been previously treated in order to remove sulfur traces which are detrimental for the cell anode (especially if Ni-based, the state-of-the-art material). The fuel undergoes the reforming process, inside the stack, before reaching the cell surfaces. Since the operation temperature of an SOFC is around 800°C, the inlet stream has to be pre-heated before it enters the hot box.

The air stream is sent with a higher mass flow than that of the fuel, and it therefore needs more heat to reach the inlet of the stack at a suitable temperature. For this reason, it exchanges heat with the exhausts that exit from a burner through a recuperator and subsequently enters the stack.

Electrochemical reactions that allow the production of electrical power and heat from irreversibility phenomena, as a by-product are activated inside the stack. Since steam reforming is an endothermic process, part of the produced heat is used to drive the reaction (thermal integration reformer-stack).

The outlet streams (both anodic and cathodic) of the stack are directed towards a burner in which combustion takes place and the produced exhausts pre-heat the inlet air, on the basis of the solution provided by the single manufacturer. The heat remaining in the gas exhaust can then be used for different purposes. In this case, it is used to warm a tank of water for domestic use.

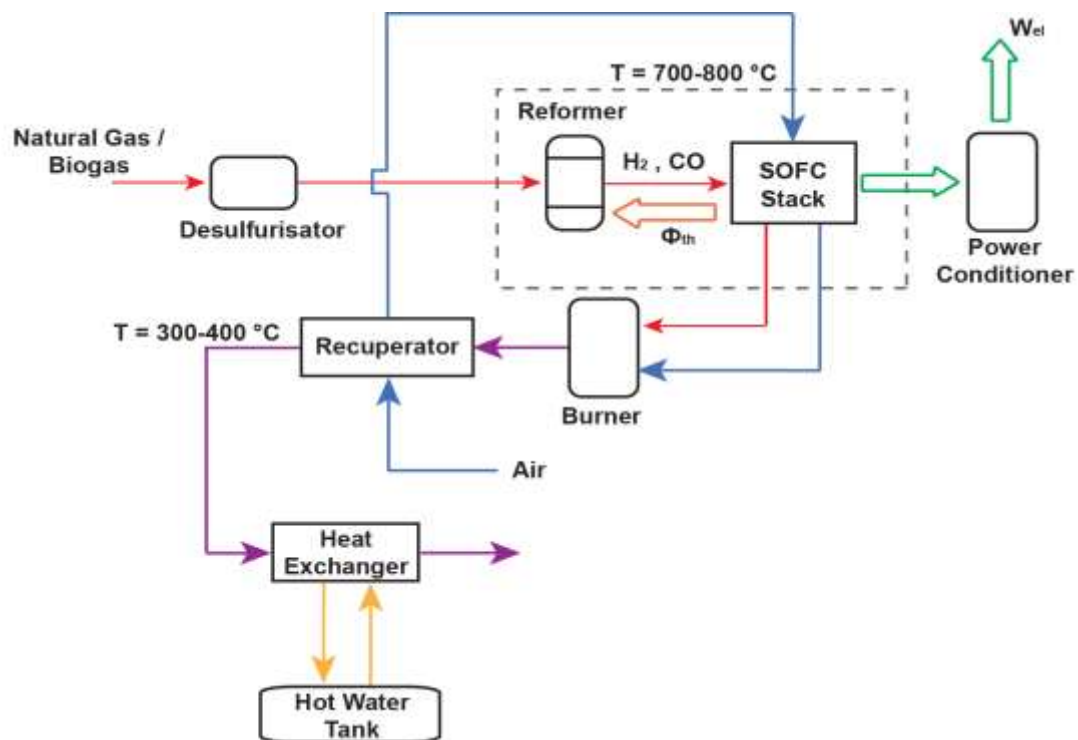


Figure 1. Schematic representation of a SOFC-based microCHP system with Internal steam-Reforming (IR) (FC-DISTRICT project, WP10).

### 1.2.2 Proton Exchange Membrane Fuel Cell

PEM fuel cells, work at a lower temperature (around 60°C) than SOFC. For this reason, the general layout of a PEM FC-based microCHP system is slightly different from that of an SOFC (Figure 2).

Firstly, operation at a lower temperature leads to a series of consequences which limit the direct use of carbon containing molecules. Then, the reforming process takes place outside the stack. As a consequence, the heat required for the activation of this endothermic reaction will be taken from the combustion of a certain quantity of Natural Gas (NG) with air. In order to reduce this amount of external fuel, the anode exhaust exiting from the stack is also recovered. Finally, the reformate has to be cooled before it enters the PEM stack.

The inlet air stream is pre-humidified and heated by the cathode exhaust.

While the electrical power is produced by the stack, the thermal power can be recovered, for example, by means of a water loop that exchanges heat with the system. Three sources of heat are available in the configuration presented below: the reformate entering the stack, the stack and burner.

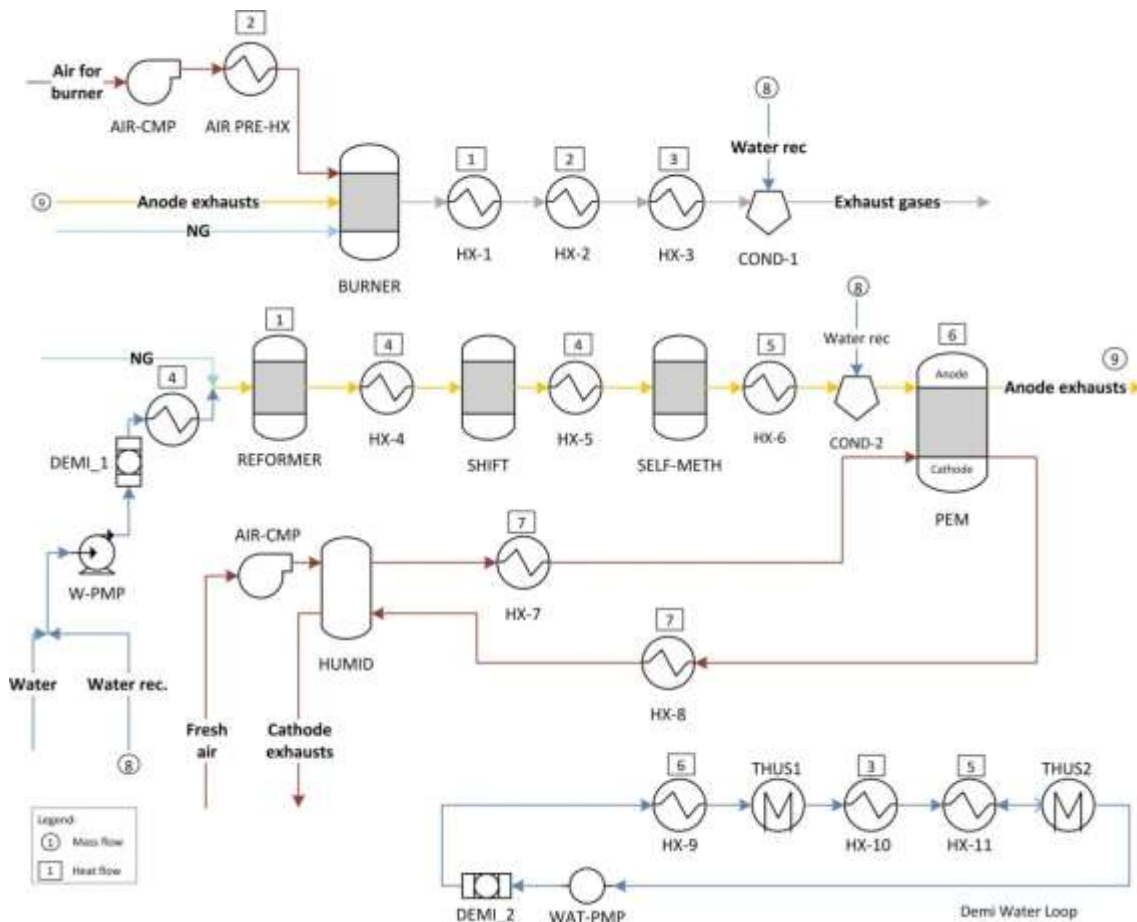


Figure 2. Schematic representation of a PEMFC-based microCHP system (Gandiglio et al., 2014).

1.2.3 Regulations Codes & Standards matrix

A general scheme was created (Figure 3), starting from the example layouts of FC-based microCHP systems. This representation consists of a system boundary analysis that allows the interfaces of the FC-based microCHP system to be identified (as shown in Figure 3, both technical and safety-related), which have to be considered in terms of installation.

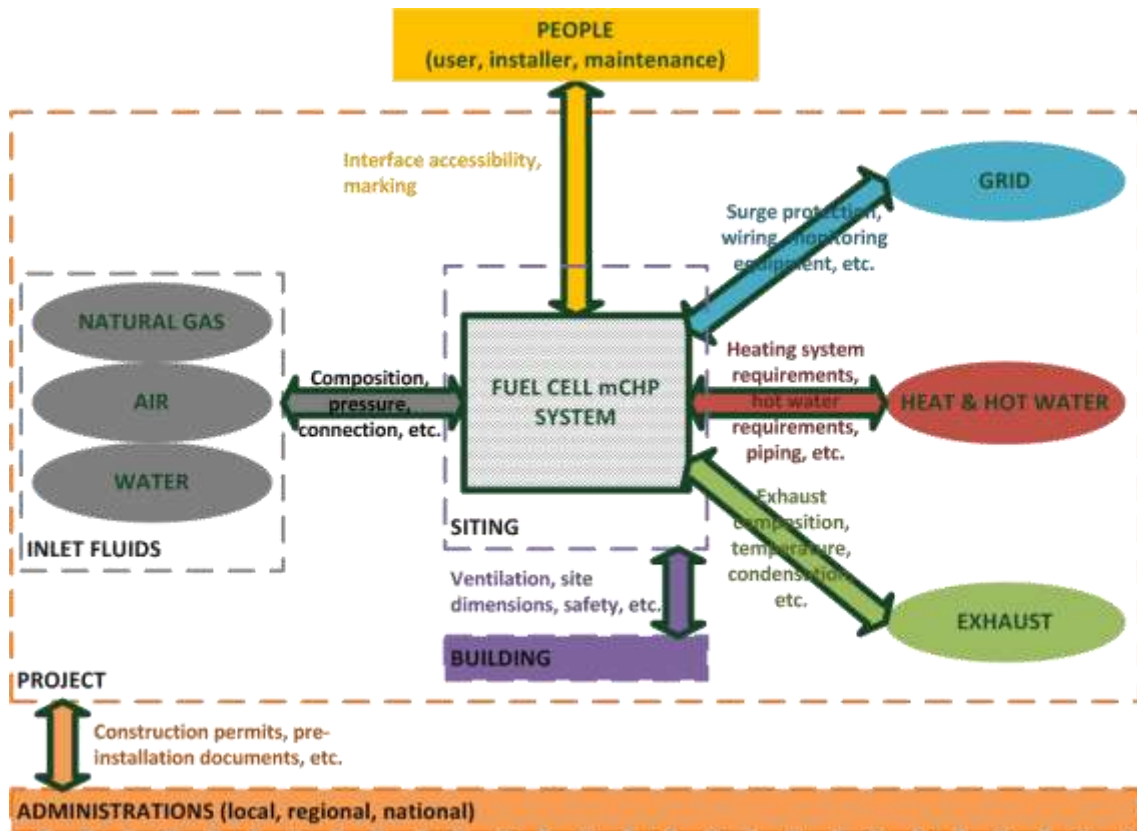


Figure 3. System boundaries analysis.

On the basis of the schematic diagram in Figure 3, 7 interfaces have been identified, representing 7 macro-topics that will be used to group together different RC&S related to FC-based microCHP system installation:

1. **Inlet fluids:** The system needs to be fed with different fluids to produce thermal and electrical energy. Both SOFC and PEMFC based systems need fuel (natural gas), oxygen (provided through air) and water for heat management and humidity control purposes. This interface's relationship with the system installation lies in the interconnection of the fluids with the distribution network and supply system requirements (backflow protection, ducts, valves, pressure control, etc.), the quality of fluid management and so on.
2. **Electrical system:** The real interface is the electrical grid, whose requirements, in terms of power quality and protection, could influence the installation of system. Regulations regarding the installation of electrical systems are also of key importance.
3. **Heat and hot water:** This interface represents the relationship between the FC-based microCHP systems and the heating and hot water systems in the house. Special requirements exist, such as temperature, insulation or heat storage, which are important for the

installation of the system. Another topic that should be considered is the hot water installation requirements.

4. **Exhaust:** The products from the electrochemical reactions in the fuel cell must be removed from the building through chimneys or other outlets. The room in which the FC-based microCHP systems is installed might require ventilation, thus venting and purging should be considered. All these issues are regularly present in RC&S documents pertaining to heating appliance installations and, thus, they are of key importance for system installation.
5. **Construction and siting:** The system is installed inside a building, where building codes apply. The related macro-topic has been called "Construction and Siting", since construction issues and siting requirements have to be considered.
6. **People:** The system should be installed by a specialized technician and used by trained users. Marking, user-safety and noise are topics related to this macro-topic.
7. **Administration:** The system installation needs to comply with national, regional and even local administration requirements, such as construction permits or technical documentation.

The RC&S matrix produced on the basis of this classification is available in Annex III. Its structure is more complex because each macro-topic includes a certain number of micro-topics. The aim of this matrix is to provide as comprehensive an overview as possible on the framework of RC&S.

This kind of categorization has not been used for the European Regulations related to FC-based microCHP systems (Annex III), which are instead classified as binding or non-binding acts.

### 1.3 Regulation Codes & Standards definitions

Before examining the RC&S framework in detail, it is necessary to define the existing legislative documentation. In this way, it will be possible to understand the level of importance and the influence of each document cited in this report.

- **Regulation:** a regulation has a general scope, it is binding in all its elements and it is directly applicable in each Member State. It gives rise to rights and obligations that are directly applicable to the citizens of the European Union.
- **Code:** this is generally a set of rules and guidelines which have the purpose of supplying sufficient information about a particular field application.
- **Standard:** this is very similar to a code. A standard is a document that provides rules or guidelines to achieve order in a given context. It is not binding, but it supplies the optimal way of reaching an objective.

In the legislative framework, it is also possible to encounter other kinds of issued acts, especially those issued by the European Commission:

- **Communication:** this is a policy act which has no mandatory power. A communication is published when the European Commission wishes to express its own ideas on a topical issue.
- **Decision:** a decision is binding for parties it is addressed to, who may be one, several, or even all the Member States or one or more natural or legal persons. It is characterized by a variety of contents, which may extend from a quasi-regulation or a quasi-directive to a specific administrative decision.

- **Directive:** a directive binds any Member State to which it is addressed, with regard to the result that has to be achieved, while allowing the national authorities the freedom to choose the form and methods to use.
- **Resolution:** this instrument enables European institutions to suggest guidelines for the coordination of national legislations or administrative practices in a non-binding manner. It is a form that suggests a political desire to act in a given area.

## 2 Previous projects

### Summary box of the chapter

Regulations, codes and standards are of great importance as far as the market entry of a new product is concerned. Fuel cells are starting to reach a level of maturity in which they can enter certain niche markets (for instance, the micro cogeneration market) and it is therefore no surprise that several international and European projects have already dealt with fuel cell RC&S status and development.

In this section, a selection of the most important projects that deal with either fuel cell RC&S or FC-based microCHP systems demonstrations are presented, and an effort has been made to relate their outcomes to the Ene.field objectives. The projects are grouped according to this criterion:

- European RC&S projects
- International RC&S projects (Annex II)
- FC-based microCHP systems demonstration projects (Annex II)

Hereinafter, a brief description and the aspects relevant for the Ene.field project for the most significant European projects are given. More detailed information about them, as well as the descriptions of other interesting projects, are reported in Annex II.

### 2.1 European Regulations Codes & Standards projects

#### 2.1.1 HarmonHy

Project	Coordinator	Date	Website
HarmonHy	AVERE (Belgium)	October 2006	<a href="http://harmonhy.com">harmonhy.com</a>

The HarmonHy project (Harmonization of Standards and Regulations for a Sustainable Hydrogen and Fuel Cell Technology) was a 15 month project that was conducted in 2005/2006 and funded by the 6<sup>th</sup> Framework Programme of the European Commission.

The self-defined objectives of the project were:

- To assess the worldwide activities on hydrogen and fuel cell related regulations and standards.
- To identify the needs for standards as perceived by industry (pre-normative aspects).
- To defining specific international collaborations.
- To identify gaps or conflicts and make propositions to solve fragmentation.

The overall results were not gathered in a final report, but presented at a final conference in October 2006 in which the partners presented the different outputs to specialists from all over the world.

### *2.1.1.1 Relevance for the Ene.field project*

In short, HarmonHy has allowed a better understanding to be obtained of the current RC&S situation for hydrogen and, to a lesser extent, for fuel cells. The most important lesson that has been learnt is that to achieve higher degrees of RC&S harmonization, better communication and cooperation schemes have to be implemented between the complex network of Regulatory Bodies (RBs) and Standard Development Organizations (SDOs), while paying particular attention to RC&S development. However, the amount of useful information for the Ene.field project is very limited, since the scope of HarmonHy was much wider and most effort was directed towards hydrogen for automotive systems.

## **2.1.2 HYPER**

<b>Project</b>	<b>Coordinator</b>	<b>Date</b>	<b>Website</b>
Hyper	The University of Manchester (UK)	February 2009	<a href="http://hyperproject.eu">hyperproject.eu</a>

The objective of HYPER project was to develop an Installation Permitting Guide (IPG) for stationary hydrogen and fuel cell applications. The project was conducted between November 2006 and February 2009, and it was funded by the European Commission under the Sixth Framework Programme.

The final document was presented as an e-guide (HYPER, 2009), with the objective of creating a compendium of the current knowledge of RC&S regarding the installation of small stationary hydrogen and fuel cell systems.

### *2.1.2.1 Relevance for the Ene.field project*

In short, HYPER has created a very complete permitting guide for stationary fuel cell system installation in Europe, from which great deal of information of interest can be found for the Ene.field consortium. For the specific RC&S task force, the HYPER guide has served as a good starting point to understand the current situation in Europe, and to decide which topics or issues for fuel cell stationary applications are of greatest interest.

### 2.1.3 HyIndoor

Project	Coordinator	Date	Website
HyIndoor	L'AIR LIQUIDE S.A. (France)	Still running	<a href="http://www.hyindoor.eu/">http://www.hyindoor.eu/</a>

The HyIndoor project consists of a pre-normative research on the safe indoor use of fuel cells and hydrogen systems. It is a 36 month project that started at the beginning of 2012, and which has been funded under the 7th Framework Programme.

The aim of the project is to provide scientific and engineering knowledge for the specification of cost-effective means to control the specific hazards related to the use of hydrogen indoors, or in confined spaces, and to develop state-of-the-art guidelines for European stakeholders.

#### 2.1.3.1 *Relevance for the Ene.field project*

From the Ene.field activitypoint of view, this project seems to be interesting since it is focused on the improvement of already existing, but incomplete, RC&S frameworks that deal with safety aspects concerning hydrogen and fuel cell system applications in closed environments. As the project is still running, the results will be considered in the second part of the T3.5 activity (M49-M51) of the Ene.field project.

### 2.1.4 HySafe

Project	Coordinator	Date	Website
HySafe	FZK - KIT (Germany)		<a href="http://www.hysafe.org">www.hysafe.org</a>

HySafe is another European Commission (EC) funded project under the 6th Framework Programme. Its objective was to facilitate the safe introduction of hydrogen technologies / applications through public awareness programmes, and the integration of fragmented research about hydrogen safety.

#### 2.1.4.1 *Relevance for the Ene.field project*

Hydrogen safety is probably not one of the main concerns in the Ene.field project, since all the systems that have to be installed run on natural gas, and hydrogen is contained inside the delivered product. However, this project presents an interesting example of the importance of knowing where the decisions regarding regulation and standardization should be taken in order to promote and influence the definition of correct regulations and standards.

### 2.1.5 HyER

HyER (<http://www.hyer.eu/>) is the European Association for Hydrogen, Fuel Cells and Electro-mobility in European Regions (formally HyRaMP), which was established in collaboration with the European Commission in 2008. With its 35-member network that represents regions and cities in Europe, HyER supports the deployment and commercialisation of hydrogen and fuel cell technologies as well as electro-mobility in Europe and the development of their associate infrastructure in Europe in order to contribute to a low-carbon economy and to a sustainable EU transport and energy system.

The aims of HyER can be summarized as follows:

1. To become the EU point of reference on electro-mobility, hydrogen and recharging infrastructure development;
2. To cooperate with key decision makers at a national and a local level in the EU and with industrial stakeholders to build an effective EU support framework;
3. To assist HyER members in effectively developing robust local deployment channels and first customer bases.

#### *2.1.5.1 Relevance for the Ene.field project*

In short, HyER is not exactly a project like the others in this report. However, this organization is closely correlated to the Ene.field project, because it is one of the active players. The HyER objectives are:

- To engage with local authorities and local distribution system operators in order to identify the role of fuel cells in clean local energy networks;
- To provide members with information on the socio-economic barriers to the widespread deployment of FC-based microCHP systems;
- To engage with EU stakeholders in order to increase the political acceptance of this technology.

During the first two years of life of the Ene.field project, HyER offered its services concerning these aspects:

- the development of the project website and contribution, on a monthly basis, of factsheets on technology developments in EU member states and regions.
- the expansion of the project to several local stakeholders and the organization of workshops in six European regions (DE, UK, IT, ES, LV, NO), in the autumn of 2013, in order to involve other local stakeholders in technology deployment.

### 2.1.6 International Regulations Codes & Standards projects

Also International projects have been considered and the most relevant for the Ene.field project are reported in Annex II, that is:

- Hydrogen and Fuel Cell Permitting Guide (USA);
- Finnish Handbook of the SOFC System in Buildings (Finland).

They were also used as a starting point for the analysis developed in the subsequent chapters.

### 2.1.7 FC-based microCHP systems: demonstration projects

Concerning this kind of projects, the following ones were considered and reported in Annex II:

- Callux (Germany);
- Ene-farm (Japan).

## 2.2 Conclusions

The previous projects section has led to a better understanding of the situation in RC&S concerning stationary fuel cell systems and, more specifically, FC-based microCHP system applications.

- The analysis of the projects in the field of the pre-normative research (PNR), such as HySafe or FCTESTQA, has been important to obtain an idea of what the important topics that are being developed or need to be developed are in order to better develop fuel cell related standards.
- RC&S projects like HarmonHy, and, especially, HYPER, the U.S Hydrogen and Fuel Cell Permitting Guide and the Finnish Handbook of SOFC System in Buildings can serve as starting points for this task development and as sources of valuable information. The HyIndoor project is also focused on the RC&S activity but, since it is still running, no valuable information for the development of Task 3.5 research is available.
- The FC-Eurogrid project does not deal with RC&S, but it is very helpful for the definition of a set of assessment criteria that could help to frame the FC-based technology among all the other existing technologies.

- Finally, the Callux and Ene-farm demonstration/incentive projects do not provide much information about RC&S, but their results and experiences could help Ene.field consortium to increase the effectiveness of their field demonstration tests.

### 3 Analysis of the International and European Regulations Codes & Standards for Fuel Cell-based microCombined Heat and Power systems status

#### Summary box of the chapter

Fuel cells and, specifically, their stationary applications (including FC-based microCHP) are being subject to an increasing standardization at an international and European level. These efforts have the aim of creating a common, normalized framework that would help them enter the market. The objective of this section is to identify the current international and the European standards, and European regulations related to FC-based microCHP systems and to analyze their adequacy, in terms of content and usability.

At a standard level, focus has been on the installation aspect of these devices while, at a regulation level, attention has been addressed to the consequences on market perspectives.

The analysis was conducted by means of two questionnaires proposed to the manufacturers involved in the Ene.field project: one refers to international and European standards and the other refers to European Regulations and Directives. Then, the results obtained were discussed.

#### 3.1 Main RC&S stakeholders

The typical stakeholders in RC&S activities are pre-normative research institutions, standard development organizations, regulatory bodies and, of course, manufacturers.

Pre-normative research is *the preliminary phase of experimental research aimed at better characterising the novel technologies and evaluating the related safety aspects by applying well established procedures and methodologies (whose development is part of the pre-normative activities)* (Conte, 2006). This important activity in RC&S development is usually carried out by research and technological centres, universities and companies.

SDOs are the ultimate and official players in proposing, development and updating of standards. They are usually structured as technical committees that are in charge of different technologies and/or services. Each committee is formed by a panel of experts from different countries (at a European or international level, these experts are usually members of equivalent national organizations) that discuss and, eventually, agree on the contents of a proposed standard. The development of standards, at the international level, related to FC-based microCHP systems, is mainly conducted by two organizations: ISO and IEC. Other institutions, such as the Institute of Electrical and Electronics Engineers (IEEE) also produce standards that might be closely related to the topic. At a European level, there are two associations that are equivalent to ISO and IEC that are, respectively, CEN and CENELEC.

Regulatory bodies are those public administrations and organizations that create regulatory frameworks regarding the design, manufacturing, installation or usage of any technology, product or service. In Europe, technical regulatory processes are normally conducted according to European Directives issued by the European Commission and approved by the European Parliament and the European Council. Directives are legally binding for all the States to whom they are addressed (usually all EU Member States) and have to be incorporated in their legal system (a certain freedom exists on how to incorporate them which depends on the specifics of the State legislation and the particular situation). Traditionally, regulations in Europe contained detailed technological requirements that sometimes clashed with the standards that were being developed in the SDOs. However, this changed after the so called "New Approach", which means that the regulation is now supposed to create a common European technological framework, but "referring to" European standards developed by the SDOs rather than defining it inside the regulation itself.

### **3.2 Regulations Codes & Standards for fuel cell-based microCombined Heat and Power systems**

As far as standards development is concerned, since fuel cells are electrochemical devices, this duty falls to CENELEC in Europe and IEC at an international level. Both organizations have formed specific technical committees on fuel cell technologies (CENELEC (CLC)/Standard Reference (SR) 105 for CENELEC and TC 105 for IEC) that develop standards for all the different technologies and applications.

Instead, the most relevant regulation for FC-based microCHP systems is related to the European Conformity (CE) marking. CE marking is a conformity marking that is adopted inside the European Union, and the countries belonging to the European Free Trade Association (EFTA), which states that a product has been assessed before being placed on the market and meets the EU safety, health and environmental protection requirements. These requirements are stated in a set of European Directives that deal with different aspects of product development and product characteristics.

Other Regulations and Directives exist which are focused on the European energy policy, and these deal with the most relevant aspects, such as the development and promotion of new renewable energy sources, the achievement of higher energy efficiency targets and the improvement of efficient energy conversion technologies, such as FC-based microCHP systems.

In the Annex III is reported an overview of the existing legislation on which the questionnaires proposed are based.

### 3.3 Methodology of analysis

The analysis of the international and European RC&S status has been conducted by analyzing the responses of two different questionnaires that were sent to the Ene.field consortium system manufacturers.

	Reference standard(s)	Question A (choose one)			Question B (choose one)			Comments
		Improve it	Confirm it	Remove it	Very good	Good enough	Bad	
Topic 1	Reference standard 1		X		X			
Topic 2	Reference standard 1						X	
	Reference standard 2			X				
Topic 15	Reference standard 1	X					X	

Figure 4. General layout for questionnaires proposed to the manufacturers of the Ene.field consortium.

Hereinafter, the two questionnaires are described separately.

#### 3.3.1 Questionnaire referred to the Codes & Standards

**Summary box of the questionnaire**

The questionnaire referred to the European and international standards is presented.

The analysis of the feedbacks from the manufacturers has emphasized a generalized situation of non-homogeneity across Europe. This leads to the need to create an open European market characterized by univocal and clear standards in order to help to eliminate national barriers towards the diffusion of the FC-based microCHP technology.

##### 3.3.1.1 Questionnaire structure

The questionnaire consists of two multiple-choice questions that must be answered for a selection of 15 topics that represent 15 typical issues that need to be considered in the installation process of a FC-based microCHP system. These questions evaluate the content quality and usability of the reference standard(s) associated with each specific topic.

Topics were selected using the existent standards, HYPER project (HYPER, 2009) and the U.S. Hydrogen and Fuel Cell Permitting Guide (Pacific Northwest National Laboratory, 2004) as references and also considering the feedback received from some of the ene.field consortium manufacturers.

Extended informations about the structure of this questionnaire are reported in Annex IV.

### 3.3.1.2 *Outcomes from the standard questionnaire*

- Several standards have been suggested for the proposed topics. Among them, EN 50465 and the 62282 series have proven to be fundamental, since they have been cited for most of the topics.
- However, the presence of so many standards is not an entirely positive aspect. In fact, some of them are at a national level (e.g., VDE AR N 4105, KTW tests and WRAS approval) and this leads to the problem of a lack of harmonization between European Countries. Sometimes, the reference standard is European, but it is supplemented by national standards for each country (as in the case of EN 50438). Furthermore, there are consistency problems between different standards dealing with similar topics: this aspect especially affects EN 50465 and the IEC EN 62282 series. All of these issues lead to the conclusion that there is still a need for the creation of common European standards and harmonization.
- Another important issue is that standards from the IEC EN 62282 series refer to Fuel Cell Power Systems and not specifically to FC-based microCHP systems. Thus, using it for FC-based microCHP units would create a consistency problem, since the definition of certain parameter limits are different for these two applications (e.g., CO emission limits). Thus, it would be interesting to consider this situation in the future updates of the standards.
- Finally, the development of a unique protocol for smart energy metering throughout EU countries has been encouraged, since up to now there are no reference standards regarding this topic.

### 3.3.2 **Questionnaire referred to the European Union Regulations**

#### **Summary box of the questionnaire**

The questionnaire referred to the European Regulations is presented.

From the opinions of the manufacturers collected, the most controversial issue that emerged refers to the energy labelling of space heaters appliances. In particular, the crucial point raised by the questionnaire is that the methodologies used for the calculation of the seasonal space heating energy efficiency penalize FC-based microCHP devices and, more generally, all the microCHP devices. An analysis has been conducted taking into account three methods currently existing.

On the other hand, the targets that have been fixed in order to fulfil ecodesign requirements for the production of these energy devices have been considered satisfactory. Therefore, the only problem seems to be the way of calculating the parameters related to their performances (that is, the seasonal space heating energy efficiency).

### 3.3.2.1 Questionnaire structure

The questionnaire shows the same features as the one referred to the Codes & Standards. The subject of this questionnaire is the EU Regulations that deal with FC-based microCHP systems and how they affect the dissemination of this technology. One or two multiple choice questions are made for each topic that has been extracted from these Regulations, and three possible answers are listed.

Again in this case, additional informations about the structure of the questionnaire are reported in Annex IV.

### 3.3.2.2 Outcomes from the European Union Regulations questionnaire

The main outcome that appears from the questionnaire is the **labeling issue**. This is a fundamental feature in the diffusion and success of the FC-based microCHP technology across the European market.

According to the manufacturers' comments, the current methodologies used for the evaluation of the *seasonal space heating energy efficiency* ( $\eta_s$ ) penalize FC-based microCHP devices and, more generally, all the microCHP devices. These methodologies are two and they are both mentioned in the European Regulation no. 811/2013 that deals with the 'Energy Labelling' of devices for the space heating. However, only one of them is fully described in this document while the other one is examined in depth in a Communication from the Commission that implements the previous cited European Regulation.

Then, a detailed analysis has been conducted on these methodologies with the aim to evaluate their effectiveness on the microCHP devices. These methods has been also compared to another one contained in the most recent version of the EN 50465 standard.

Summarizing, the analysis consists on the comparison among three methods for the calculation of  $\eta_s$  on a system composed by a microCHP device and a boiler as a supplementary heater. The three methods are fully described in the following three documents:

- the "Commission communication in the framework of the implementation of Commission Regulation (EU) No 813/2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters, and of the implementation of Commission Delegated Regulation (EU) No 811/2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device" that has been released on the 3<sup>rd</sup> of July, 2014;

- the “Commission delegated Regulation no. 811/2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labeling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device” that has been released on the 18<sup>th</sup> of February, 2013;
- the 2014 version of the EN 50465 standard “Gas appliances – Combined heat and power appliance of nominal heat input inferior or equal to 70 kW”.

**Labelling – Communication from the Commission**

This method is introduced in the European Regulation no. 811/2013, but its structure is fully described in the Communication from the Commission mentioned above. Then, in order to distinguish it from the other method contained in the same European Regulation, from now on it will be identified as the method of the Communication.

The formula for the calculation of  $\eta_s$  is the following:

$$\eta_s = \eta_{son} - \sum F(i) \tag{1}$$

Term	Description
$\eta_s$	Seasonal space heating energy efficiency
$\eta_{son}$	Seasonal space heating energy efficiency in active mode
$F(1)$	Negative correction due to adjusted contributions of temperature controls
$F(2)$	Negative correction due to auxiliary electricity consumption
$F(3)$	Negative correction due to standby heat loss
$F(4)$	Negative correction due to ignition burner power consumption
$F(5)$	Positive correction due to the electrical efficiency

Table 1. Description of the terms involved in the formula referred to the cogeneration space heaters.

Focusing on the equation above, it is possible to note that it is composed by two terms.

The first term ( $\eta_{son}$ ) is calculated by balancing the efficiency of the cogenerative device alone and that of the entire system by means of fixed coefficients that account for the contribution to the annual heat demand of each configuration (see equation below).

$$\eta_{son} = 0.85 \cdot \eta_{CHP100+SUP0} + 0.15 \cdot \eta_{CHP100+SUP100} \tag{2}$$

In this equation  $\eta_{CHP100+SUP0}$  and  $\eta_{CHP100+SUP100}$  refer **only** to the **thermal efficiency** of the FC-based microCHP device respectively without and with the supplementary heater enabled.

Concerning the second term ( $\sum F(i)$ ), it is a sum of five correction terms that account for losses and the additional production of electricity performed by the FC-based microCHP device. Each term is defined by means of some specific parameters that characterize each FC-based microCHP device, according to the choices of the manufacturers that produced it (Table 2).

Term	Description
Elmax	Average electric auxiliary energy consumed in the <b>100% CHP + 100% SUP</b> case
Elmin	Average electric auxiliary energy consumed in the <b>100% CHP + 0% SUP</b> case
$P_{SB}$	Average electric auxiliary energy consumed by the FC-based microCHP device in standby mode
$P_{stby}$	Standby heat loss referred to the entire system 'FC-based microCHP device + supplementary heater'
$P_{ign}$	Permanent ignition burner heat input

Table 2. List of the parameters used to define the correction terms in the Communication from the Commission.

Some of the  $F(i)$  terms deserve some additional considerations:

- The choice of fixed parameters, contained in the formula of  $\eta_{son}$ , is also adopted inside the formula for the calculation of  $F(2)$
- This methodology is structured in such a way that the electricity production is considered as an additional output of the FC-based microCHP device. Then, the electrical contribution to the overall efficiency is treated as a positive correction of it ( $F(5)$  term).

### Labelling – European Regulation no. 811/2013

Two aspects differentiate this method to the one described in the Communication from the Commission:

- First of all, the method described in the European Regulation is intended for systems (CHP + supplementary heater) that are combined into a package by the installer, while the other method refers to systems that are offered as one set by the manufacturers.
- The second difference is the weighting methods adopted for the calculation of  $\eta_s$ . In fact, while the method of the Communication uses fixed coefficients (see equation 2), the method of the European Regulation introduces variable weighting factors ( $F_{CHP}$ ) that are correlated to the ratio between the thermal output of the supplementary heater and the thermal output of the overall system.

This method is applicable to packages of space heater, temperature control and solar device. In this analysis, the package considered is composed by a cogeneration heater, a supplementary heater and a temperature control device.

The calculation of the  $\eta_s$  of the system consists in the sum of a certain number of contributions, each corresponding to one of the components of the package under investigation. In particular, the terms that contribute to the achievement of  $\eta_s$ , as far as this analysis is concerned, are the followings:

- The seasonal space heating energy efficiency of the cogeneration space heater (calculated using the equation 1 applied to a microCHP device without supplementary heater);
- A positive contribution due to the presence of a temperature control device (for this analysis it has been fixed equal to 3%);
- A negative contribution, due to the presence of a supplementary heater, weighted by the  $F_{CHP}$  factor.

The last consideration that has to be done is that the formulas for the calculation of the  $F(i)$  terms are always contained in the Communication from the Commission, but are different from those of the previous method because, in this case, they are used to calculate the seasonal space heating energy efficiency of the microCHP device only (first term of the list above).

**Labelling – EN 50465 standard**

The general formula for the definition of  $\eta_s$  is the same adopted by the other two methods (see Equation 1). The main differences are: the formula for the calculation of  $\eta_{son}$  and the lack of the  $F(5)$  term.

Referring to  $\eta_{son}$ , the EN 50465 standard uses a coefficient ( $F_{CHP}$ , the same used in the method of the European Regulation) that varies depending on the ratio between the output of the FC-based microCHP device and that of the entire system:

$$\eta_{son} = F_{CHP} \cdot \eta_{eq,CHP} + (1 - F_{CHP}) \cdot \eta_{eq,CHP+SUP} \tag{3}$$

The two efficiency terms,  $\eta_{eq,CHP}$  and  $\eta_{eq,CHP+SUP}$ , are obtained by formulas that consider **not only** the thermal efficiency but also the electrical efficiency. In particular, the first term refers only to the cogenerative device while the second one to the entire system.

As mentioned before, the contribution of the electrical efficiency is contained in the calculation of  $\eta_{son}$  and, in particular, of  $\eta_{eq,CHP}$  and  $\eta_{eq,CHP+SUP}$ . This different approach is due to the fact that, in this standard, the possibility to produce electricity is seen as a saving of primary energy consumed. For this reason, the  $F(5)$  term is not present in the formula for the calculation of  $\eta_s$ .

In general, the  $F(i)$  terms are defined by the specific parameters listed in Table 3.

Term	Description
$P_{auxmax}$	Average electric auxiliary energy consumed in the <b>100% CHP + 100% SUP</b> case
$P_{auxmin}$	Average electric auxiliary energy consumed in the <b>100% CHP + 0% SUP</b> case
$P_{SB}$	Average electric auxiliary energy consumed by the FC-based microCHP device in standby mode
$P_{stby}$	Standby heat loss referred to the entire system 'FC-based microCHP device + supplementary heater'
$Q_{pilot}$	Permanent ignition burner heat input
$P_{min}$	Minimum sustained controlled heat output of the FC-based microCHP device

Table 3. List of the parameters used to define the correction terms in the EN 50465 standard.

As it is possible to note, despite some expressions are different from those defined in the Communication from the Commission, they refer to the same quantities.

As a conclusion, it is important to signal some additional considerations about the  $F(i)$  terms:

- As for the Communication from the Commission, the same coefficients used in the formula of  $\eta_{son}$  are also used in that of the  $F(2)$  term
- Aside from the consideration above, referring to the  $F(2)$ ,  $F(3)$  and  $F(4)$  terms, their definition is identical to that of the Communication from the Commission except for a weighting factor 'b' that considerably contributes to the reduction of their negative impact.

### Labelling – Final results

The analysis has been conducted on the system chosen at different configurations of thermal and electrical efficiency, while some parameters have been fixed for all the devices considered in order to make the comparison more effective (see Table 4). The values of efficiency considered are based on the Net Calorific Value (NCV) of the fuel consumed.

Parameter	Fixed value
Electrical output of the FC-based microCHP device ( $P_{el,CHP100+SUP 0}$ )	1 kW
Thermal output of the supplementary heater ( $P_{th,SUP}$ )	10 kW
FC-based microCHP device, total efficiency ( $\eta_{tot,CHP}$ )	90%
Supplementary heater, thermal efficiency ( $\eta_{th,SUP}$ )	95%

Table 4. Fixed values for some parameters common to all the devices compared.

Referring to the parameters for the definition of the  $F(i)$  terms, real values have been used, supplied by a real company well inserted in the FC market, that are referred to a device of 1 kW electrical size.

	Communication from the Commission					European Regulation no. 811/2013					EN 50465				
$\eta_{eL,CHP}$ (%)	20	30	40	50	60	20	30	40	50	60	20	30	40	50	60
$\eta_{th,CHP}$ (%)	70	60	50	40	30	70	60	50	40	30	70	60	50	40	30
$\eta_s$ (%)	107.0	117.2	127.6	138.2	148.9	98.0	98.1	98.2	98.0	98.2	120.2	162.1	212.0	223.8	213.4
$PES_{CHP100+SUP0}$	0.191	0.276	0.345	0.402	0.449	0.191	0.276	0.345	0.402	0.449	0.191	0.276	0.345	0.402	0.449
$PES_{CHP100+SUP100}$	0.071	0.084	0.092	0.097	0.100	0.071	0.084	0.092	0.097	0.100	0.071	0.084	0.092	0.097	0.100
Labelling class	A+	A+	A++	A++	A++	A+	A+	A+	A+	A+	A+	A+++	A+++	A+++	A+++

Table 5. Results obtained by means of the two methods analyzed for different configuration of electrical and thermal efficiency.

The cases considered for this analysis, and reported in Table 5, span from the Internal Combustion Engine (ICE), where the thermal efficiency is predominant, to the SOFC, characterized instead by an high electrical efficiency.

Figure 5 reports the results listed in Table 4 highlighting the difference between the three methods. It is evident from the graph that in the formula used by the Communication from the Commission  $\eta_s$  is linearly correlated to the electrical efficiency. Referring to the EN 50465 standard, the relation between these two parameters is more complicated and depends on the whole configuration of the microCHP device. In fact, using this method, the maximum is not reached at the highest electrical efficiency, but when also the thermal efficiency is significant (the total efficiency is always fixed). Focusing then on the method of the European Regulation, it gives the worst results and, furthermore, it seems that it is not affected by the different configurations considered since the curve is almost horizontal.

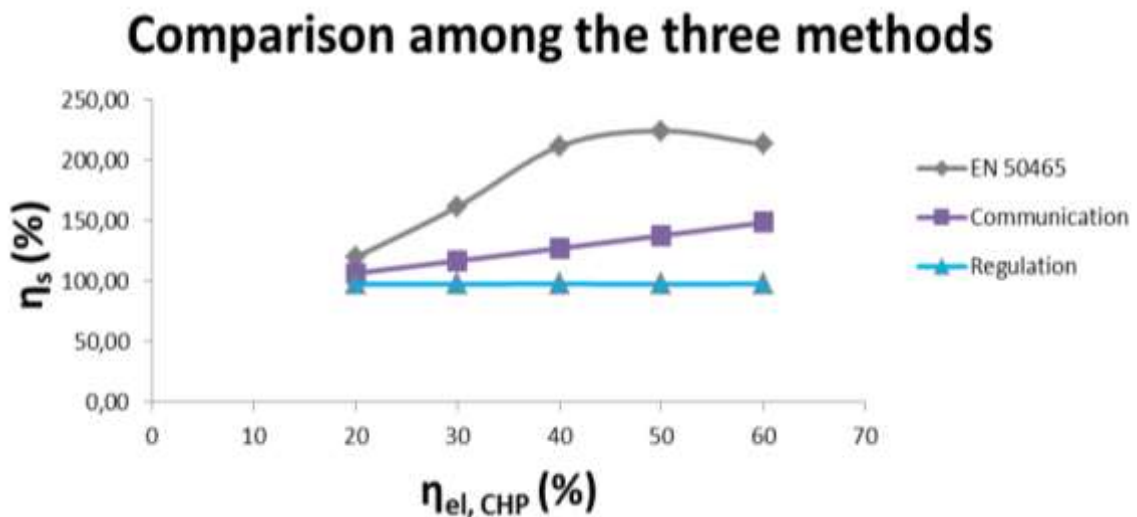


Figure 5. Comparison among the results obtained by the three methods analyzed with respect to the electrical efficiency of the FC-based microCHP device.

In order to make the analysis more complete, also the **Primary Energy Saving (PES)** of the entire system, for each case considered, has been calculated.

The PES has been obtained comparing the output of the system object of the analysis to the separate production of heat performed by a generic boiler and of electricity performed by the grid. Since it depends only by the electrical and thermal efficiency of the entire system, the values obtained are the same for all the methods considered (see Table 5).

For this analysis, two configurations have been chosen for the calculation of the PES:

- CHP100+SUP0 (equation 4), in which the supplementary heater is disabled; this can be considered the best case.
- CHP100+SUP100 (equation 5), in which the supplementary heater works at 100%; this can be considered the worst case.

$$PES = 1 - \frac{1}{\frac{\eta_{th,CHP100+SUP0}}{\eta_{Boiler}} + \frac{\eta_{el,CHP100+SUP0}}{\eta_{Grid}}} \quad (4)$$

$$PES = 1 - \frac{1}{\frac{\eta_{th,CHP100+SUP100}}{\eta_{Boiler}} + \frac{\eta_{el,CHP100+SUP100}}{\eta_{Grid}}} \quad (5)$$

A crossed comparison of PES and  $\eta_s$  values has also been conducted and the results obtained are shown in the following Figures.

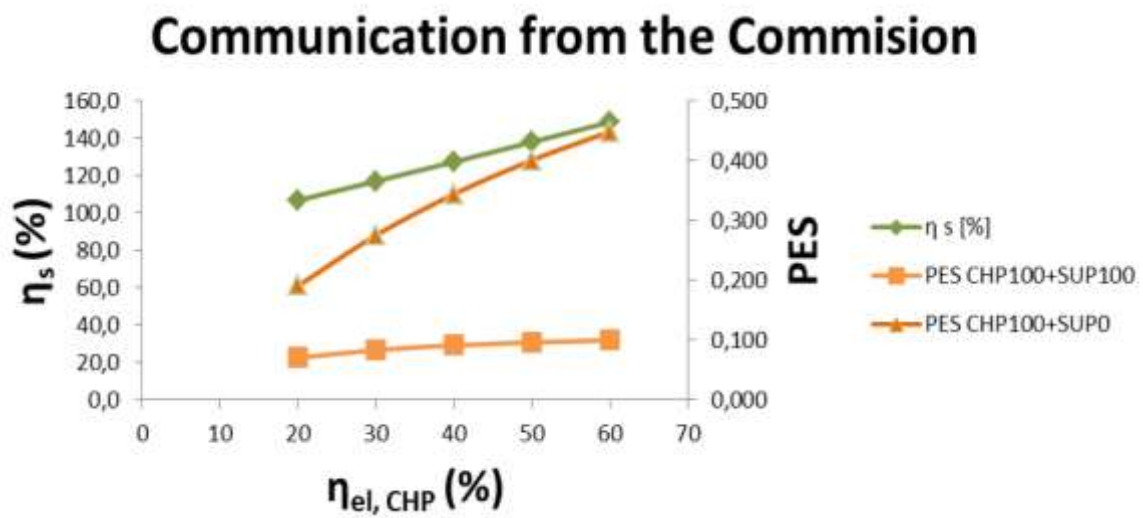


Figure 6. Comparison between the PES and  $\eta_s$  values related to the Communication from the Commission method.

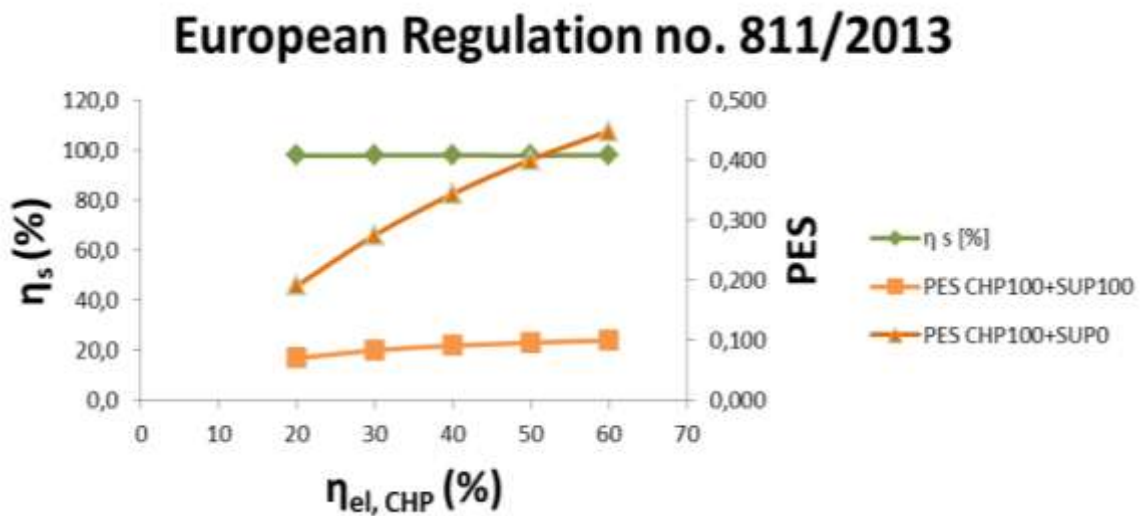


Figure 7. Comparison between the PES and  $\eta_s$  values related to the European Regulation method.

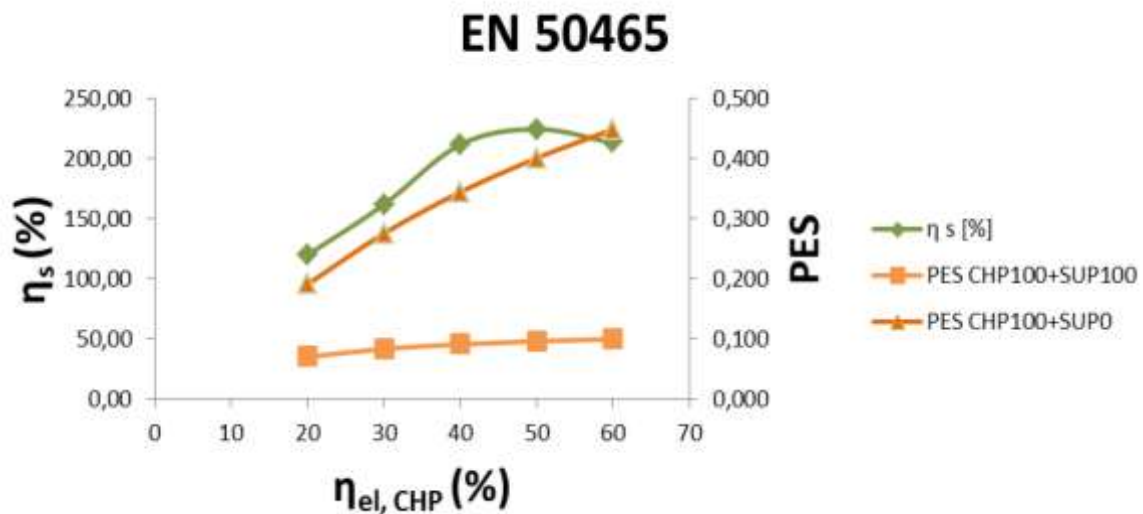


Figure 8. Comparison between the PES and  $\eta_s$  values related to the EN 50465 method.

Focusing on the PES curves, the first aspect that stands out is that the slopes of those that represent PES values calculated in the case CHP100+SUP0 are higher than those of the other configuration. This is due to the presence of the supplementary heater that has a negative effect to the efficiencies of the entire system.

Referring, instead, on the CHP100+SUP100 configuration, some other considerations can be made.

In the Figure 6, the behavior of the two curves is almost parallel, then, to an increase of the overall efficiency corresponds an increase of the primary energy saved. In the Figure 7, instead, the overall efficiency is almost constant for all the configurations considered in this analysis, and the PES values increase is due only to the increase of the electrical efficiency.

More interesting, instead, is what Figure 8 shows. In fact, it is possible to note that the curves representing PES values continue to increase despite, for a certain value of the electrical efficiency,  $\eta_s$  starts to decrease. This is, in a certain way, correct because, from the point of view of the calculation of the PES, the effect of the increase of the electrical efficiency of the entire system is more significant with respect to the decrease of the thermal efficiency. What one expects is that to an increase of the PES corresponds automatically an increase of the overall efficiency. This is true in theory, but it is important to take into account that the purpose of this method is to label devices intended mainly for the space heating. Then it is almost obvious that a device with lower thermal efficiencies has to be penalized. However, the overall increase of the PES, in the range of electrical efficiency considered, is of the order of some hundredth, then almost negligible.

### Labelling - Conclusion

The analysis of the three methods brings to some conclusions that can be summarized in the three following points:

- The method described by the EN 50465 standard seems to reflect more the real use of the microCHP device due to the adoption of variable coefficients. In fact, this solution allows to tune the formulas to the different situations without losing their effectiveness.  
The impossibility to find a linear correlation between the electrical efficiency and the  $\eta_s$  is due to the fact that this method takes into account the purpose of this devices, that is the space heating. From this point of view, a device with a lower thermal efficiency, despite the high production of electricity, will obtain a value of its  $\eta_s$  far from the maximum value achievable.
- On the contrary, the method described in the Communication from the Commission appears very 'simplified'. Fixed parameters are used supposing that whatever the thermal efficiency of the device is, the percentage of use of the supplementary heater remains constant.  
In addition, looking at the Figure 5, all the calculation seems to be reduced at a linear correlation between the final  $\eta_s$  and the electrical efficiency of the cogenerative device. Despite this, the slope of the curve representing this method, for the same range of electrical efficiency, is lower than that of the EN 50465 standard (Figure 5). Then, it is impossible to reach the class A+++ for cogenerative devices.
- In conclusion, the method of the European Regulation employs, in the seasonal heat efficiency methodology, variable coefficients as the EN 50465 standard. Despite this similarity, the European Regulation yields the poorest results in terms of the seasonal space heating energy efficiency values, and thus the label assigned to each technology or package of technologies that include microCHPs.  
In addition, applying the method in the European Regulation results in a virtually flat line in Figure 5, showing that this methodology does not vary with the different efficiency configurations considered. For example, when it is applied to microCHP systems which have different electrical efficiencies (i.e. ICE vs. SOFC based microCHP), there will be no difference in the seasonal space heating energy efficiency, resulting in the same label being assigned to the two units.

### Other results

Although the labelling scheme towards FC-based microCHP technology has considered inadequate, this was not the case of Regulations referring to ecodesign specifications. In fact, it seems that the real problem concerns the method that is used to calculate the efficiency of this kind of technology. Targets fixed in order to fulfil ecodesign requirements, according to Directive 2009/125/EC, are considered acceptable. However, besides all the ecodesign requirements that have already been set, aspects related to the disposal and recycling of SOFC Systems should also be taken into account.

The analysis of the questionnaire on Regulations was concluded with a question on Directives related CE marking aspects, but feedback obtained was less. In other words, the Low Voltage Directive (LVD), the Gas Appliances Directive (GAD) and the Electromagnetic Compatibility Directive (EMC) are the ones that are considered most frequently by manufacturers, who have defined them good enough.

Finally, the Machinery Directive only applies for industrial FC-based microCHP systems, and is not yet applicable for household application.

## 4 Analysis of the Regulations Codes & Standards status related to fuel cell microCombined Heat and Power installation in Countries involved in the Ene.field project

### Summary box of the chapter

An analysis of the national legislation of the Countries involved in the Ene.field project has proved to be necessary due to.

In particular, the purpose of this section is to address the requirements that anyone willing to **install** a FC-based microCHP system would have to satisfy, due to the regulations and standards in most of the countries that the Ene.field consortium is considering for the field tests.

What comes out from this survey is that a heterogeneity of standards is present and that scenario represents a barrier for the manufacturers who want to diffuse their products throughout the Europe.

### 4.1 Installation requirements

The installation requirements for a FC-based microCHP systems are no different from those of any other CHP system that has to be installed in a building. In most of the countries the requirements are actually more general, as they address the installation of any sort of heating system or electrical energy distributed generation.

The objective of the section is to create a sort of consulting document in which anyone intending to install a FC-based microCHP unit, in a given country, could check the installation requirements of the corresponding country.

In the document, each country section is subdivided into five parts, which deal with the five typical areas that installation requirements consider:

- **Interconnection with natural gas and water networks**
- **Interconnection with the electrical grid**
- **Exhaust and environment**
- **Building and safety**
- **Heating and hot water systems**

A list of the different requirements regulated in a country, and where to find information about it, are given in each section. The amount of information and how it is structured for each country might vary, depending on the way each country regulates/normalizes the topics, and also according to the quality of information available. This implies that the country sections are not necessarily all subdivided into the five aforementioned areas.

#### 4.1.1 Why a national level?

As was explained in 1.1.1.1, special focus has been placed on installation requirements, on the basis of a suggestion made by the Ene.field FC-based microCHP systems manufacturers. However, international or European levels are not the best sources of installation requirements from regulations or standards, since this is an issue that is usually addressed by national (or even regional) standard organizations and regulatory bodies.

This led the RC&S task force to conduct a country-by-country analysis. The Countries considered are the following:

- Austria
- Belgium
- Denmark
- France
- Germany
- Ireland
- Italy
- The Netherlands
- Slovenia
- Spain
- The United Kingdom

The documentation found and grouped using the outline given in 4.1.1 for each country is reported in the Annex V.

## 4.2 Conclusions

The analysis conducted in this section has highlighted some important elements that could be useful for the final purpose of this paper.

- First, during the survey, it emerged that there is an important presence of accepted international and European standards. They represent a significant segment of the standardization body of each country that has been investigated. According to the results of the standard questionnaire, the most accepted are the IEC 62282 series and EN 50465. However, EN 50438, it is not fully accepted, because each country has its own version.
- Focusing on a national level, the first element that appears is the heterogeneity of the standards, in terms of their range of applicability, such as the allowed pressure range for gas

pipeline installations or the electrical and thermal size of domestic appliances. This leads to a significant problem for manufacturers because they have to tune their products according to the different requirements of each country. This can be one of the main barriers to the diffusion of FC-based microCHP technology throughout Europe.

In light of what has emerged from this standard analysis, it appears clear that a harmonisation at a European level is necessary in order to create a framework of homogenized standards that could be accepted by each country.

## 5 Conclusions from the Position Paper

This work has been conducted in order to obtain a general overview of the RC&S framework throughout Europe, related to FC-based microCHP technology. The main aim was to identify the most relevant problems and barriers, and to try to analyse any possible suggestions that could help reduce these RC&S-related problems, with the final aim of increasing the diffusion of the FC-based microCHP technology.

The first part of this position paper is a sort of introduction, where **Chapter 1** describes the project in which this work is inserted, and supplies a general basis of the work, while **Chapter 2** offers a general view of the most important projects that deal with either RC&S or FC-based microCHP demonstration activities in the FC sector. The aim of Chapter 2 is to identify any possible outcomes from these projects, some of which have already been completed, which could be related to the Ene.field objectives.

The second part represents the core of the position paper. The current status of European Regulations and international and European standards is evaluated in **Chapter 3**. The analysis is conducted focusing on the installation aspect, which has been considered the most relevant by the manufacturers involved in the Ene.field project.

Since interaction with partners is important in order to obtain an exhaustive work, two questionnaires about Standards and Regulations are described at the end of Chapter 3. The collected outcomes have highlighted two main results:

- With reference to the Codes and Standards, it has been found that the creation of a more homogeneous legislative body to help eliminate national barriers is necessary.
- concerning EU Regulations, it has been found that more clarity towards the promotion strategy of energy-related technologies operated by the European Commission is necessary.

On the basis of the results about standard status dealt with in Chapter 3, a more detailed country-by-country analysis has been conducted at a national level in Chapter 4 in order to define a standard framework. What has emerged is a mosaic in which each country creates standards with its own requirements and ranges of applicability. This is surely a very significant problem because it obliges any manufacturer who wants to sell its product in Europe to tune it according to the country market in which he wants to enter.

Finally, **Chapter 5** represents the position of this paper, in which the results of the previous Chapters are summarized and the opinion of the Task 3.5 group is expressed.

In general, the message that has emerged from this work is that, at the moment, some barriers block the FC-based microCHP technology (non-homogeneity of C&S European framework and some legislative indications from Regulation Authorities): some effort still has to be made in order to improve its diffusion.

## Tables

Table 1. Description of the terms involved in the formula referred to the cogeneration space heaters.....	25
Table 2. List of the parameters used to define the correction terms in the Communication from the Commission.....	26
Table 3. List of the parameters used to define the correction terms in the EN 50465 standard.....	28
Table 4. Fixed values for some parameters common to all the devices compared... ..	28
Table 5. Results obtained by means of the two methods analyzed for different configuration of electrical and thermal efficiency.....	29
Table 6. Priority valuation of industrial needs issues (Bellerate&Brusaglino, 2006).....	47
Table 7. Template of RC&S matrix in US-DOE Permitting Guide. ....	56
Table 8. US DOE Permitting Guide RC&S list (updated).....	58
Table 9. RC&S that affect the installation of fuel cell systems in Finland (Klobut, et al., 2009).....	59
Table 10. Binding acts. ....	70
Table 11. Non-binding acts. ....	71
Table 12. Additional binding acts.....	73
Table 13. Additional non-binding acts. ....	73
Table 14. List of the RC&S related to the macro-topic "Inlet Fluids".....	75
Table 15. List of the RC&S related to the macro-topic "Electrical system" ..	77
Table 16. List of the RC&S related to the macro-topic "Heat and hot water".....	79
Table 17. List of the RC&S related to the macro-topic "Construction and siting" .....	81
Table 18. List of the RC&S related to the macro-topic "Exhaust".....	83
Table 19. List of the RC&S related to the macro-topic "Administration" .....	83
Table 20. List of the RC&S related to the macro-topic "People". .....	84
Table 21. International and European RC&S status: topic explanation.....	85
Table 22. Name of the reference standards used for the questionnaire .....	86
Table 23. Question A about standard(s) quality. ....	90
Table 24. Question B referring to the manufacturers experience with the standards considered in the questionnaire.....	90
Table 25. Question A1 about products information.....	98
Table 26. Question A2 about the creation of a labelling scale. ....	98
Table 27. Question B1 about ecodesign requirements. ....	99
Table 28. Question B2 about targets for ecodesign requirements.. ..	99
Table 29. Question C about CE marking Directives.....	99

## Figures

Figure 1. Schematic representation of a SOFC-based microCHP system with Internal steam-Reforming (IR) (FC-DISTRICT project, WP10). .....	9
Figure 2. Schematic representation of a PEMFC-based microCHP system (Gandiglio et al., 2014). .....	10
Figure 3. System boundaries analysis. ....	11
Figure 4. General layout for questionnaires proposed to the manufacturers of the Ene.field consortium .....	22
Figure 5. Comparison between the results obtained by the two methods analyzed with respect to the electrical efficiency of the FC-based microCHP device. ....	30
Figure 6. Comparison between the PES and $\eta_s$ values related to the Communication from the Commission method. ....	31
Figure 7. Comparison between the PES and $\eta_s$ values related to the European Regulation method. ....	31
Figure 8. Comparison between the PES and $\eta_s$ values related to the EN 50465 method. ....	32
Figure 9. HarmonHy RC&S harmonization recommendations. Source: (Vergels, 2006). ....	45
Figure 10. HarmonHy PNR status results for fuel cell categories (Conte, 2006).. ....	46
Figure 11. Scheme in which is shown the organization of the different WPs. ....	50
Figure 12. HySafe project WP and activities. ....	51
Figure 13. International committees addressing hydrogen-related technologies standardization. ....	52
Figure 14. Structure of the set of indicators used (Steinberger-Wilkens, 2012) .....	55
Figure 15. Callux project enquiry: Customer satisfaction (Callux project, 2012).. ....	63
Figure 16. Ene-farm cumulative sales until the end of 2011(Fuel Cell Commercialization Conference of Japan, 2012). ....	65
Figura 17. Layout for extended versions of questions and answers. ....	88
Figure 18. Layout for the Codes & Standards questionnaire.....	89
Figure 19. Layout for extended versions of questions and answers.. ....	96
Figure 20. Layout for the EU Regulations questionnaire. ....	97

## Annex I

### Glossary

ATEX	ATMosphère EXplosibles
BS	British Standard
CC	Conversion Coefficient
CE	European Conformity
CEI	Comitato Elettrotecnico Italiano
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat and Power
CLC	CENELEC
CNR	Co-Normative Research
CTE	Código Técnico de la Edificación
DB	Documento Básico
DHW	Domestic Hot Water
DIN	Deutsches Institut für Normung
D. Lgs.	Decreto Legislativo
DoE	Department of Energy
D.P.R.	Decreto del Presidente della Repubblica
DS	Danish Standard
DVGW	Deutsche Vereinigung des Gas- und Wasserfaches
EC	European Commission
EFTA	European Free Trade Association
EMC	Electromagnetic Compatibility
EN	European Standard

ENA	Energy Network Association
ErP	Energy-related Products
ESBN	Electricity Supply Board Networks
EU	European Union
FC	Fuel Cell
FCHA	Fuel Cell Heating Appliance
FCH-JU	Fuel Cell and Hydrogen Joint Undertaking
FID	Feed-in-Tariff
GAD	Gas Appliances Directive
GS	Gas Safety
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPG	Installation Permitting Guide
IPHE	International Partnership for Hydrogen Economy
IR	Internal Reforming
IS	Irish Standard
ISO	International Organization for Standardization
ITC	Instrucciones Técnicas Complementarias
KTW	Kunststoffe und Trankwasser
LVD	Low Voltage Directive
MCFC	Molten Carbonate Fuel Cell
MCS	Microgeneration Certification Scheme
MEA	Membrane Electrode Assembly
MID	Measuring Instruments Directive
MIS	Microgeneration Installation Standard
NBN	Bureau de Normalisation
NEN	NEderlandse Norm

NF	Norme française
NG	Natural Gas
NTA	Nederlands Technische Afspraak
ÖNORM	Österreichisches Normungsinstitut
ÖVGW	Österreichische Vereinigung für das Gas- und Wasserfach
PAFC	Phosphoric Acid Fuel Cell
PED	Pressure Equipment Directive
PEMFC	Proton Exchange Membrane Fuel Cell
PES	Primary Energy Saving
PNR	Pre-Normative Research
RB	Regulatory Bodies
RC&S	Regulations, Codes & Standards
RGIE	Règlement Général des Installations Électriques
RITE	Reglamento de Instalaciones Térmicas en los Edificios
RT	La Réglementation Thermique
SCOP	Seasonal Coefficient of Performance
SDO	Standard Development Organization
SOFC	Solid Oxide Fuel Cell
SR	Standard Reference
TC	Technical Committee
TR	Technical Report
UN/ECE	United Nations - Economic and Social Council
UNE	Una Norma Espanola
UNI	Ente Nazionale Italiano di Unificazione
VDE	Verband Deutscher Elektrotechniker
VDI	Verein Deutscher Ingenieure
WRAS	Water Regulations Advisory Scheme

## Annex II

In this Annex are reported additional details, especially on the results produced, about the European projects mentioned in the Chapter 2 of this Position Paper. Additional sub-sections refers to the International and the demonstration projects that were considered, in some way, relevant for the Ene.field project.

### European Regulations Codes & Standards projects

#### HarmonHy

A great deal of information can be found and quite interesting outputs and recommendations can be extracted from the final conference of this project.

The aim of WP1 was to identify the current activities of standardization and regulation bodies regarding hydrogen and fuel cells and to assess the state-of-the-art of RC&S (regulations, codes and standards). Two main conclusions were drawn from the analysis: RC&S activity has been developing rapidly but with discrepancies and duplications in some fields.

WP3 was in charge of evaluating the relationships between the regulatory bodies and standardization development organizations. It was concluded that further communication and cooperation schemes should be established between the organizations in order to facilitate RC&S harmonization (Figure 9). During the final conference, in October 2006, a presentation was made with recommendations about how to establish this cooperation. The main points were:

- To continue adopting the "new approach", in which a regulation defines the essential requirements and uses harmonized standards (international or European) in order to establish technical requirements.
- To establish a European RC&S Platform (within the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)) which would support the different sections in order to coordinate RC&S efforts. This platform would act as an intermediary with the RC&S system ( SDO and RB), and make sure that the lessons learnt from demonstration projects effectively arrive to them.
- Further emphasis should be given to link PNR and co-normative research (CNR) projects to SDOs, so, that standardization activities include the latest developments.
- Both RC&S and PNR activities should be internationalized, with bodies such as ISO, IEC or United Nations - Economic and Social Council (UN/ECE) being the main actors and cooperation in PNR should be encouraged through international forums such as IPHE (e.g. the FCTESTQA project).

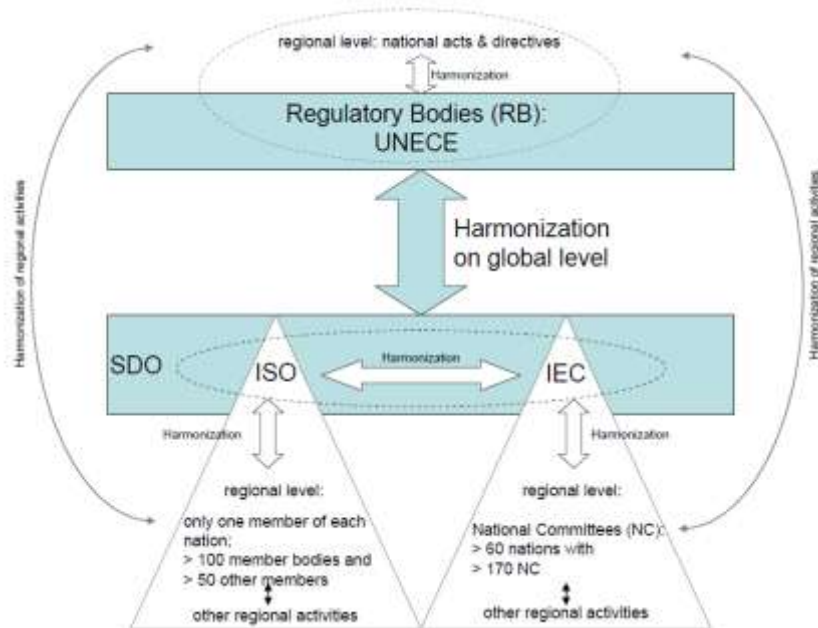


Figure 9. HarmonHy RC&S harmonization recommendations. Source: (Vergels, 2006).

The scope of Ene.field is not to analyze the current status of fuel cell PNR and RC&S activities, but a detailed analysis can show that, since 2006, the situation has improved thanks to the publication of international and European fuel cell standards in all the application fields and that some recommendations in the HarmonHy project had been considered in the European Commission FP7 implementation by FCH-JU, including PNR-specific projects such as HyIndoor, HyQ, MATHRYCE, Stack-Test and so on, and RC&S activities in several other projects like Ene.field.

WP2 conducted an assessment of PNR projects (including fuel cell or hydrogen projects with different levels of priority as far as RC&S development and assessment are concerned) in Europe, the USA and Japan in order to have an overall picture of the current situation (Conte, 2006). For that purpose, they created a list of categories which was sub-divided into two groups (hydrogen and fuel cells) and analyzed if each of the pre-identified projects were considering them (altogether, 24 European, 4 Japanese and 7 American projects were evaluated). This analysis was done separately for transport and stationary applications, and a general overview was also developed considering both of them.

Project		Categories																																			
		Jap 1	Jap 2	Jap 3	Jap 4	USA 1	USA 2	USA 3	USA 4	USA 5	USA 6	USA 7	EU 1	EU 2	EU 3	EU 4	EU 5	EU 6	EU 7	EU 8	EU 9	EU 10	EU 11	EU 12	EU 13	EU 14	EU 15	EU 16	EU 17	EU 18	EU 19	EU 20	EU 21	EU 22	EU 23	EU 24	
Application		T	B	S	S	B	B	T	B	B	T	T	B	B	T	B	T	T	T	S	T	B	S	T	T	T	S	S	T	B	S	S	T	T	T	S	
General	Fuel quality	G	R																																		
	Safety (in all the phases)																																				
FC compon	Materials compatibility					Y																															
	MEA characterization																																				
FC stacks	Materials compatibility																																				
	Characterization procedures																																				
	Environmental tests																																				
FC system	Balance of plant																																				
	Fuel processor testing																																				
	Environmental tests																																				
	EMC																																				
FC applications	Vehicle operation																																				
	Emission measure																																				
	Fuel consumpt.																																				
	Materials compatibility																																				
	Testing profile																																				
	Refuelling interface																																				
	H2 sensors																																				
	EMC																																				

Figure 10. HarmonHy PNR status results for fuel cell categories (Conte, 2006).

The HarmonHy results, regarding fuel cell categories, are shown in Figure 10. The results are presented in a "traffic light" pattern:

- Red means that the research work does not address a specific RC&S activity
- Yellow means that some activities could be used for RC&S development
- Green means that the project's activities can be considered a certain source of data for RC&S development

Figure 10 shows that fuel cell PNR activity was developing much faster for transport applications than for stationary ones. Furthermore, some categories were being considered in several projects (e.g. safety, fuel consumption, testing profile), while others were barely mentioned (Membrane Electrode Assembly (MEA) characterization, fuel processor testing or environmental tests). In an attempt to solve these issues, HarmonHy proposed a way-to-go for PNR, recommending the next steps that should be taken (Conte, 2006). The four categories that were considered as key topics for fuel cell technologies and which should be included in PNR projects, were the establishment of common procedures for MEA characterization (physical and performance properties), the definition of materials characterization and compatibility tests as well as environment condition tests (vibration and extreme conditions) and the harmonization of test protocols for stationary and transport applications.

WP4 assessed the societal and industrial needs for standardization and regulations. It is the only WP that has issued a public report that can be found online (Bellerate & Brusaglino, 2006). The objectives of the assessment were to evaluate the key issues (from an industrial and social perspectives) that would allow the existing barriers to the commercialization of hydrogen and fuel cell products to be overcome. The identification of these needs and their consideration while creating harmonized RC&S would be a benefit for the development of hydrogen and fuel cell markets. To do this, WP4 established a list of issues that should be assessed concerning the combinations of stationary/vehicular applications of fuel cells/hydrogen, and then conducted an investigation to determine which ones should be prioritized. Table 17 shows some of the results of the report, which correspond to the main issues that affect the stationary application of fuel cells.

Issue	Priority
Terminology	3
Material compatibility	3
Material recycling	1
Safety measures in enclosed spaces	3
Performance standards and codes	3
EMC	3
Protection from electric hazards	3
Fuel cell system power output definition	2
Risk assessment and documentation of industry	-
Gas appliance safety	3
Low voltage grid connection	3
Software control system	1

Table 6. Priority valuation of industrial needs issues (Bellerate&Brusaglino, 2006).

Priority is defined using the following grading system:

- 3 points mean the issue is essential for commercialization
- 2 points mean the issue is important for commercialization
- 1 point means the issue is not important for commercialization

However, the report was developed by the automotive industry (CRF - Fiat, BMW) and the focus was on hydrogen rather than fuel cells, and on vehicular applications rather than stationary ones. No explicit comments were made regarding the origin of the ranking in, therefore it is not clear whether the issues priority is for both hydrogen and fuel cells under both applications or just for hydrogen (the author's personal opinion is that certain comments at the end of the analysis, p.28, suggests the latter).

## HYPER

An interesting guide, which has been structured in three main sections, together with an introduction to fuel cells and hydrogen, and appendices, has been produced.

The first section deals with general and higher level requirements. It is divided into three sub-sections according to the different steps in the approval of system installation (design and manufacturing, installation, operation and maintenance), and an additional sub-section about regulatory approval. The most interesting of these sub-sections, from the Ene.field perspective, is that pertaining to system installation. It considers several aspects that should be addressed while installing a small stationary fuel cell system:

- Installation location
- Ventilation
- Pressure systems
- Material selection for installation
- Mechanical and thermal hazards
- Slipping, tripping or falling hazards
- Lightning protection
- Gas venting
- Manual handling

However, all the other sub-sections contain also information of interest that has been used in the development of this paper.

Section 4 in the HYPER guide is probably the most useful one, from Ene.field perspective, and its reading is highly recommended. It considers safety, siting, fire and explosion prevention and interconnectivity of the systems. These topics are present during the whole lifetime of the system and they are extensively referred to in international and national regulations and standards.

As far as safety is concerned, sub-sections 4.1 and 4.2 deal with hydrogen generation and hydrogen containment and piping respectively. These two points are not considered of great importance, from Ene.field perspective, since the hydrogen is produced inside the FC-based microCHP system through natural gas reforming and, as a result, the amounts of hydrogen present at any moment are limited. However, hydrogen safety issues might be of importance when designing the systems and, for this purpose, HYPER refers to ISO technical report ISO/TR 15916 (*“Basic considerations for the safety of hydrogen systems”*) and, more specifically, to ISO standard 16110-1 (*“Stationary hydrogen generation for indoor or outdoor commercial, industrial and residential applications using fuel-processing technologies”*) regarding hydrogen generation, and a set of recommended best practices for hydrogen storage and piping are given in 4.2.

Sub-section 4.3 deals with system siting. This is one of the main issues that needs to be addressed when installing a stationary fuel cell system, and HYPER offers very useful recommendations and guidelines in 4.3.1, which are also included in the ISO 62282-3-300 standard (*“Stationary fuel cell power systems – Installation”*). Recommendations can be found about ventilation, exhaust outlet, safety distances and fuel storage. The necessity of complying with the national building regulations (in particular electrical and heating systems, safety and environment) has been also pointed out.

Explosion risks and mitigation are addressed in 4.4. The document specifically refers to hydrogen issues, but the methodology could be transferred to other fuels, such as natural gas, simply by changing the ranges or values. The proposed methodology suggests following a simple risk reduction path: 1. Minimization of leakage by following 4.1 and 4.2., 2. Prevention of explosive atmospheres through ventilation (4.4.1), 3. Avoidance of ignition sources using appropriate materials: EN 60079 series (*“Explosive atmospheres”*) for electrical equipment and EN 13463 series (*“Non-electrical equipment for use in potentially explosive atmospheres”*) as well as EN 15198 (*“Methodology for the risk assessment of non-electrical equipment and components for intended use in potentially explosive atmospheres”*) for non-electrical equipment (4.4.2), 4. Explosion mitigation (4.4.3).

Sub-section 4.6 deals with fire protection. Overheating of surrounding equipment (SOFCs work at very high temperatures of over 800°C) must be avoided using insulation and adequate materials, and fire fighting recommendations are given in 4.6.2.

Finally, section 5 is a permitting route that provides checklists for commercial/industrial installations and for domestic/residential ones.

Among the HYPER guide appendices, interesting information can be found about national regulations for natural gas systems (Appendix 1) and international RC&S (Appendix 2).

HyIndoor

In the context of this project, the main areas in which the efforts have been focused on are:

- the assessment of the dispersion of hydrogen in an enclosure in different configurations (WP2);
- ignition of a flammable hydrogen-air mixture, and its deflagration, in a ventilated/vented room or enclosure (WP3);
- the early ignition and combustion of released hydrogen in an enclosure in the form of a jet fire (WP4).

The generated knowledge will be described in state-of-the-art safety guidelines which will include contemporary engineering tools and recommendations to provide the safe introduction of fuel cells and hydrogen on early markets (WP5). The recommendations will be formulated for integration in ongoing or new Regulations Code and Standard activities in order to be implemented at a national and at an international level (WP6).

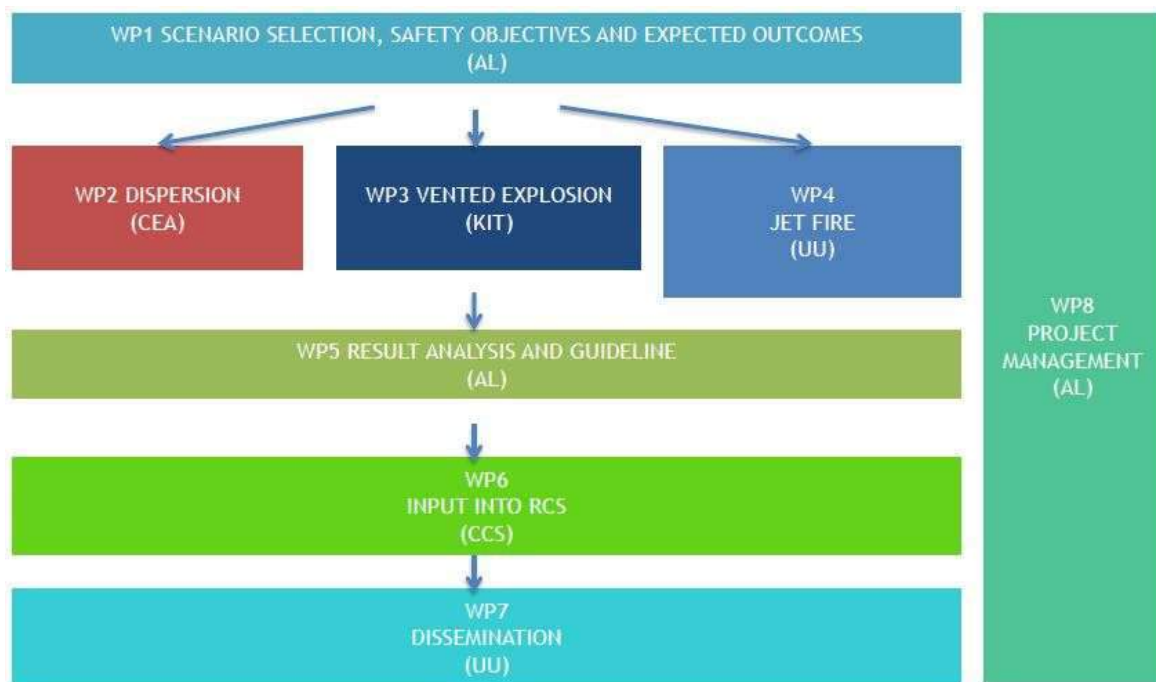


Figure 11. Scheme in which is shown the organization of the different WPs.

At the moment, no results have been published on the project website.

## HySafe

HySafe covered a wide range of topic concerning safety in the use of hydrogen for energy (Figure 12). The core activities of the project (research-related) were dedicated to hydrogen release, mixing and distribution (WP8), hydrogen ignition and jet fires (WP9), hydrogen explosions (WP10), mitigation (WP11) and risk assessment methodologies (WP12). Moreover, WP (1 - 6) were oriented towards the internal integration of results and WP 13 - 16 which were in charge of the dissemination and spreading of results. In particular, WP16 dealt with RC&S activity, consisted on:

1. As a PNR project, HySafe created knowledge on hydrogen safety issues that could be used to develop standards. An objective was to introduce the obtained results into SDOs so they could be included in the standard development process.
2. HySafe created a specific group of delegates to SDOs (ISO, IEC, UN/ECE) in order to actively participate in the hydrogen-related committees by presenting consensual scientific knowledge and promoting consensus on draft RC&S developments through position papers (Jordan, 2006). Figure 13 shows the activities in which HySafe could support RC&S development.

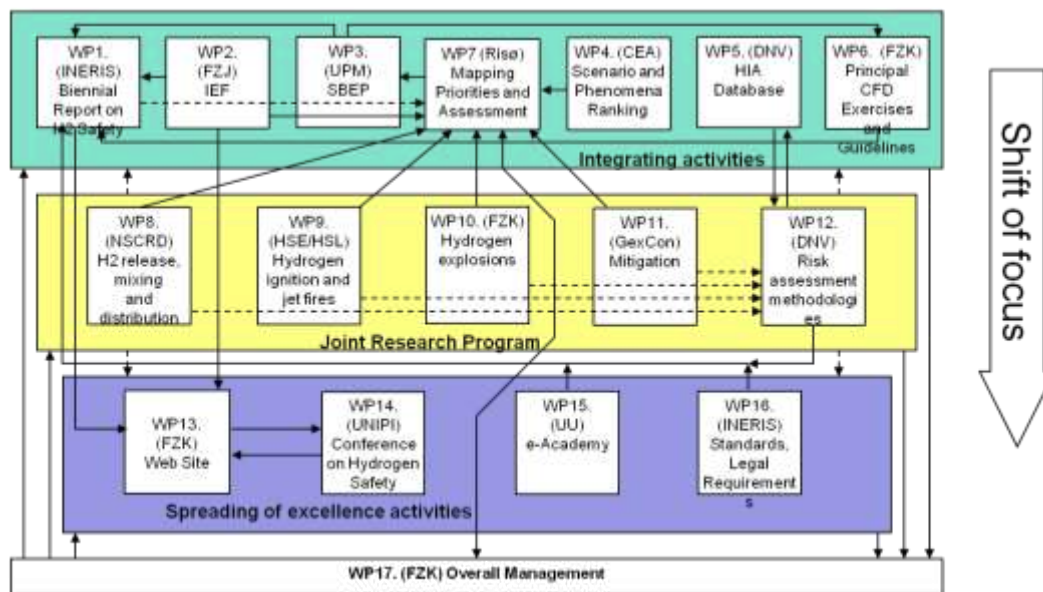


Figure 12. HySafe project WP and activities.

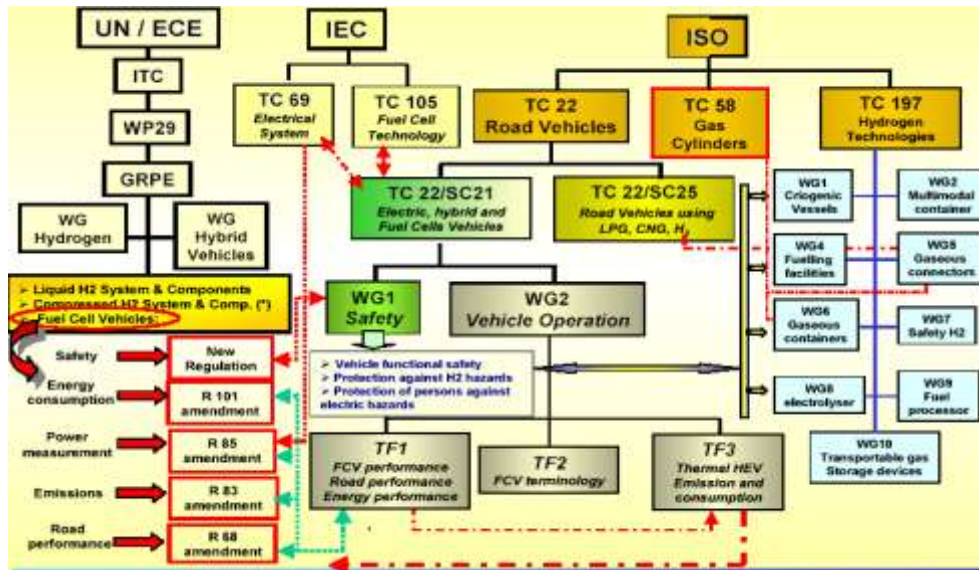


Figura 13. International committees addressing hydrogen-related technologies standardization.

## Other projects

### Fuel Cell System Testing, Safety & Quality Assurance

Project	Coordinator	Date	Website
FCTESTQA	ENEA (Italy) / JRC	April 2010	<a href="http://iet.jrc.ec.europa.eu/fuel-cells/about-fctesqa-project">http://iet.jrc.ec.europa.eu/fuel-cells/about-fctesqa-project</a>

Fuel Cell System Testing, Safety & Quality Assurance (FCTESTQA) is a European Commission co-funded project (under the 6th Framework Programme) with the additional participation of the International Partnership for Hydrogen Economy (IPHE) members (the USA, Japan, South Korea, China, Russia). It is closely related to the previous (5th Framework Programme) Fuel Cell Testing and Standardization Network (FCTESTNET) project.

The objective of the project was "to provide validated and benchmarked testing procedures and testing methodologies applied to fuel cells, fuel cell stacks and fuel cell systems". Its deliverables included testing procedures for different fuel cell types (PEMFC, SOFC, Molten Carbonate Fuel Cell (MCFC)) and for stationary fuel cell system applications in particular (FCTESTNET WP2, 2006). Its reliance to the RC&S issues is that it is an important pre-normative research project, whose results could be further used to develop standards and regulations for fuel cell testing. The FCTESTQA webpage (FCTESTQA project, 2013) presents a set of documents which shows the results of the project:

- PEMFC single cell testing procedures
  - Dynamic load ageing cycling test
  - Accelerated ageing on/off cycling test
  - Polarization curve test

- Characterization of the performances of a PEMFC operating with fuel and an oxidant at various relative humidity levels
- Long term durability steady test
- PEMFC stack testing procedures
  - Measuring voltage, power and efficiency as functions of the reactant stoichiometry for a water-cooled PEMFC stack
  - Long term durability steady test
  - Polarization curve test
  - Measuring voltage, power and efficiency as functions of the pressure for a water-cooled PEMFC stack
  - Dynamic Load Cycling Ageing Test
- SOFC single-cell testing procedures
  - Performance and endurance test modules
  - Polarization curve test
- SOFC stack testing procedures
  - Performance and endurance test modules
  - Polarization curve test
- MCFC single-cell testing procedures
  - Polarization curve test
  - Cross over at steady state conditions
  - Testing the MCFC Single Cell Voltage as a function of fuel utilization and current density
- MCFC stack testing procedures
  - Testing the MCFC sub-scale stack voltage as a function of the current density at constant gas flow rates for stationary applications

An interesting Ene.field-related document, regarding stationary applications from FCTESTNET, has also been provided. This document presents test methods for fuel cell system assessment which addresses issues, such as function, handling, durability, safety and environmental impact. The proposed tests are:

- Durability test programme under severe operating conditions
- Normal efficiency test under constant load
- Testing of thermal load following for stationary fuel cell systems
- Testing of electrical load following for stationary fuel cell systems
- Test module concerning the behaviour of stationary fuel cell systems upon start- stop cycles
- Type test electric module (inverter, DC/AC-converter)
- Testing CURRENT ADJUSTMENT AND INVERTER EFFICIENCY as a function of the OPERATING PARAMETERS OF THE INVERTER
- Testing AC QUALITY, ENS-FUNCTIONING as a function of the OPERATING PARAMETERS OF THE INVERTER
- Testing VOLTAGE RANGE DC as a function of the OPERATING PARAMETERS OF THE INVERTER
- Testing the CONTINUOUS OPERATION TEST as a function of the OPERATING PARAMETERS OF THE INVERTER
- Testing the INSULATION TEST as a function of the OPERATING PARAMETERS OF THE INVERTER

### *Relevance for the Ene.field project*

The relevance of this document with the interests of Ene.field is not very close since the focus of the RC&S is on the installation-related regulations and standards. However, the proposed tests are of obvious interest for the manufacturers of FC-based microCHP systems during the design and manufacturing processes.

### **FC Eurogrid - Evaluating the performance of fuel cells in European energy supply grids**

<b>Project</b>	<b>Coordinator</b>	<b>Date</b>	<b>Website</b>
FC Eurogrid	University of Birmingham	September 2012	

FC Eurogrid was a 24 month project that was funded under the 7th Framework Programme.

The project was introduced in a context in which the differences between the energy supply grid contexts from country to country, the FC types and their applications made the setting of realistic goals complicated in terms of efficiency, emissions and technical specifications. As a result of this complex situation, there was no simple way of predicting the advantages that a stationary fuel cell system could offer in any given energy supply context.

Therefore, the main objective of the project was to contribute to solving this problem by establishing technical and economic targets and benchmarks that would allow the assessment of fuel cells in stationary power generation. The strategy used to obtain these results was developed in two phases. The first one was characterized by:

- the collection of the necessary data regarding typical EU electricity supply grids from utility companies and Eurostat;
- the definition of a set of performance indicators, such as emissions per energy unit of electricity delivered to customers, types of fuels and percentages used (Figure 14);
- the simulation of FC system operation in a variety of scenarios, in order to determine the average values of indicators for specific operating contexts.

The second phase was instead focused on the implementation of the developed analyses and the determination of appropriate assessment methodologies.

The overall results will be presented in a final report centered on the energy efficiency and GHG impact assessment of stationary fuel cell technologies, under various operating and grid constraints. The purpose of this work is to encourage a more focused allocation of research funding, the identification of research and development gaps and to offer an objective comparison of fuel cells with competing technologies.

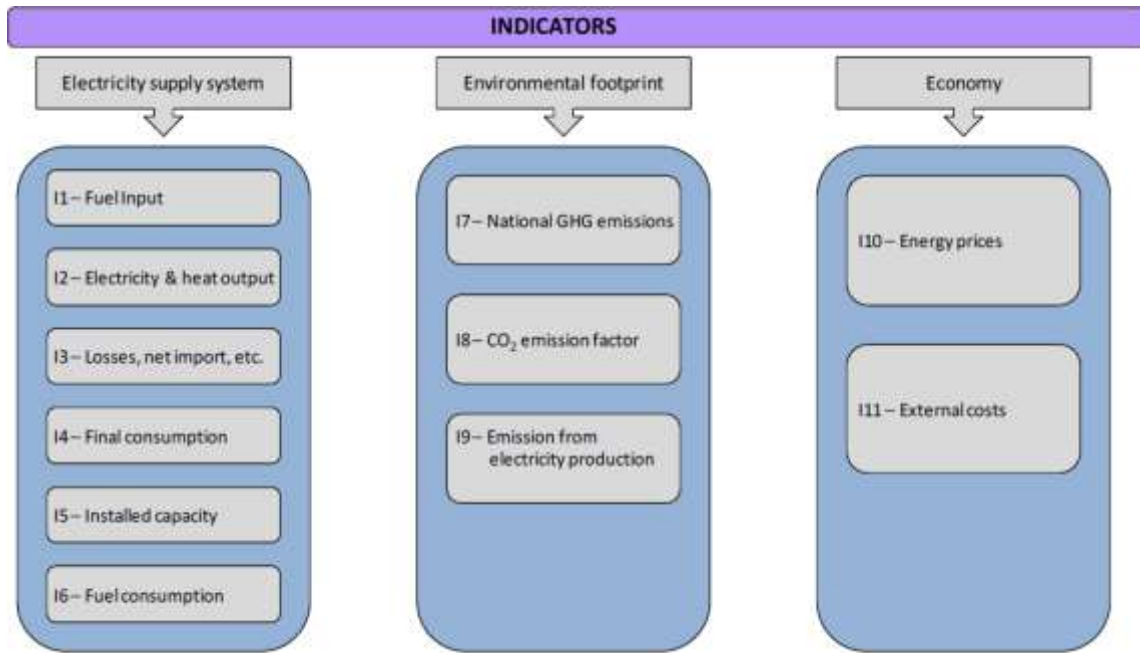


Figure 14. Structure of the set of indicators used (Steinberger-Wilkens, 2012)

**Relevance for the Ene.field project**

The outcomes of this project will allow a clearer framework about the situation of FC systems in Europe to be created. The benefits of this improvement will help manufacturers to more precisely target their research and development. No activities were conducted regarding RC&S aspects, which are fundamental for the Ene.field project.

**International Regulations Codes & Standards projects**

**Hydrogen and Fuel Cell Permitting Guide (USA)**

Project	Coordinator	Date	Website
Hydrogen and Fuel Cell Permitting Guide	Pacific Northwest National Laboratory (USA)	December 2004	<a href="http://www.pnl.gov/fuelcells/permit_guide.stm">http://www.pnl.gov/fuelcells/permit_guide.stm</a>

The Hydrogen and Fuel Cell Permitting Guide was developed by the Pacific Northwest National Laboratory (in collaboration with other institutions) for the US Department of Energy. It contains three modules, where Module 1 is the one corresponding to stationary fuel cell installations (Pacific Northwest National Laboratory, 2004).

Permitting Guide Module 1 is divided into four sections, plus an introduction (section 1):

Section 2 is a detailed description of the fuel cell working principle and a description of the fuel cell types.

Section 3 presents a schematic of a typical stationary fuel cell system, together with its components. This schematic has the purpose of introducing the different interfaces of the system that define the different topics into which the RC&S issues will be grouped in section 4.

Section 4 is the most interesting one as far as the Ene.field activities are concerned, as it presents a compendium of International and American RC&S that could affect the installation of stationary fuel cell systems. First, a list of the most important regulations, codes and standards in the United States is given. This information has been gathered and updated in Table 8. Then, the Permitting Guide further develops this information, creating a sort of RC&S matrix that could serve as an example for this report, where different critical issues concerning the installation of stationary fuel cell systems are analyzed following the template outlined on Table 7.

Issue	Requirement description	What to look for	Code/Standard
Natural Gas Fuel Supplies	Covers piping, components, and connections from the point of delivery to the fuel feedstock inlet of the fuel cell.	Natural gas in accordance with NFPA 54 or IFGC, as applicable. Compressed natural gas in accordance with NFPA 52 and IFC	NFPA 853 §4-2

Table 7. Template of RC&S matrix in US-DOE Permitting Guide.

The headings in Table 7 stand for (Pacific Northwest National Laboratory, 2004):

- Issue – The provision title used in the code/standard.
- Requirements – A brief description of each of the code provisions is provided to give the user an overview of the code text.
- What to look for – Guidance is provided for enforcement personnel on what is necessary to review for a hydrogen fuel cell installation submittal. The description includes the documentation that should be submitted (e.g., a label or listing) and where the information should be included in the plans or specifications.
- Code/Standard – The requisite code or standard that affects the design, installation, equipment specification, or operation of a hydrogen fuel cell installation is listed in abbreviated form.

The RC&S matrix is presented in Table 4.2, in the guide, there the different issues have been grouped into five key sections that correspond to different aspects of the system:

1. Fuel supply and storage
2. General fuel cell siting
3. Fuel cell equipment
4. Fire protection
5. Interconnections

Section 5 presents a case study of the installation of a UTC Fuel Cell 200 kW PHosphoric Acid Fuel Cell (PAFC) in a High School in South Windsor (Connecticut) fired by natural gas. There is a short description of the project and the national, state and local RC&S requirements that have to be considered.

Apart from this Permitting Guide, the US Department of Energy (DoE) has created a webpage ([fuelcellstandards.com](http://fuelcellstandards.com)), in which up-to-date information about national and international standards can be found.

#### ***Relevance for the Ene.field project***

This document has been identified as a good resource for the Ene.field RC&S task force, since Section 4 provides detailed information about which topics/issues are of most importance for stationary fuel cell applications. Together with the HYPER permitting guide and the Finnish Handbook of SOFC Systems in Buildings, it has served as a starting point for the development of this position paper.

RC&S	Description	SDO
International Mechanical Code (IMC) Last update: 2012	Regulates and controls the design, construction, installation, quality of materials, location, operation and maintenance of use of mechanical systems.	ICC
International Fuel Gas Code (IFGC) Last update: 2012	Regulates and controls the design, construction, installation, quality of materials, location, operation and maintenance or use of fuel gas systems.	ICC
International Fire Code (IFC) Last update: 2012	The purpose of IFC is to establish the minimum requirements, consistent with nationally recognized good-practice to provide a reasonable level of like safety and property protection from the hazards of fire, explosion or dangerous conditions in new and existing buildings, structures and premises.	ICC
International Residential Code (IRC) Last update: 2012	Provides the minimum requirements to safeguard life or limbs, health and public welfare for one and two family occupancies and townhouses.	ICC
International Building Code (IBC) Last update: 2012	Establishes the minimum requirements to safeguard public health, safety and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety of life and property from fire and other hazards attributed to the built environment.	ICC
International Plumbing Code (IPC) Last update: 2012	Regulates and controls the design, construction, installation, quality of materials, location, operation and maintenance or use of plumbing equipment and systems.	ICC
NFPA 70: National Electric Code Last update: 2011	§692, Fuel Cell Systems—Requirements for the installation of fuel cell power systems, which may be stand-alone or interactive with other electrical power production sources, and may be with or without electrical energy storage, such as batteries.	NFPA
NFPA 50A / 50B Withdrawn NFPA 55: Compressed Gases and Cryogenic Fluids Code Last update: 2013	NFPA 50A – Standard for Gaseous Hydrogen Systems at Consumer Sites Covers the general principles recommended for the installation of gaseous hydrogen systems on consumer premises, where the hydrogen supply to the consumer premises originates outside the consumer premises and is delivered by mobile equipment. NFPA 50B – Standard for Liquefied Hydrogen Systems at Consumer Sites Covers the general principles recommended for the installation of liquefied hydrogen systems on consumer premises, where the liquid hydrogen supply to the consumer premises originates outside the consumer premises and is delivered by mobile equipment.	NFPA

RC&S	Description	SDO
NFPA 54 : National Fuel Gas Code Last update: 2012	Natural Gas Systems Applies to the installation of fuel gas piping systems, fuel gas utilization equipment, and the related accessories.	NFPA
NFPA 58: Liquefied Petroleum Gas Code Last update: 2011	LPG Applies to the motorway transportation of liquefied petroleum gas and to the design, construction, installation and operation of all liquefied petroleum gas systems.	NFPA
NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Plants Last update: 2010	Applies to the design and installation of 1) a singleprepackaged self-contained power plant unit; 2) a combination of prepackaged self-contained units; 3) power plant units comprised of two or more factory matched modular components intended for assembly in the field.	NFPA
ASME Boiler and Pressure Vessel Code Last update: 2013	The International Boiler and Pressure Vessel Code establishes safety rules that govern the design, fabrication, and inspection of boilers and pressure vessels as well as nuclear power plant components during construction.	ASME
UL 1741: Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources Last update: 2010	Covers inverters, converters, charge controllers and output controllers intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Utility-interactive inverters and converters are intended for use in parallel with the electric supply system or an electric utility to supply common loads.	UL
ANSI Z21.83, substituted by ANSI FC1-2012: Stationary fuel cell power systems Last update: 2012	Basic standard for safe operation, substantial and durable construction, and acceptable performance of Stationary Fuel Cell Power Systems. Applies to stationary packaged, self-contained fuel cell power systems or fuel cell power systems comprised of factory matched packages of integrated systems which generate electricity through electrochemical reactions	CSA

Table 8. US DOE Permitting GuideRC&S list (updated).

## Finnish Handbook of the SOFC System in Buildings (Finland)

Project	Coordinator	Date	Website
Finnish Handbook of the SOFC System in Buildings	VTT (Finland)	2009	<a href="http://www.vtt.fi/inf/pdf/tiedotteet/2009/T2465.pdf">http://www.vtt.fi/inf/pdf/tiedotteet/2009/T2465.pdf</a>

The "Finnish Handbook of the SOFC System in Buildings: Legislation, standard and requirements"(Klobut, et al., 2009) was published by VTT as part of a fuel cell technological programme run by Tekes (Finnish Funding Agency for Technology and Innovation). The final aim of the project was the installation of a 50kW SOFC in an office building and, to do so, the current RC&S situation (international and Finnish) was evaluated. The system is larger than the FC-based microCHP systems that have to be installed in Ene.field (ranging from 0.3 to 5 kW electric output) and it was installed in an office building rather than a residential one, but it is still a valid case and most of the RC&S presented in the document are still valid.

The handbook is structured in sections, according to the different requirements that have to be considered (e.g. building/siting, natural gas, interconnection to low-voltage grid, etc.). Each section then analyzes the Finnish regulations and, if these are inexistent or incomplete, the international fuel cell standards (IEC 62282-3-1,3 and prEN 50465, now updated to IEC 62282-3-100,300 ("*Stationary fuel cell power systems – Safety and Installation*") and EN 50465 ("*Gas appliances - Fuel cell gas heating appliance - Fuel cell heating appliance of nominal heat input inferior or equal to 70 kW*").

Section 4 deals with the building and siting requirements. The Finnish building code was analyzed but, since no specific regulation for fuel cell appliances exists, the international fuel cell standards were taken as references (IEC 62282-3-300 and EN 50465).

Section 5 analyzes the requirements coming from the natural gas interface. In this case, national regulations about natural gas heating appliances, safety and so on are dealt with.

Sections 6 and 7 are related to district heating networks and substations. National regulations apply in both cases.

Section 8 deals with electrical interconnection. It considers two international standards (EN 50438 ("*Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks*") and IEEE 1547 ("*Standard for interconnecting distributed resources with electric power systems*")) concerning distributed generation interconnection and specific national legislation.

Table 9 gathers all the RC&S that pertain to the installation of fuel cell systems in Finland according to this handbook.

RC&S	Description	Type	Cited in
IEC 62282-3-100	Fuel cell technologies – Part 3-1: Stationary fuel cell power systems – Safety.	International	Section 4
IEC 62282-3-300	Fuel cell technologies – Part 3-3: Stationary fuel cell power systems – Installation	International	Section 4
EN 50465	Gas appliances – Fuel cell gas heating appliances – Fuel cell appliance of nominal heat input inferior or equal to 70 kW	European	Section 4
IEC 60079 series	Explosive atmospheres.	International	Section 4
Suomenrakennusmääräyskokoelma	The National Building Code of Finland.	Finnish	Section 4
Talotekniikka RYL 2002 Osa 1, G1 Lämmitysjärjestelmät LVI 01-10355	The Finnish general quality requirements of heating systems.	Finnish	Section 4 Section 5
Talotekniikka RYL 2002 Osa 1, G5 Kaasujärjestelmät LVI 01-10355	The Finnish general quality requirements of real estate gas systems.	Finnish	Section 4 Section 5
LVI-ohjekortti, Maakaasulämmitys LVI 62-10287	Natural gas heating – Instruction card. The HEVAC File contains building engineering information. The file contains standards, regulations and product files.	Finnish	Section 4 Section 5
KH-ohjekortti, Maakaasulämmitys KH 23-00362	Natural gas heating – Instruction card. The KH Property Management File is designed for technical, financial and administrative property maintenance. The file contains standards, regulations and product files.	Finnish	Section 4 Section 5
EI, K1/2003	District heating for buildings; rules and guides.	Finnish	Section 6
EI, K13/2008	District heat meters.	Finnish	Section 6
EI, KK3/2007	Treatment of circulation water in district heating systems.	Finnish	Section 6
IEC 61000-3-3	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with a rated current $\leq 16$ A and not subjected to conditional connection.	International	Section 8

RC&S	Description	Type	Cited in
IEC 61000-3-11	Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low voltage supply systems – Equipment with a rated current $\leq 75$ A and subject to conditional connection.	International	Section 8
IEC/TS 61000-3-5	Electromagnetic compatibility (EMC) - Part 3-5: Limits - Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with a rated current greater than 75 A.	International	Section 8
IEC 62282-3-200	Fuel cell technologies – Part 3-2: Stationary fuel cell power systems – Performance test methods.	International	Section 8
IEEE 1547-2003	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.	International	Section 8
EN 50438	Requirements for the connection of micro-generators in parallel with public low-voltage networks.	European	Section 8
SFS-EN 50160	Voltage characteristics of electricity supplied by public distribution systems	Finnish	Section 8
SFS Handbook 600	Low voltage electrical installations and safety for electrical work	Finnish	Section 8

Table 9. RC&S that affect the installation of fuel cell systems in Finland (Klobut, et al., 2009).

### *Relevance for the Ene.field project*

Overall, the report is a good overview of what should be considered when installing a fuel cell system in Finland, and a good source for which European standards are of greater importance. As previously mentioned, it is one of the documents that has been used as a starting point for the study developed in this report.

## FC-based microCHP systems: demonstration projects

### Callux (Germany)

Project	Coordinator	Date of completion	Website
Callux	ZSW (Germany)	Ongoing	<a href="http://www.callux.net">www.callux.net</a>

Callux is an ongoing German project which has a very similar aim to that of Ene.field: the deployment of FC-based microCHP systems for residential use. It is funded by the Ministry of Transport, Construction and Urban Development (approx. 48% of the costs) and, by the end of 2013, it is planned to have around 560 fuel cell heating appliances working in German households, which will keep running until 2015. The Callux project is divided into two activities: a Field test and support measures.

The Field test has been divided into six modules with different energy suppliers and manufacturers. A set of common characteristics and target values have been specified for all the manufacturers, and the installation and operation is conducted by the energy supplier.

Support measures are structured in six working groups that tackle different tasks pertaining to project coordination, the market and partnerships, data gathering, scientific support and communication.

- The market research group is carrying out enquiries with the fuel cell system customers who have given very positive feedback. For instance, Figure 15 shows the answers, until July 2012, to the question "How satisfied are you with the fuel cell heating appliance?" The red colour indicates negative feedback (bottom two options), green indicates positive feedback (top two options) and grey is in-between positive and negative. The figures indicate the survey population.
- A working group is in charge of the infrastructure that has developed a standardized communication interface using the "Callux box". Thus has been developed according to standard IEC 61850-7-420 "Communication networks and systems for power utility automation" and it allows the different systems used in Callux project to be operated.

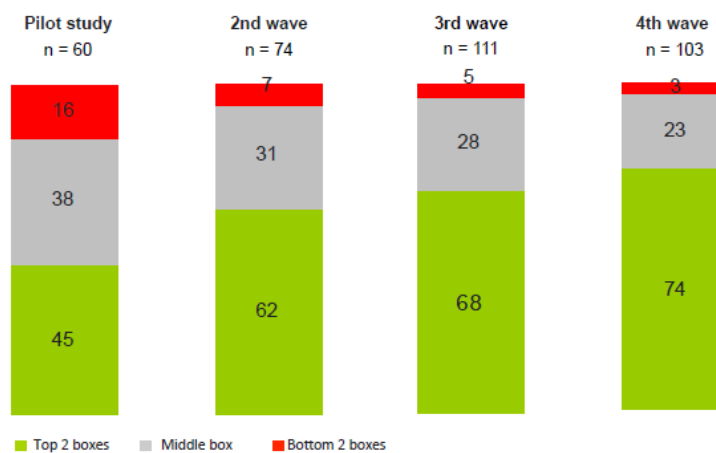


Figure 15. Callux project enquiry: Customer satisfaction (Callux project, 2012).

**Relevance for the Ene.field project**

Although it seems there is no specific RC&S activity, the project is gathering a great deal of operational data and details on installation experience, whose analysis could be useful to improve the systems and, by looking through the RC&S glass, to have a better understanding of the regulations that affect system installation and, eventually, to help future RC&S developments.

Callux and Ene.field share the objective of deploying FC-based microCHP units in field trials to gather experience and information that will help their market entry. Both projects also share some members, which could lead to a better information exchange between the projects.

**Ene-farm (Japan)**

Project	Coordinator	Date of completion	Website
Ene-farm		Ongoing	<a href="http://www.fca-enefarm.org">http://www.fca-enefarm.org</a>

Ene-farm is not a project from an EU point of view, but a commercialization subsidy programme organised by the Japanese administration (there are parallel regional subsidies, like the 10 billion yen project funded by the Tokyo Metropolitan Government (Nikkei, 2013)) for a specific product (FC-based microCHP systems) whose objective is to reduce costs in order to facilitate product market readiness. Five different systems are included in the subsidy (three PEMFC-based and two SOFC-based ones).

The FC-based microCHP development project was started in 2002, with a demonstrative research project, which then continued in 2005 with a full demonstration project with more than 3,300 units installed throughout all of Japan. After these projects finished (2009), the Japanese government started the current subsidy programme Ene-farm, in which each system acquired installed is partially paid by the public administration. The budget has increased from 2009 (6 billion yen (aprox. 45.5 million euros)) to 2012 (9 billion yen (68.3 million euros)), but the subsidy for each unit has been reduced (1.4 million yen (10,600 euros) in 2009 versus 0.7 million yen (5,300 euros) in 2012 (Fuel Cell Commercialization Conference of Japan, 2012)), due to the constant reduction in prices (for instance, the new unit presented by Tokyo Gas and Panasonic in January 2013 costs of less than 2 million yen (15,200 euros), 760,000 yen (5,700 euros) less than its predecessor (Panasonic Corporation, 2013)). These subsidies only apply to systems that satisfy certain technical, operational and safety conditions (Fuel Cell Commercialization Conference of Japan, 2012), including efficiency limits, electrical output, grid connection, etc.

The chart in Figure 16 shows the total number of units sold and installed until the end of 2011: more than 22,000 units, all of which have been subsidized by the government. According to information from Fuel Cell Today (Carter, 2013), an additional 20,000 units were installed in 2012 (the Japanese Ministry of Economy allocated additional resources after the initial 12,000 units had already been

delivered in 2012) and the budget for 2013 (fiscal year) has allocated subsidies that foresee the installation of an additional 50,000 units.

## ENE-FARM Sales & Dissemination in Japan ('09~)

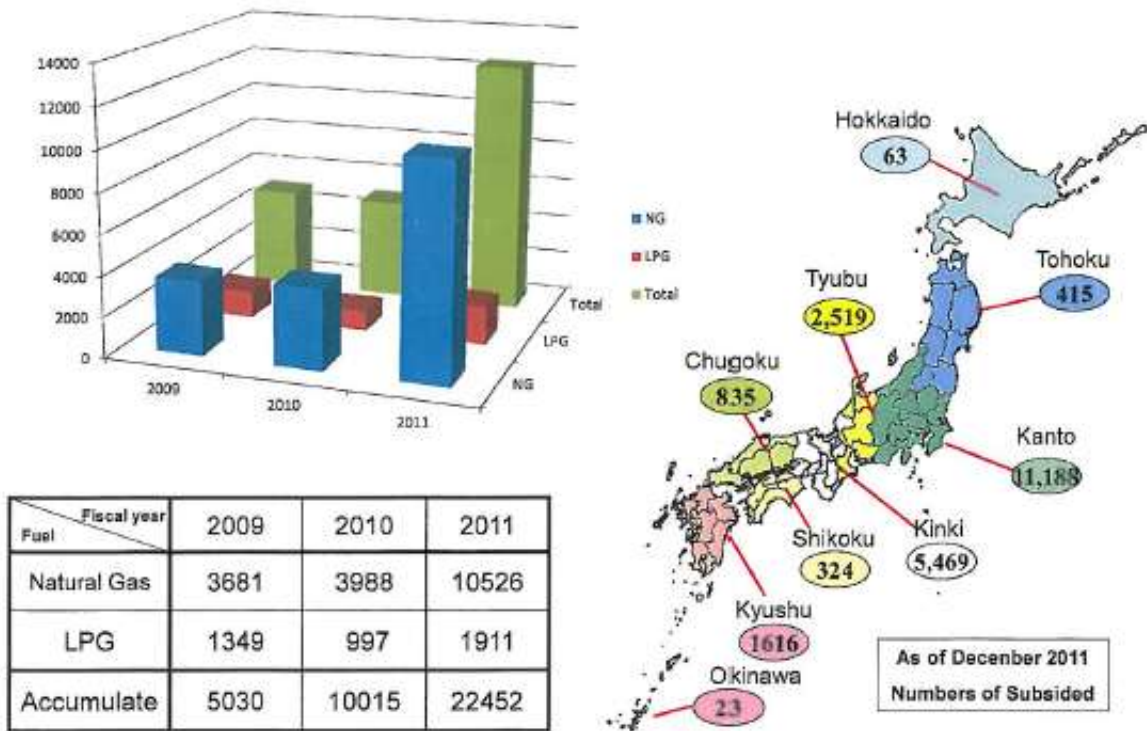


Figure 16. Ene-farm cumulative sales until the end of 2011(Fuel Cell Commercialization Conference of Japan, 2012).

### *Relevance for the Ene.field project*

Like Callux, Ene-farm has no specific RC&S objective, but its results will provide valuable information for any future development at a domestic or an international level. Since Ene-farm is one step ahead of the current demonstration projects in Europe, analyzing its results could be of great interest for the Ene.field consortium in order to establish the way forward.

## Annex III

### Overview of the existing legislation

In this Annex is reported an overview of the existing legislation referred to the most relevant aspects of the FC-based microCHP systems. This documentation does not pretend to be complete because of the huge amount of documents existing, but represents a good panorama of the current RC&S status.

Firstly are described the most referenced standards both at an international and a national level, also considering feedbacks obtained by the questionnaire on standards proposed to the manufacturers.

The subsequent section deals with the most relevant European Regulations and Directives.

Finally, a series of Tables is reported (composing the RC&S matrix) in which the RC&S are grouped according to the macro-topic subdivision of the section 1.2.3.

### Main International Standards

#### IEC 62282 series

Regarding stationary fuel cell applications, IEC has issued the IEC 62282 series.

The IEC 62282-2 standard ("*Fuel cell technologies - Part 2: Fuel cell modules*") focuses on fuel cell systems. In particular, it provides the minimum requirements for safety and the performance of fuel cell modules, and applies to fuel cell modules with different kinds of electrolytes. The standard only deals with dangerous situations that can involve people or the external part of these devices.

The IEC 62282-3 standard deals with stationary fuel cell power systems (FC-based microCHP applications are also part of the scope of the standard). It is divided into three parts:

- IEC 62282-3-100: Stationary fuel cell power systems - Safety.
- IEC 62282-3-200: Stationary fuel cell power systems - Performance test methods.
- IEC 62282-3-300: Stationary fuel cell power systems - Installation.

**Part 1 (Safety).** It regulates different safety aspects. It starts by setting a framework through a general safety strategy and, then further elaborates upon safety issues in the physical/operating environment, on materials, pressure equipment, the electrical system, electromagnetic compatibility, control and protective systems, pneumatic and hydraulic equipment, valves, rotating

equipment, cabinets, thermal insulating materials, utilities and during installation and maintenance. The following sections are dedicated to the definition of safety type tests and routine tests and to the marking, labelling and packaging requirements.

**Part 2 (Performance test methods).** The aim is to create a common set of test methods in order to evaluate the performance of stationary fuel cell power systems. Tests are proposed to measure their power output under stationary and transient conditions, to assess their electric and thermal efficiency and to evaluate their environmental characteristics.

**Part 3 (Installation).** This part specifically deals with issues related to safety during the installation of a stationary fuel cell power system. These issues are grouped into five sections: siting, ventilation and exhaust, fire protection and gas detection, interconnections with site interfaces and environmental requirements. As the installation of such systems is influenced to a great extent by national regulations, the standard has the aim of creating a framework of what things should be considered, rather than being too specific. It also includes the requirements for the approval and maintenance tests that have to be performed after the system is installed.

These standards have been included in the European framework by CENELEC as IEC EN 62282-2 and IEC EN 62282-3 and the last update of both was in 2012.

Actually, the IEC 62282-3 is composed also by a fourth part that at the moment is under draft phase (the final draft will be finished by June 2014).

The standard IEC 62282-3-400 (*“Stationary fuel cell power systems - Small stationary fuel cell power systems with combined heat and power output”*) specifies requirements for construction, safety, installation, fitness for purpose, rational use of energy, marking and performance measurement of fuel cell power systems (with an heat input based on net calorific value of less than or equal to 70 kW) that act as a heating appliances supplying both electrical power and useful heat. Furthermore, the direct connection to the mains (parallel operation) is also within its scope. Finally, it applies to both indoor and outdoor installations and Type Testing only.

According to the manufacturers, this series of standards (except for the IEC 62282-3-400 that is not still available) is well organized even though it would be useful to link it to other relevant standards covering FC-based microCHP topics.

## Main European Standards

### EN 50465

The CLC/SR 105 technical body of CENELEC has been working on another standard that deals with the use of fuel cells as heating appliances (FC-based microCHP systems). This standard is coded EN 50465 (last update in 2010) and it is the only standard that specifically addresses the issues of designing and manufacturing FC-based microCHP systems.

- EN 50465: Gas appliances - Fuel cell gas heating appliance - Fuel cell heating appliances of nominal heat input inferior or equal to 70 kW.

**Section 4** of this standard establishes that fuel cell heating appliances are classified in categories according to EN 437. This standard regulates the test gases families, groups and ranges, as well as the gas appliance categories, on the basis of which of the previous test gases are suitable for them. The fuel cell heating appliance categories allowed in each Member State are given in the Annex A. Furthermore, another classification, based on CEN/TR 1749 (pertaining to the mode of air supply and evacuation of combustion products) is also given.

**Section 5** is dedicated to construction requirements, and includes general construction (connection to gas and water pipes, use and servicing, soundness, air supply, etc.), conversion to different gases (the standard allows certain actions to convert the appliance from one gas family to another), materials and thicknesses (including material selection, thicknesses, welding, thermal insulation, control and safety devices, combustion product evacuation, etc.), gas circuits (composition and control), cooling and water circuits, electrical equipment (calls IEC EN 60335-2-102 (Household and similar electrical appliances - Safety. Part 2: Particular requirements for gas, oil and solid-fuel burning appliances with electrical connections)) and control systems (including adjusters as well as control and safety devices).

**Section 6** deals with operational requirements, such as the soundness of the air supply and exhaust evacuation circuits, heat input and output, safety of operations (surface temperature limits, hot water temperature limits and control, exhaust temperature, etc.) and control systems.

**Section 7** describes the test methods that should be used to check the requirements stated in sections 5 and 6.

**Section 8** formally makes IEC EN 60335-2 (Household and similar electrical appliances - Safety. Part 2: Particular requirements for gas, oil and solid-fuel burning appliances with electrical connections), EN 50438 (Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks) and IEC EN 61000 (Electromagnetic compatibility standard series) the reference standards for the electrical system and EMC.

**Section 9** establishes the requirements for the marking, installation and operation instructions.

The standard also contains 11 informative annexes that complement the information.

In the same way as for the IEC 62282 series, it would seem necessary to have a better interaction with other reference standards as well as the treatment of issues that until now have not been considered (3.3.1.2).

## European Regulations

### CE marking-related EU Directives

In the case of a FC-based microCHP system, the Directives that have to be considered are:

- **ATEX Equipment Directive** (Directive 94/9/EC, amended by Regulation (EC) No 1882/2003 and Regulation (EU) No 1025/2012). This Directive applies to any equipment (electrical or non-electrical) or protective system designed, manufactured or sold for use in a potentially explosive atmosphere.
- **Pressure Equipment Directive (PED)**(Directive 97/23/EC, amended by Regulation (EC) No 1882/2003 and Regulation (EU) No 1025/2012). This applies to the design, manufacture and conformity assessment of pressure equipment with a maximum allowable pressure greater than 0.5 bar above atmospheric over the temperature range it has been designed for.
- **Low Voltage Directive (LVD)**(Directive 2006/95/EC). This applies to electrical equipment designed for use with a voltage rating of between 50 and 1,000 V for AC, and between 75 and 1,500 V for DC.
- **Electromagnetic Compatibility Directive (EMC)** (Directive 2004/108/EC). This Directive applies to commercially available equipment, or combinations of equipment made into a single unit, intended for an end user and likely to generate electromagnetic disturbance, or the performance of which is likely to be affected by such a disturbance.
- **Gas Appliances Directive (GAD)**(Directive 2009/142/EC). This applies to appliances that burn gaseous fuels used for cooking, heating, hot water production, refrigeration, lighting or washing, and which have, where applicable, a normal water temperature that does not exceed 105°C. This is not applicable to fuel cells as no fuel is burnt, but the Directive also covers such components as safety, and regulating and controlling devices, which may be fitted to the gas side of a fuel cell or a reformation unit to generate hydrogen.
- **Machinery Directive** (Directive 2006/42/EC, amended by Regulation (EC) No 596/2009 and Directive 2009/127/EC). This applies to machinery, interchangeable equipment, safety components, lifting accessories, chains, ropes and webbing, removable mechanical transmission devices and in part to completed machinery. This Directive does not apply to the fuel cell installation itself, but could apply to the associated equipment that is necessary to operate the installation, e.g. a hoist for lifting gas cylinders.

Apart from the CE marking Directives, there is another Directive that might be of interest during system installation, that is, **Directive 2004/22/EC on measuring instruments (MID)**, which regulates the characteristics of devices and systems with a measuring function, such as water meters, gas meters and volume conversion devices, active electrical energy meters, heat meters, material measures and exhaust gas analysers.

## European Union legislative acts related to microCombined Heat and Power

All the acts that are relevant to FC-based microCHP systems technology are mentioned hereinafter. Table 10 is a compendium of the legally binding acts for the EU Member States (namely, Regulations and Directives), whereas Table 11 contains the non-binding acts, whose aim is to outline the European Commission’s policy regarding FC-based microCHP systems related issues, without giving specific details, but just the main points in order to reach certain objectives.

Any additional documents that refer to this technology, but which are either old or treated it in a marginal way, are listed separately in this section (Tables 12 and 13).

Directive/Regulation	Explanation
<b>Directive 2003/87/EC</b>	This Directive aims at significantly reducing greenhouse gas emissions in order to prevent their impact on the climate change. Directives 2004/101, 2008/101 and 2009/29 have amended the original text.
<b>Directive 2009/125/EU</b>	This Directive establishes the framework and requirements for energy-related product ecodesign, with the aim of ensuring the free movement of such products within the internal market.
<b>Directive 2010/30/EU</b>	This Directive deals with the harmonization of end-user information inside the EU. In other words, it establishes a common way of labelling and it standardizes the product information on the consumption of energy and other essential resources during use. The objective is to increase end-users' awareness of energy consumption and, thus, allow them to choose more efficient products.
<b>Directive 2010/31/EU</b>	This Directive aims at promoting the energy performance of buildings and building units by proposing guiding principles for Member States, such as the valorisation of cogeneration systems.
<b>Directive 2012/27/EU</b>	This Directive establishes a common framework of measures for the promotion of energy efficiency within the European Union in order to ensure the achievement of the EU’s 2020 20% headline target on energy efficiency and to pave the way for further energy efficiency improvements after that date. Directive 2013/12/EU is an upgrade of Directive 2012/27/EU introduced after the accession of the Republic of Croatia. It repeals Directives 2004/8 and 2006/32, which refer to the promotion of the cogeneration and energy end-use efficiency respectively.

<p><b>Delegated Regulation (EU) n. 244/2012</b></p>	<p>This Regulation supplements Directive 2010/31/EU and establishes a comparative methodology framework to calculate optimal cost levels of minimum energy performance requirements for buildings and building elements.</p>
<p><b>Commission Decision 2013/242/EU</b></p>	<p>This Directive is about the template for the National Energy Efficiency Action Plans, which, according to Article 24(2) and Annex XIV of Directive 2012/27/EU, has to be adopted.</p>
<p><b>Delegated Regulation (EU) n. 811/2013</b></p>	<p>This Regulation establishes the requirements for energy labelling and the provision of supplementary product information on:</p> <ul style="list-style-type: none"> <li>• Space heaters and combination heaters with a rated heat output <math>\leq 70</math> kW,</li> <li>• Packages of space heater <math>\leq 70</math> kW, temperature control and solar device</li> <li>• Packages of combination heater <math>\leq 70</math> kW, temperature control and solar device.</li> </ul>
<p><b>Regulation (EC) n. 813/2013</b></p>	<p>This Regulation establishes the ecodesign requirements for the introduction on the market and/or installation of space heaters and combination heaters with a rated heat output <math>\leq 400</math> kW, including those integrated in packages of space heater, temperature control and solar device or packages of combination heater, temperature control and solar device as defined in Article 2 of Commission Delegated Regulation (EU) No 811/2013.</p>

Table 10. Binding acts.

European act	Explanation
<p><b>Commission Communication of 10 January 2007: "Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future"</b></p>	<p>The Road Map sets out the Commission's long-term strategy on renewable energy in the European Union (EU). The aim of this strategy is to enable the EU to meet the twin objectives of increasing the security of energy supply and reducing greenhouse gas emissions.</p> <p>In the Road Map, the Commission proposes setting a mandatory target of 20% for the renewable energy share of energy consumption in the EU by 2020 and a mandatory minimum target of 10% for biofuels. It also proposes creating a new legislative framework to enhance the promotion and use of renewable energy.</p>

<p><b>Communication from the Commission to the European parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Second Strategic Energy Review: an EU energy security and solidarity action plan</b></p>	<p>Security and solidarity are essential factors that contribute to an efficient energy policy. The European Union intends to change its energy policy by putting the accent on these two values. The aim is to reduce energy consumption by almost 15% and energy imports by 26 % by 2020. The proposed plan, organised around five main points, should contribute to the achievement of these aims. It is expected that, by 2050, renewable energies will completely replace carbon-based technologies.</p>
<p><b>European Parliament resolution of 14 March 2013 on the Energy roadmap 2050, a future with energy</b></p>	<p>This Resolution promotes Energy roadmap 2050 and offers some suggestions on how to reach the predetermined objectives.</p>
<p><b>European Parliament resolution of 21 May 2013 current challenges and opportunities for renewable energy in the European internal energy market</b></p>	<p>This Resolution emphasizes the important role that renewable energies can play in the European energetic framework (efficiency improvements, reduction in energy importations , etc.). It therefore encourage countries to increase their efforts to reach the objectives fixed in Energy roadmap 2050 (i.e., a share of at least 30% of renewable energies in the EU's energy mix in 2030) and, if possible, to surpass these objectives.</p>
<p><b>European Parliament resolution of 12 September 2013 on microgeneration – small-scale electricity and heat generation</b></p>	<p>This Resolution underlines the importance of the microgeneration in order to meet the EU renewable energy targets in the long term it encourages the realization of an effective regulatory framework that would help the diffusion of this technology and suggests future actions in order to make microgeneration economically viable (e.g. access to current funding).</p>

Table 11. Non-binding acts.

*Additional European Regulations related to microCombined Heat and Power technology*

Standard	Explanation
<b>Directive 2009/28/EC</b>	This Directive establishes a common framework for the production and promotion of energy from renewable sources.
<b>Directive 2009/72/EC</b>	This Directive is aimed at introducing common rules for the generation, transmission, distribution and supply of electricity. It also lays down universal service obligations and consumer rights, and clarifies competition requirements.
<b>Regulation (EC) n. 663/2009 + Regulation (EC) n. 1233/2010</b>	These two Regulations establish the European Energy Programme for Recovery (EPR) whose aim is to provide for the granting of financial assistance to the energy sector, especially for the introduction of interconnection infrastructures, energy production based on renewable sources, carbon capture and for the promotion of energy efficiency.  In the Regulation n. 1233/2010 was introduced the microgeneration as a financiable project in the framework of the EPR, whereas in the previous Regulation this sector was not mentioned.

Table 12. Additional binding acts.

Standard	Explanation
<b>Council Resolution of 18 December 1997 on a Community strategy to promote combined heat and power</b>	This Resolution gives a positive opinion about the cogeneration technology and encourages its development. Moreover, some actions that can be useful for the purpose are given.
<b>Council Resolution of 7 December 1998 on energy efficiency in the European Community</b>	This Resolution asserts the importance of an energy efficiency strategy at a community level and suggests some actions that can lead to the objective, among which the exploitation of the cogeneration technology.
<b>Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the</b>	The Energy Efficiency Plan 2011 forms part of the European Union's (EU) 20 % target (aimed at reducing primary energy consumption) and the 2020 Energy strategy. It aims at: - promoting an economy that respects the planet's resources; - implementing a low carbon system;

<p><b>Regions of 8 March 2011 – Energy Efficiency Plan 2011</b></p>	<ul style="list-style-type: none"> <li>- improving the EU’s energy independence;</li> <li>- strengthening security of energy supply.</li> </ul>
<p><b>European Parliament resolution of 10 September 2013 on making the internal energy market work</b></p>	<p>This Resolution gives some information about the fundamental points on which it is necessary to be focused on making the internal european energy market work.</p> <p>Among various arguments, the need to have infrastructures able to link all EU Member States, to give adequate support to the customers and to focus on technologies that have potentiality not still completely exploited, such as the cogeneration.</p>
<p><b>European Parliament resolution of 10 September 2013 on the implementation and impact of the energy efficiency measures under Cohesion Policy</b></p>	<p>This Resolution analyzes the impact of the energy efficiency measures adopted and discusses on which aspects it is necessary to focus in preparation for the upcoming programming period 2014-2020.</p>

Table 13. Additional non-binding acts.

## Regulations Codes & Standards matrix

### Inlet fluids

The system needs to be fed with different fluids to produce thermal and electrical energy. Both SOFC and PEMFC based systems need fuel (natural gas), oxygen (provided through air) and water for heat management and humidity control purposes. This interface's relationship with the system installation lies in the interconnection of the fluids with the distribution network and supply system requirements (backflow protection, ducts, valves, pressure control, etc.), the quality of fluid management and so on.

INLET FLUIDS (natural gas, air, water)		
Topics	RC&S	Information
NG quality (composition, HV, Wobbe index)	National Document "EUROPEAN GAS INTERCHANGEABILITY" gives values and talks about gas quality harmonization needs in Europe.	IEC 62282-3-100 establishes that systems must be design to operate with the provided fuel quality. EN 437 establishes test gases, pressures and appliance categories to obtain CE mark.
	ISO 13686	Natural gas - Quality Designation.
	ISO 15970	Natural gas – Measurement of properties – Volumetric properties: density, pressure, temperature and compression factor.
	ISO 15971	Natural gas – Measurement of properties – Calorific value and Wobbe index.
Water quality	IEC 62282-3-100	Establishes that the manufacturer should define the quality and characteristics of the water supply.
NG supply system	EN 50465: 5.1/5.3/5.4	Includes pipelines, components (control valves, shut-off, connections, etc.) and soundness. Specifies connection types and references ISO 228-1, ISO 7-1, EN 1057 (threads) and ISO 7005-1 (flanges). NATIONAL conditions in Appendix A.3 (EN 50645).
	IEC 62282-3-1: 4.11	Gas circuit valves (shut-off, fuel). Reference to ISO 23551-1, ISO 23553-1, ISO 23550.
Water supply system	EN 50465: 5.1/5.3	Pipelines, components. Reference to ISO 228-1, ISO 7-1 (threads) and EN 1057 (copper).
	EN 1487, EN 1488, EN 1489, EN 1490, EN 1491, EN 1567	Water valves: Expansion, pressure relief and safety, pressure reduction.
	EN 805	Water supply - Requirements for systems and

		components outside buildings.
Air supply system	EN 50465: 5.1/5.3	Ducts, NG/air ratio control, components.
Hydrogen production	ISO 16110-1	Safety issues about hydrogen production using fuel processing technologies. Requirements mainly for the design, but there are some requirements for the installation, marking, EMC, etc. that could be as well of interest.
Pressure equipment and control	IEC 62282-3-1: 4.9	Pressure limiting devices to comply with IEC 60730-2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements.
	ISO 4126 series	Safety devices for protection against excessive pressure (1: valves, 2: bursting discs, 3: combination, 4: pilot operated valves).
Gas detectors	IEC 62282-3-1: 4.9	Comply with ISO 26142 or IEC 60079-29-1.
Purging and venting	IEC 62282-3-3: 6.4	Venting and purging outside the building. States LFL and CO concentration limits to allow doing it into room atmosphere.
Water pollution protection	EN 1717	Means to be used to prevent the pollution of potable water inside premises and the general requirements of protection devices to avoid pollution by backflow.
System efficiency	EN 15316-4-4	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems. System efficiency for each installation must be assessed depending on the system operational method (continuous operation or heat following). Most countries require specific efficiency levels in order to give incentives.

Table 14. List of the RC&S related to the macro-topic "Inlet Fluids".

## Electrical system

The real interface is the electrical grid, whose requirements, in terms of power quality and protection, could influence the installation of system. Regulations regarding the installation of electrical systems are also of key importance.

ELECTRICAL SYSTEM		
Topics	RC&S	Information
Grounding/earthing	EN 60335-1: 27	"Provision for earthing"--> Affects the design, but also the installation of the systems.
	EN 50438: 4 HD 384.5.54	Earthing procedure and requirements.
Construction	EN 60335-1: 22	Requirements to meet during the construction of the system so the electrical system is not cause of hazards or subject to fail.
Marking and instructions	EN 50645: 5.6 EN 60335-2-102 EN 60335-1: 7	Marking and instructions influences the design of the FC system, but also the installation since requirements of distances, accessibility and legibility must be satisfied.
Protection against access to live parts	EN 50645: 5.6 EN 60335-2-102 EN 60335-1: 8 IEC 60529	This applies more to the manufacturing of the system, but it shall be considered during the installation as well.
Supply connection and external flexible cords	EN 60335-1: 25	Applicable to the manufacturing, it may have implications in the installation process (e.g. where or how to install the system).
Terminals for external conductors	EN 60335-1: 26	The installation requirements may affect the design/manufacturing.
Disconnection from supply	IEC 62282-3-1: 4.15	Disconnection devices might be outside the FC system and, thus, they are to be installed separately using the standard requirements.
Electrical installation	EN 50438: 4	Reference to HD 384 (IEC 60364) and NATIONAL regulations for electrical installations.
	IEC 60364 (Low-voltage)	The most relevant parts are the following: - Part 1: General - Part 4: Protection for safety - Part 5: Selection and erection of electrical equipment - Part 6: Verification
Over-current protection	EN 50438: 4	Reference to HD 384 (IEC 60364).
Power quality	IEC EN 61000	Electromagnetic compatibility (harmonics,

	EMC Directive IEEE 1547: 4.3 EN 55014	flicker...)
Power quality	EN 50438: 5	Power factor
	EN 50438: 5 IEEE 1547: 4.3	DC injection
Interface protection	EN 50438:4	The purpose of the interface protection is to ensure that the connection of a micro-generator unit will not impair the integrity or degrade the safety of the distribution network. According to the standard it might be incorporated in the micro-generator control system or through mounted devices. Reference to IEC 60255-6 (electrical relays) and HD 384. NATIONAL settings must be followed --> Voltage, Frequency and Loss of Mains. Includes reconnection and synchronization requirements.
	IEEE 1547: 4.2	Similar purpose than the previous one.
Metering equipment (A.C.)	IEC 62052 IEC 62053 IEC 62054	This set of standards deal with all the aspects referring to the electricity metering.

Table 15. List of the RC&S related to the macro-topic "Electrical system".

## Heat and hot water

This interface represents the relationship between the FC-based microCHP system and the heating and hot water systems in the house. Special requirements exist, such as temperature, insulation or heat storage, which are important for the installation of the system. Another topic the should be considered is the hot water installation requirements.

HEAT and HOT WATER		
Topics	RC&S	Information
Heat exchangers	IEC 62282-3-1: 4.5	As pressurized equipment, they have to comply with the requirements of IEC 62282-3-1 standard.
Heat storage	IEC 62282-3-1: 4.5	As pressurized equipment, they have to comply with the requirements of IEC 62282-3-1 standard.
	EN 12897	Water supply - Specification for indirectly heated unvented (closed) storage water heaters.
Temperature control	EN 50465: 5.7	Thermostat characteristics.
	IEC 60730-2-9	Automatic electrical controls for households and similar use. Part 2-9: Temp. Sensing controls.
Overheat cut-off	EN 50465: 5.7	Cut-off device specifications.
Water valves	EN 1487, EN 1488, EN 1489, EN 1490, EN 1491, EN 1567	Water valves: Expansion, pressure relief and safety, pressure reduction.
Water pollution protection	EN 1717	Means to be used to prevent the pollution of potable water inside premises and the general requirements of protection devices to avoid pollution by backflow.
Heating system installation	EN 14336	Requirements for the installation and commissioning of water-based heating systems in buildings with a maximum operating temperature of 110 °C and a maximum operating pressure of 6 bar. It is very dependent on the manufacturer's design, which has to consider EN 12828.
	EN 12828	Design criteria for water based heating systems in buildings with a maximum operating temperature of up to 105 °C. It takes into account heating requirements of attached systems (e.g. domestic hot water, process heat, air conditioning, ventilation) in the design of a heat supply, but does not cover the design of these systems.
System efficiency	EN 15316-4-4	Heating systems in buildings - Method for

		<p>calculation of system energy Requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems.</p> <p>System efficiency for each installation must be assessed depending on the system operational method (continuous operation or heat following). Most countries require specific efficiency levels in order to give incentives.</p>
--	--	---

Table 16. List of the RC&S related to the macro-topic "Heat and hot water".

### Construction and siting

The products from the electrochemical reactions in the fuel cell must be removed from the building through chimneys or other outlets. The room in which the FC-based microCHP system is installed might require ventilation, thus venting and purging should be considered. All these issues are regularly present in RC&S documents pertaining to heating appliance installations and, thus, they are of key importance for system installation.

CONSTRUCTION, SITING AND BUILDING		
Topics	RC&S	Information
Foundations	IEC 62282-3-3: 5.1	Firm foundations capable of support the equipment.
Location and protection	IEC 62282-3-3: 5.1	Resistance to wind, rain, ice, freezing temperatures , seismic events, vehicles, etc. Avoidance of hazardous atmospheres (IEC 60079-10). Takes into account the presence of combustible materials. Avoidance of unauthorized access. Permission of service, maintenance and emergency access.
Exhaust and vent outlet	IEC 62282-3-3: 5.1	Located to prevent its introduction in the building and/or the direct emission to walkways or other pedestrian paths.
Indoor locations: building regulations	National level	Heating and electrical appliances, fuel storage systems, conservation of fuel and power, protection against pollution, and more generally to securing reasonable standards of health and safety for people in or about buildings and any others who may be affected by buildings or matter connected with buildings. Some of these topics may be considered in other macro-topics.
Ventilation needs and installation	IEC 62282-3-3: 6 IEC 62282-3-1 IEC 60079-10 ATEX directive	HYPER description: 4.4.1 Prevention of explosive atmospheres.
Ignition sources	IEC 60079 IEC 62282-3-1: 4.6	If the formation of an explosive atmosphere cannot be prevented or the process operates with a flammable atmosphere, the next level of protection is the avoidance of ignition sources in areas where a flammable atmosphere may occur.

		<p>Electrical and non-electrical equipment appropriate for use in the different areas of the workplace should be determined once the hazardous areas have been identified and classified. The EN 60079 series of standards specifies the requirements and testing of electrical equipment for use in the different zones.</p> <p>Appropriate protection is also required against the risk of lightning strike when designing outdoor fuel cell or hydrogen storage facilities.</p>
Explosion mitigation	<p>EN 14994 EN 14797 EN 14373 EN 15089 EN 12874 EN 14460 IEC 62282-3-1: 4.6</p>	<p>If explosive atmospheres may be present and ignition sources cannot be eliminated, then measures to mitigate the effects of the explosion, should an ignition occur, and prevent the explosion propagating to surrounding areas are required (explosion venting or suppression isolation systems, containment systems, blast walls).</p>
Overheating	IEC 62282-3-1: 4.6	<p>Related to thermal insulation of surrounding materials when working at high temperature (SOFC) to avoid fire.</p>
Fire detection and protection	IEC 62282-3-1: 4.6	<p>Provision of automatic fire detection systems.</p>
Air quality	IEC 62282-3-1: 4.4	<p>The environment contaminants must be considered to assess the suitability of the siting place.</p>
Leak containment	IEC 62282-3-1: 4.4	<p>The enclosure must be design to contain any anticipated leak.</p>
Pressure equipment	IEC 62282-3-1: 4.5	<p>Comply with national/regional legislation.</p>
Rotational equipment	IEC 62282-3-1: 4.12	<p>If any compressors and pumps must be installed, they should satisfy the standards requirements. The section 4.12 of IEC 62282-3-1 gives a list of related standards.</p>
Hydrogen generator installation	ISO 16110-1	<p>Annex D provides information about vent system, hydrogen piping and marking. Since the systems are provided with the hydrogen generator included in the package, only the venting requirements must be considered and, also, a hydrogen mark should be included.</p>

Table 17. List of the RC&S related to the macro-topic "Construction and siting".

## Exhaust

The system is installed inside a building, where building codes apply. The related macro-topic has been called "Construction and Siting", since construction issues and siting requirements have to be considered.

EXHAUST		
Topics	RC&S	Information
Exhaust circuit	EN 50465: 5.1	Ducts, components.
Condensate disposal	ISO 16110-1	Sub-section 4.4.8 Regulates the exhaust condensate disposal for the hydrogen generator.
Purging and venting	IEC 62282-3-3: 6.4 IEC 62282-3-1: 4.5	Venting and purging outside the building. States LFL and CO concentration limits to allow doing it into room atmosphere. Requirements for venting pipelines.
Chimneys	EN 1443 EN 1856-1,2	The first reference standard is more general while the other deals with metal chimneys.
Exhaust composition	ISO 16110-1: 4.4.9	Carbon monoxide content in exhaust from hydrogen generator

Table 18. List of the RC&S related to the macro-topic "Exhaust".

## Administration

The system should be installed by a specialized technician and used by trained users. Marking , user-safety and noise are topics related to this macro-topic.

ADMINISTRATION		
Topics	RC&S	Information
CE label	2009/142/EC (ex 90/396/EEC)	Gas appliance directive.
	94/9/EC	ATEX equipment directive.
	97/23/EC	Pressure Equipment Directive.
	2004/108/EC	Electromagnetic Compatibility Directive.
	2006/95/EC	Low Voltage Directive.
	2006/42/EC	Machinery Directive.

Table 19. List of the RC&S related to the macro-topic "Administration".

## People

The system installation needs to comply with national, regional and even local administration requirements, such as construction permits or technical documentation.

PEOPLE: User, installer and maintenance interface		
Topics	RC&S	Information
Accessible parts	IEC 62282-3-1: 4.4	No sharp/rough surfaces/edges to avoid injuries.
Noise control	IEC 62282-3-1: 4.4 ISO 16110-1: 4.4.7	Comply with national/regional legislation.
Surface temperature	IEC 62282-3-1: 4.4 ISO 16110-1: 4.4.4	Reference to IEC 60335-1. Table of temperatures given. If this is considered in the design, it may not affect the installation. ISO 16110-1 for hydrogen generator.
Stability, secure mounting, rigid support	IEC 62282-3-1: 4.4	Related to topics in the "Construction, siting and building" macro-topic.
Sampling and take-off points	IEC 62282-3-1: 4.4	Design and marking precautions if flammable/toxic fluids inside the pipes.
Marking and instructions	IEC 62282-3-1: 4.9 EN 50645: 5.6 EN 60335-2-102 EN 60335-1: 7	Appropriate marking and instructions to avoid operation and installation issues. Regarding levers, controlling and setting devices and electrical equipment.
User's information manual	IEC 62282-3-1: 7	For fuel cell power systems to be installed for residential use, the system supplier shall provide to the residence owner a user's information manual, together with any appropriate additional information to facilitate maintenance.
Installation manual	IEC 62282-3-1: 7	The installation manual shall provide the installer with all the information necessary for the preliminary work of setting-up the fuel cell power system.
Operating manual	IEC 62282-3-1: 7	The operating manual shall detail proper procedures for the set-up and use of the fuel cell power system.
Maintenance manual	IEC 62282-3-1: 7	The maintenance manual shall detail proper procedures for adjustment, servicing, and preventive inspection, and repair.
Heating systems	EN 12170 EN 12171	This standard specifies requirements for providing documents for the operation, maintenance and use of heating systems in buildings.

Table 20. List of the RC&S related to the macro-topic "People".

## Annex IV

### Additional informations on the questionnaires proposed

This Annex contains all the details related to the questionnaires proposed, with the extended versions of their structure, the questions made and the feedbacks received, topic-by-topic, from the manufacturers to which they were addressed.

#### Questionnaire referred to the Codes & Standards

##### Structure

As can be seen from the Table below, the topics are not too specific and contain different issues that are somehow related to each other (e.g. the exhaust and environment topic includes various issues, such as noise, exhaust composition or exhaust outlet system). The logic behind this was to create a more comprehensive questionnaire for the analysis that would provide more meaningful results.

Topic	Explanation	Reference standard(s)
<b>Natural gas quality</b>	Composition, heating value, Wobbe index. It also includes the type of heating appliance, according to the gas fuels it can use.	<b>EN 50465</b>
<b>Natural gas supply system</b>	Pipelines, valves, pressure management	<b>EN 50465</b> <b>IEC EN 62282-3-300</b>
<b>Air supply system</b>	Ducts, fans, compressors	<b>EN 50465</b>
<b>Hydrogen production unit</b>	Natural gas reformer system	<b>ISO 16110</b>
<b>Electrical system installation</b>	Wiring, grounding, electrical protection, etc.	<b>IEC EN 60335</b> <b>IEC EN 60364</b> <b>EN 50438</b>
<b>Islanding</b>	Islanding for distributed generators in the electrical grid	<b>IEEE 1547</b>
<b>Power quality</b>	Harmonics, flicker, DC injection, power factor, etc.	<b>EN 50438</b> <b>IEEE 1547</b>
<b>Electromagnetic compatibility</b>	-	<b>IEC EN 61000</b>
<b>Energy metering</b>	Electrical and thermal energy	<b>CEN/CLC/ETSI/TR 50572</b>

Topic	Explanation	Reference standard(s)
	metering for billing purposes	<b>IEC EN 62052</b> <b>IEC EN 62053</b> <b>IEC EN 62054</b>
<b>Thermal insulation</b>	Insulation for hot box and hot water pipelines	<b>EN 50465</b> <b>IEC EN 62282-3-100</b> <b>EN 12828</b>
<b>Hot water</b>	System installation (pipelines, valves, heat storage, HEX) and working temperature limits	<b>EN 50465</b> <b>EN 12828</b> <b>EN 12897</b>
<b>Exhaust &amp; environment</b>	Exhaust composition and outlet system (ducts, chimneys) and other environmental issues (waste water, noise, etc.)	<b>EN 50465</b> <b>IEC EN 62282-3-300</b>
<b>Ventilation</b>	Appliance room and inside the hot box	<b>IEC EN 62282-3-300</b>
<b>Safety</b>	General (fires, explosions, hazardous substances, etc.) and user safety (moving parts, surface temperatures, pressurization, etc.)	<b>IEC EN 62282-3-100</b> <b>EN 50465</b> <b>EN 12828</b>
<b>Control system</b>	Control strategies and devices	<b>EN 50465</b> <b>EN 12828</b>

Table 21. International and European RC&S status: topic explanation.

Reference standard	Name
<b>EN 50645</b>	Gas appliances - Fuel cell gas heating appliance - Fuel cell gas heating appliance of nominal heat input inferior or equal to 70 kW.
<b>IEC EN 62282-3-300</b>	Fuel cell technologies. Part 3-300: Stationary fuel cell power systems - Installation.
<b>ISO 16110</b>	Hydrogen generators using fuel processing technologies
<b>IEC EN 60335-1</b>	Household and similar electrical appliances - Safety. Part 1: General requirements.
<b>IEC EN 60335-2-102</b>	Household and similar electrical appliances - Safety. Part 2: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections.
<b>IEC EN 60364</b>	Electrical Installations for Buildings. Parts 1 (General), 4 (Protection for safety), 5 (Selection and erection of electrical equipment), 6 (Verification).
<b>CEN/CLC/ETSI/TR 50572</b>	Functional Reference Architecture for Communications in Smart

Reference standard	Name
	Metering Systems.
<b>EN 50438</b>	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks.
<b>IEEE 1547</b>	Standard for Interconnecting Distributed Resources with Electric Power Systems.
<b>IEC EN 61000</b>	Electromagnetic compatibility standard series.
<b>IEC EN 62052</b> <b>IEC EN 62053</b> <b>IEC EN 62054</b>	Electricity metering equipment (a.c.).
<b>IEC EN 62282-3-100</b>	Fuel cell technologies. Part 3-100: Stationary fuel cell power systems - Safety.
<b>EN 12828</b>	Heating systems in buildings. Design for water-based heating systems.
<b>EN 12897</b>	Water supply. Specification for indirectly heated unvented (closed) storage water heaters.

Table 22. Name of the reference standards used for the questionnaire.

<b>QUESTION A --&gt; To be answered if a standard already exists</b>	Feel free to add comments about it in column L
Regarding the quality of the standard contents dealing with the addressed issue, do you think they should be <b>improved, confirmed</b> (stay as they are) or that it is better not to include this issue in international standards ( <b>remove it</b> )?	
<b>Possible answers:</b>	
<b>Improve it:</b> The standards addressing the issue need to be revised and updated with better contents to be useful	
<b>Confirm it:</b> The standards addressing the issue are good enough and the issue-related contents don't need to be revised	
<b>Remove it:</b> The issue is not properly handled by current standards and we think it should actually be either not standardized or left to regional/national regulation/standardization	
<b>QUESTION B --&gt; To be answered if a standard already exists</b>	
Feel free to add comments about it in column L	
Have the standards been effectively used in your company's products development? How has it been your experience while using it?	
This question aims to gather knowledge about the usability of the standard (i.e. the content might be good, but either the content organization, language or any other thing might make its usage inconvenient or even impossible)	
<b>Possible answers:</b>	
<b>Very good:</b> The standards usage experience is very good (useful, helpful, easy...)	
<b>Good enough:</b> The standard can be used, but sometimes is not clear enough or it lacks specific explanations that would make its usage optimal	
<b>Bad:</b> The standard is not helpful and its usage creates problems that require too much time to be solved (contradictions, poor language, same things are regulated in several sections...)	

Figure 17. Layout for extended versions of questions and answers.

	Reference standard(s)	Question A (choose one)			Question B (choose one)			Comments
		Improve it	Confirm it	Remove it	Very good	Good enough	Bad	
1 Natural gas quality	EN 50465							
2 Natural gas supply system	EN 50465 IEC EN 62282-3-300							
3 Air supply system	EN 50465							
4 Hydrogen production unit	ISO 16110							
5 Electrical system installation	IEC EN 60335 (electrical appliances) IEC EN 60364 / HD 384 (electrical installations) EN 50438							
6 Islanding	IEEE 1547							
7 Power quality	EN 50438 IEEE 1547							
8 Electromagnetic compatibility	IEC EN 61000							
9 Energy metering	CEN/CLC/ETSI/TR 50572 IEC EN 62052 IEC EN 62053 IEC EN 62054							
10 Thermal insulation	EN 50465 IEC EN 62282-3-100 EN 12828							
11 Hot water	EN 50465 EN 12828 EN 12897 (heat storage)							
12 Exhaust & environment	EN 50465 IEC EN 62282-3-300							
13 Ventilation	IEC EN 62282-3-300							
14 Safety	IEC EN 62282-3-100 EN 50465 EN 12828							
15 Control system	EN 50465 (FC mCHP system) EN 12828 (heating system)							

Figure 18. Layout for the Codes & Standards questionnaire.

*Questions*

**Question A** has the aim of obtaining information about quality of the contents.

<p><b>Question A:</b> <i>Regarding the quality of the standard(s) contents with the addressed issue, do you think they should be <b>improved</b>, <b>confirmed</b> (stay as they are) or that it is better not to include this issue in international standards (<b>remove it</b>)?</i></p>	<p><b>Improve it:</b> The standard(s) addressing the issue need to be revised and updated with better contents in order to be useful.</p>
	<p><b>Confirm it:</b> The standard(s) addressing the issue are good enough and the issue-related contents donot need to be revised.</p>
	<p><b>Remove it:</b> The issue is not properly handled by current standard(s) and we think it should not be standardized or left to regionalnational regulations/standardization.</p>

Table 23. Question A about standard(s) quality.

The objective of **Question B** is to know whether the standard(s) usage experience is satisfactory.

<p><b>Question B:</b> <i>Have the standards been effectively used in your company's products development? What has your experience while using it?</i></p>	<p><b>Very good:</b> The standards usage experience is very good (useful, helpful, easy...).</p>
	<p><b>Good enough:</b> The standard can be used, but sometimes it is not clear enough or it lacks specific explanations that could make its usage optimal.</p>
	<p><b>Bad:</b> The standard is not helpful and its usage creates problems that require too much time to solve (contradictions, poor language, the same topics are regulated in several sections...).</p>

Table 24. Question B referring to the manufacturers experience with the standards considered in the questionnaire.

The manufacturers were also encouraged to make comments to help explain their answers.

### *Results obtained from the answers*

The answers supplied by manufacturers have been collected and organized in the most suitable way. After an analysis conducted topic by topic, the main outcomes have been extracted.

#### **Natural gas quality (EN 50465)**

The main outcome about this topic is that there is a lack of harmonization of gas quality throughout Europe. The differences arise from the local gas (and perhaps hydrogen, especially in the future) producers.

Standard EN 50465 refers to EN 437 ("*Test gases - Test pressures - Appliance categories*") about test gas but it does not mention anything about the gas composition aspects.

ISO 13686 ("*Natural gas - Quality designation*"), which deals with the Quality Designation of natural gas is an interesting International Standard. It specifies the parameters that describe processed natural gas and, where required, other natural gas-based mixtures. A list of these parameters, their units and references to measurement standards (e.g., ISO 15970 "*Natural gas – Measurement of properties – Volumetric properties: density, pressure, temperature and compression factor*" and 15971 "*Natural gas – Measurement of properties – Calorific value and Wobbe index*") are given in the main text. However, no specific reference values or limits are supplied. Examples of typical values for some of these parameters are provided in the annexes where special focus is put on the health and safety-related aspects. Information is also given in the annexes about the methods that should be used to define the interchangeability of gases as well as some national standards that refer to specific natural gas parameters.

#### **Natural gas supply system (EN 50465 and IEC EN 62282-3-300)**

Reference standard, EN 15502-2-1:2012 ("*Gas-fired central heating boilers - Part 2-1: Specific standard for type C appliances and type B2, B3 and B5 appliances of a nominal heat input not exceeding 1 000 kW*") gives information that also applies to FC-based microCHP units and it supersedes EN 483.

Standard EN 62282-3-300 deals with the installation of stationary fuel cell power systems. This standard refers to EN 62282-3-100, which supersedes EN 62282-3-1.

However, because of some considerations, such as the free gas distribution market, new local biogas producers, new LNG terminals and interchangeability of gas, the distribution system is not fixed.

#### **Air supply system (EN 50465)**

The reference standard does not treat an important aspect, that is, air quality.

Besides the reference standard, the following have been suggested:

- TR 1749 standard ("*European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types)*") which gives a classification of appliances in terms of combustion product discharge methods;
- EN 62228-4-400 standard (also cited in other topics of the questionnaire) which, at the moment, is apparently not available at the draft stage.

#### **Hydrogen production unit (ISO 16110)**

There is currently no standardization of the hydrogen production units inside the FC-based microCHP systems. Thus, an interesting improvement of the EN 50465 and IEC EN 62282 standards would be to mention the natural gas reforming standard for hydrogen production (ISO 16110). However, this standard is the current reference for hydrogen production when natural gas reforming is used, which makes it an important document for FC-based microCHP units.

#### **Electrical system installation (IEC EN 60335, IEC EN 60364, and EN 50438)**

Besides the reference standards cited in Table 19, several other documents have been suggested by Ene.field partners, at both a national and a European level:

- **VDE AR N 4105** ("*Power generation systems connected to the low-voltage distribution network - Technical minimum requirements for the connection to and parallel operation with low-voltage distribution networks*") is a German application guide pertaining to the planning, mounting, operation and modification of generators connected to the low-voltage distribution network and operated in parallel;
- the **ENTSO-E network code** defines a common framework of grid connection requirements for Power Generating Facilities, including Synchronous Power Generating Modules, Power Park Modules and Offshore Generation Facilities;
- the Low Voltage Directive (LVD) 2006/95/EC;
- the Electromagnetic Compatibility (EMC) Directive 2004/108/EC;
- the '*Installation permitting guidance for hydrogen and fuel cell stationary applications*' (2009) developed as a UK version of the Guide developed in the HYPER project by the UK Health Safety Executive (HSE).

Standard EN 50438 it has been reviewed considering the Network Code on the Requirements for Generators draft of April 2012, and it has already been distributed to the national committees for commenting on and approval.

Another important aspect mentioned in the manufacturers' answers to the questionnaire is that FC-based microCHP system inverters should comply with standard EN 62109 ("*Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters*") about

photovoltaic inverters rather than EN 60335. Taking this as an example, an important outcome of the analysis is that current standards for other technologies can be used for FC-based microCHP systems, which would make the market entry of these units simpler and faster.

#### **Islanding (IEEE 1547)**

This topic did not receive any specific comments from the Ene.field FC-based microCHP systems manufacturers, which has been taken as a sign that it is less important in system standardization.

#### **Power quality (EN 50438 and IEEE 1547)**

As in the topic '*Electrical system installation*', the ENTSO-E network code and VDE AR N 4105 ("*Power generation systems connected to the low-voltage distribution network - Technical minimum requirements for the connection to and parallel operation with low-voltage distribution networks*") have been suggested.

Moreover, it has been highlighted that standard EN 50438 is linked to national standards. This is explained by the fact that deviations of it exist, in terms of "interface protection settings", for several countries.

#### **Electromagnetic compatibility (IEC EN 61000)**

In addition to the proposed IEC 61000 series (Table 19), which deals with limits and generic standards related to electromagnetic compatibility, the following standards have been suggested:

- the **EN 55014 series** ("*Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus*"), which deals with the requirements for household appliances, electric tools and similar apparatus;
- **EN 60335-2-102**, which deals with the safety of household and similar electrical appliances;
- **EN 62233** ("*Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure*"), which deals with measurement methods for the electromagnetic fields of household appliances and similar apparatus with regard to human exposure.

#### **Energy metering (CEN/CLC/ETSI/TR 50572, IEC EN 62052, IEC EN 62053 and IEC EN 62054)**

European Directive 2004/22/CE could be useful for this topic. It deals with measuring instruments, and in particular it regulates the characteristics of devices and systems with a measuring function, including water meters, gas meters and volume conversion devices, active electrical energy meters, heat meters, material measures and exhaust gas analysers.

However, it has been pointed out, by some manufacturers, that the development of a common protocol for smart metering throughout the EU should be considered and encouraged by the ene.field consortium.

#### **Thermal insulation (EN 50465, IEC EN 62282-3-100 and EN 12828)**

Standard EN 50465 does not refer to EN 62282-3-100 (4.14) as far as thermal insulation is concerned. This lack of consistency should be considered in future revisions of both standards.

#### **Hot water (EN 50465, EN 12828 and EN 12897)**

The main conclusion is that there is a need of harmonization at a European level because, till now, just documents and guidelines exist at a national level (e.g., KTW tests and WRAS approval).

Another point that should be underlined is that standard EN 50465 should include references to specific domestic hot waters standards (such as EN 12828).

#### **Exhaust&environment (EN 50465 and IEC EN 62282-3-300)**

Harmonization at a European level should be considered since, till now, only national or regional standards exist. Sometimes, there are also requirements linked to specific funding schemes, which makes the situation even more complicated.

Besides the cited references in Table 19, EN 62282-3-100 should also be considered. However, standards belonging to the 62282 series have the problem that they deal with Fuel Cell Power Systems without taking into account FC-based microCHP systems. This is relevant, particularly in the definition of parameter limits (e.g., CO emission limits).

As far as this topic is concerned, the European Commission has released Directive 2009/125/EC (also named Energy-related Products (ErP) Directive) which establishes a framework for the setting of ecodesign requirements for energy-related products. This is an important Directive and its contents will be discussed in the questionnaire about EU regulations.

#### **Ventilation (IEC EN 62282-3-300)**

In a similar fashion to the previous topic, the main issue is that the IEC EN 62282 series refers to Fuel Cell Power Systems, and as a result the values for parameter limits are not adequate for FC-based microCHP systems.

Besides the cited reference standard, the 60079-10 series ("*Explosive atmospheres*") is suggested. This series of two standards treats the classification of areas in which explosive atmospheres are present.

### **Safety (IEC EN 62282-3-100, EN 50465 and EN 12828)**

A part from the reference standards, there are also some European Directives that deal with this topic:

- Gas Appliances Directive (GAD) 2009/142/EC;
- Low Voltage Directive (LVD) 2006/95/EC;
- Electromagnetic Compatibility (EMC) Directive 2004/108/EC.

Furthermore, the UK Health Safety Executive (HSE), has produced an excellent document from work conducted as part of the HYPER project, that is, '*Installation permitting guidance for hydrogen and fuel cell stationary applications*' (2009) which is intended as a compendium of the current knowledge and RC&S regarding the installation of small stationary hydrogen and fuel cell systems.

Finally, it is important to underline that there is no agreement, regarding gas safety aspects, between IEC EN 62282-3-100 and EN 50465.

### **Control system (EN 50465 and EN 12828)**

Several standards are suggested:

- EN 298 ("*Automatic burner control systems for burners and appliances burning gaseous or liquid fuels*"), which deals with automatic control systems for burners and appliances that burn gaseous or liquid fuels;
- EN 13611 ("*Safety and control devices for gas burners and gas burning appliances - General requirements*"), which deals with safety and control devices for gas burners and gas appliances;
- EN 60730 ("*Automatic electrical controls for household and similar use*"), which deals with automatic electrical controls for households and similar use.

Another aspect mentioned in the questionnaire answers is the lack of clarity in EN 50465, EN 62282 and EN 298 regarding the definition of some parameters (e.g., lock-out and reset conditions).

## **Questionnaire referred to EU Regulations**

### *Structure*

<b>QUESTION A1</b>	<i>Feel free to add comments about it</i>
Referring to the labelling, to the product fiche and to the technical documentation, as they are described in the present Regulation, are they complete in terms of information supplied for the characterization of the product? For example, in the label scheme of a cogeneration space heater is not present any information about its electrical efficiency; this information is present only in the product fiche and in the technical documentation.	
<b>Possible answers:</b>	
<b>Complete:</b> These elements are well structured.	
<b>To be modified:</b> The general structure is well designed but there are some aspects that need to be modified.	
<b>To be changed:</b> These elements are not well structured because they don't supply a complete and sincere characterization of the product described.	
<b>QUESTION A2</b>	<i>Feel free to add comments about it</i>
In this Regulation, a labelling scale is introduced in order to characterise heating devices in terms of seasonal space heating energy efficiency. Can the creation of these energetic classes be penalizing for the cogeneration technology due to the high values of efficiency considered?	
<b>Possible answers:</b>	
<b>Yes:</b> This kind of labelling scale is penalizing.	
<b>Partially:</b> The labelling scale introduced could be penalizing for the cogeneration technology if won't be done some changes.	
<b>No:</b> This kind of labelling scale is not penalizing.	
<b>QUESTION B1</b>	<i>Feel free to add comments about it</i>
The Directive 2009/125 establishes a framework for the setting of ecodesign requirements for energy-related products. What do you think about the methods for setting generic (Annex I) and specific (Annex II) ecodesign requirements?	
<b>Possible answers:</b>	
<b>Very good:</b> The methods established are well described and consider all the requirements needed for ecodesign.	
<b>Good enough:</b> The methods are well described but probably not all the aspects are considered.	
<b>Bad:</b> The methods established are not clear and don't consider fundamental aspects for ecodesign.	
<b>QUESTION B2</b>	<i>Feel free to add comments about it</i>
The Regulation 813/2013 establishes ecodesign requirements for space heaters and combination heaters. Are targets fixed for cogeneration devices, in terms of ecodesign requirements (Annex II), reasonable (e.g., from 26 September 2015 the seasonal space heating energy efficiency for cogeneration space heaters shall not fall below 86% and from 26 September 2017 shall not fall below 100%)?	
<b>Possible answers:</b>	
<b>Yes:</b> The targets fixed are well chosen without affecting the development of the cogeneration technology.	
<b>Partially:</b> The targets fixed require high efforts in order to be reached.	
<b>No:</b> The targets fixed are impossible to fulfill and this choice penalize the development of the cogeneration technology.	
<b>QUESTION C</b>	<i>Feel free to add comments about it</i>
Regarding the contents of Directives dealing with system installation issues, could you give a comment about them?	
<b>Possible answers:</b>	
<b>Very good:</b> The Directive is perfect for the purpose.	
<b>Good enough:</b> The Directive is useful for the purpose but there are some aspects that should be considered.	
<b>Bad:</b> The Directive is not useful for the purpose.	

Figure 19. Layout for extended versions of questions and answers.

	Reference Regulation	Question A1 (choose one)			Question A2 (choose one)			Comments
		Complete	To be modified	To be changed	Yes	Partially	No	
Energy labelling	Commission Regulation (EU) n. 811/2013							

	Reference Regulations	Question B1 (choose one)			Question B2 (choose one)			Comments
		Very good	Good enough	Bad	Yes	Partially	No	
Ecodesign requirements	Directive 2009/125/EC Commission Regulation (EU) n. 813/2013							

	Reference Regulation	Question C (choose one)			Comments
		Very good	Good enough	Bad	
Equipment and protective systems in potentially explosive atmospheres	Directive 94/9/EC				
Pressure equipment	Directive 97/23/EC				
Electrical equipment for use within certain voltage limits	Directive 2006/95/EC				
Electromagnetic Compatibility	Directive 2004/108/EC				
Appliances burning gaseous fuels	Directive 2009/142/EC				
Machinery	Directive 2006/42/EC				
Measuring instruments	Directive 2004/22/EC				

Figure 20. Layout for the EU Regulations questionnaire.

### Questions

Questions A1 and A2 refer to European Commission Regulation (EU) no. 811/2013 about energy labelling.

**Question A1** in particular focuses on the information contained in labels, product sheets and on the technical documentation of devices that are the subject of this Regulation.

<p><b>Question A1:</b> Referring to the labelling, to the product fiche and to the technical documentation, as described in the present Regulation, are they complete in terms of information supplied for the characterization of the product? As an example, in the label scheme of a cogeneration space heater is not present any information about its electrical efficiency (this information is present only in the product fiche and in the technical documentation): do you think this could be a sort of limitation for the FC-based microCHP systems?</p>	<p><b>Complete:</b> These elements are well structured.</p>
	<p><b>To be modified:</b> The general structure is well designed but there are some aspects that still need to be modified.</p>
	<p><b>To be changed:</b> These elements are not well structured because they do not supply a complete and honest characterization of the described product.</p>

Table 25. Question A1 about products information.

**Question A2** instead refers directly to the labelling scale introduced in the Regulation.

<p><b>Question A2:</b> In this Regulation, a labelling scale is introduced in order to characterise heating devices in terms of seasonal space heating energy efficiency. Can the creation of these energetic classes be penalizing for the cogeneration technology due to the high values of efficiency considered?</p>	<p><b>Yes:</b> This kind of labelling scale is penalizing.</p>
	<p><b>Partially:</b> The introduced labelling scale could be penalizing for the cogeneration technology unless some changes are introduced.</p>
	<p><b>No:</b> This kind of labelling scale is not penalizing.</p>

Table 26. Question A2 about the creation of a labelling scale.

**Question B1** is aimed at establishing the manufacturers' opinions about the methods for setting ecodesign requirements.

<p><b>Question B1:</b> <i>The Directive 2009/125 establishes a framework for the setting of ecodesign requirements for energy-related products. What do you think about the methods for setting generic (Annex I) and specific (Annex II) ecodesign requirements?</i></p>	<p><b>Very good:</b> The established methods are described clearly and consider all the requirements needed for ecodesign.</p>
	<p><b>Good enough:</b> The methods are described clearly, but probably not all the aspects are considered.</p>
	<p><b>Bad:</b> The established methods are not clear and donot consider the fundamental aspects for ecodesign.</p>

Table 27. Question B1 about ecodesign requirements.

**Question B2** has been phrased focusing more specifically on the definition of the ecodesign requirements in Regulation no. 813/2013.

<p><b>Question B2:</b> <i>The Regulation 813/2013 establishes ecodesign requirements for space heaters and combination heaters. Are targets fixed for cogeneration devices, in terms of ecodesign requirements (Annex II), reasonable (e.g., from 26 September 2015 the seasonal space heating energy efficiency for cogeneration space heaters has not to fall below 86% and from 26 September 2017 has not to fall below 100%)?</i></p>	<p><b>Yes:</b> The fixed targets are well chosen and will not affect the development of the cogeneration technology.</p>
	<p><b>Partially:</b> The fixed targets require a great deal of effort in order to be reached.</p>
	<p><b>No:</b> The fixed targets are impossible to fulfil and this choice penalizes the development of cogeneration technology.</p>

Table 28. Question B2 about targets for ecodesign requirements.

Finally, **Question C** looks for opinions regarding CE marking Directives and the MID Directive.

<p><b>Question C:</b> <i>Regarding the contents of Directives dealing with system installation issues, could you give a comment about them?</i></p>	<p><b>Very good:</b> The Directive is perfect for the purpose.</p>
	<p><b>Good enough:</b> The Directive is useful for the purpose, but there are some aspects that should be reconsidered.</p>
	<p><b>Bad:</b> The Directive is not useful for the purpose.</p>

Table 29. Question C about CE marking Directives.

### *Results obtained from the answers*

The answers supplied by the manufacturers have been collected and then organized in the most suitable way. After an analysis was conducted on each Regulation, the main outcomes were extracted and are presented in the following sections.

For convenience, the reference Regulations/Directives are also reported next to each topic.

#### **Energy labelling - Question A1 (Commission Regulation (EU) no. 811/2013)**

In general, the scheme used for the energy labelling of FC-based microCHP devices has not been considered satisfactory.

First, this Regulation does not adequately take into account the specific characteristics of these devices, and more specifically their ability to generate electric power. Furthermore, when regarding the definition of electrical efficiency, is not clear whether it refers to the rated power output or to the highest efficiency point.

Another aspect that greatly penalizes FC-based microCHP devices is the efficiency estimation equation presented in "Communication from the Commission" referring to Directives 2010/30/EC and 2009/125/EC.

Finally, the manufacturers have suggested that the following information should be displayed, on the label, the product sheet or on the technical documentation:

- Type of microgeneration device (Stirling Engine, PEM Fuel Cell, SOFC etc);
- Rated Electrical Power Output/Generating Capacity;
- Electrical Efficiency at rated power and/or turn down;
- Time to reach full rated power (this differs depending on which technology is used);
- If an UPS mode is available (which allows heating continuity in the event of a power cut).

This problem has been discussed by the German Fuel Cell Association (IBZ), and several letters had already been sent to Brussels (EC).

#### **Energy labelling - Question A2 (Commission Regulation (EU) no. 811/2013)**

Any device with a low heat-to-power ratio will be penalized by the 'Seasonal Space Heating Efficiency' calculation, due to the fact that the device (in this case a fuel cell) will still be operating outside the heating season and generating electricity (displacing most of the base load of the household). It, therefore, appears that the 'Seasonal Space Heating Efficiency' calculation does not take this aspect into account adequately.

**Ecodesign requirements - Question B1 (Directive 2009/125/EC)**

According to the questionnaire answers, Directive 2009/125/EC overall defines an adequate methodology. However, the feedback from the manufacturers, identified some areas, related to the development of FC-based microCHP devices, that still require further consideration:

- first, SOFC Systems do not have well defined guidelines or information in the codes/standards about disposal and recycling. For this reason, some documents with a similar aim to that of SAE-J-2594 "Recommended Practices to Design for Recycling PEM Fuel Cell Systems (Automotive Industry)" would be useful to solve this issue.
- it would be helpful to have a better understanding of how this Directive is inserted in the framework of the EU Directives, pertaining to FC-based microCHP products, which already exist.

**Ecodesign requirements - Question B2 (Commission Regulation (EU) no. 813/2013)**

Despite the concerns highlighted about the "Seasonal Space Heating Energy Efficiency" calculation, the efficiency figures are considered well-chosen, and should not adversely affect the development of fuel cell cogeneration technology.

**Equipment and protective systems in potentially explosive atmospheres - Question C (Directive 94/9/EC)**

It seems that this Directive does not have any specific problems since only a few comments have been made and all of them are positive.

**Pressure equipment - Question C (Directive 97/23/EC)**

It seems that this Directive does not have any specific problems since only a few comments have been made and all of them are positive.

**Electrical equipment for use within certain voltage limits - Question C (Directive 2006/95/EC)**

The issue of the connection of FC-based microCHP devices to the electricity grid is covered by standard EN 50438. However, it is partially accepted across Europe, and supplemented with national versions that refer to European Directives 2006/95/EC and 2004/108/EC (as in the case of the Engineering Recommendations G83 in the UK).

**Electromagnetic compatibility - Question C (Directive 2004/108/EC)**

The feedback received from the manufacturers indicates that this Directive is good enough regarding FC-based microCHP system installation issues.

**Appliances burning gaseous fuels - Question C (Directive 2009/142/EC)**

This Directive is presently being reviewed in order to include the conversion of gas to electricity inside FC-based microCHP systems.

Another important aspect that needs further guidance is the one that refers to hazardous substances and materials. In fact, FC-based microCHP systems contain, or have the potential of producing a number of substances that are not commonly found in household appliances, some of which are hazardous (e.g. Ni(CO)<sub>4</sub>, used as a De-Sulphuriser media).

**Machinery - Question C (Directive 2006/42/EC)**

This Directive is relevant for industrial FC-based microCHP system applications and not for household ones.

This should be taken into account in theEne.fieldproject.

**Measuring instruments - Question C (Directive 2004/22/EC)**

It is not possible to draw any conclusion on this Directive, due to the lack of comments on it. According to the manufacturers, the topic is probably not important for the present development of FC-based microCHP units.

## Annex V

### National legislation

#### Austria

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but all European (EN) standards are usually automatically valid inside EU countries. If not specified, these standards can be found at <https://shop.austrian-standards.at>.

#### *Interconnection to natural gas and water networks*

Standard	Explanation
<b>ÖNORM G 6 (2001):</b> Gas-Inneninstallationen für Betriebsdrücke > 100 mbar <= 5 bar - Technische Richtlinien für Errichtung, Änderung, Betrieb und Instandhaltung von Gasleitungsanlagen für Betriebsdrücke > 100 mbar <= 5 bar ( <i>Gas installations with pressures over 100 mbar and up to 5 bar - Technical rules for construction, modification, operation and maintenance of gas installations with operating pressures over 100 mbar and up to 5 bar</i> ).	This Directive clarifies the ÖNORM EN 1775 standard for gas-line installations with a maximum allowable operating pressure (MOP)> 100 mbar to <= 5 bar. It is intended for gases from the second gas family.
<b>ÖVGW G 55 (2008):</b> Gasversorgungsleitungen mit einem Betriebsdruck <= 5 bar - Funktionale Anforderungen für Planung, Bau, Betrieb und Wartung ( <i>Gas service pipes with an operating pressure &lt;= 5 bar - Functional requirements for planning, construction, operating and maintenance</i> ).	This Directive applies to the establishment of service lines with an operating pressure <= 5 bar for gases of the secondgas family.

The following standards pertain to water installations.

Standard	Explanation
<b>ÖNORM B 2531 (2012):</b> Technische Regeln für Trinkwasser-Installationen - Nationale Ergänzungen zu den ÖNORMEN EN 806-1 bis -5 ( <i>Codes of practice for drinking water installations - National supplements to the ÖNORMEN EN 806-1 to -5</i> ).	This document applies to European standards from EN 806-1 to EN 806-5, and describes additional requirements for the planning, execution, testing, operation and maintenance of both water supply systems, supply pipes and the calculation of connection cables.
<b>ÖNORM H 5142 (1990):</b> Haustechnische Anlagen; hydraulische Schaltungen für Heizungsanlagen ( <i>Building services, hydraulic circuits for heating systems</i> ).	This standard contains a compilation of the most important hydraulic circuits (especially valves and measuring devices), and their application in automation power systems in houses. It refers to the "heat production" area, although in principle the same requirements are valid for cold supply systems.

### *Interconnection to the electrical grid*

Different Regulations exist in Austria, concerning the electrotechnical field of application. The OVE (Austrian Electrotechnical Association) is the organization that deals with security and technical development in the electrical engineering field.

The most relevant Regulations are:

- **Electrical Engineering Regulation 2002 - ETV 2002;**
- **Electromagnetic Compatibility Regulation - EMVV 2006;**
- **Low Voltage Regulation - NspGV 1995;**
- **Electrical Protection Regulation - ESV 2012.**

It is possible to consult this documentation on request (all information is available at <http://www.ove.at/>).

This organization has also made a book available: "**Electrical installation in buildings**" which has the purpose of helping in the interpretation of standards concerning electrical installations in building. In particular it deals with all the aspects concerning the safety of people and protection against failure.

### *Exhaust and environment*

Standard	Explanation
<b>ÖNORM B 8200 (2013):</b> Abgasanlagen - Benennungen und Definitionen ( <i>Exhaust systems - Terms and definitions</i> ).	This standard specifies the terms and definitions of the components that should be used to discharge exhaust gases and supply or remove air.

<p><b>ÖNORM B 8211 (2001):</b> Rauch- und Abgasfänge - Abgasabführung von gebläseunterstützten atmosphärischen Gas-Feuerstätten (<i>Smoke and gas exhaust chimneys (flues) - Flue gas exhaust from fan-assisted atmospheric gas-fired appliances</i>).</p>	<p>This standard deals with the exhaust system of type-approved fan-assisted atmospheric gas-fired appliances (but excludes furnaces with forced draft burners).</p>
--	--

### Building and safety

Standard	Explanation
<p><b>ÖNORM B 2260 (2009):</b> Wärme-, Kälte-, Schall- und Branddämmarbeiten an betriebs- und haustechnischen Anlagen - Werksvertragsnorm (<i>Heat, cold, noise and fire insulation work on industrial and domestic installations - Factory standard contract</i>).</p>	<p>This ÖNORM contains procedural and contractual provisions for the implementation of heat, cold, noise and fire insulation work on operational and technical systems, such as industrial systems, heating, ventilation and sanitary installations as well as refrigeration systems.</p>
<p><b>ÖNORM H 5170 (2008):</b> Heizungsanlagen - Anforderungen an die Bau- und Sicherheitstechnik sowie an den Brand- und Umweltschutz (<i>Heating systems - Requirements for the construction and safety engineering as well as for fire and environmental protection</i>).</p>	<p>This ÖNORM is effective for heating systems with liquid heat transfer fluids for which boiler rooms, holding spaces and / or fuel storage areas are required or permitted by legal regulations. It applies to heating systems in which the boiler is designed for heating in central heating systems, and the heat carrier is water or water mixtures, with a maximum operating temperature of 100°C and a maximum operating pressure of 6 bar.</p>
<p><b>ÖNORM H 5190 (2011):</b> Heizungsanlagen - Schallschutztechnische Maßnahmen (<i>Heating systems - Sound protection Engineering measures</i>).</p>	<p>The present standard pertains to the following tasks:</p> <ul style="list-style-type: none"> <li>- of identifying the noise situation in the holding spaces of heat supply systems, hereafter referred to as boiler rooms;</li> <li>- of establishing the requirements for sound insulation in buildings;</li> <li>- of indicating the measures necessary to reduce noise in the design, in the configuration and in the installation of new facilities as well as of improving existing ones.</li> </ul>
<p><b>ÖNORM H 6036 (2007):</b> Lüftungstechnische Anlagen - Bedarfsabhängige Lüftung von Wohnungen oder einzelner Wohnbereiche - Planung, Montage, Betrieb und Wartung (<i>Ventilation systems - Demand-based ventilation of apartments or individual living areas - planning, installation, operation and maintenance</i>).</p>	<p>This standard deals with the planning, installation, operation and maintenance of ventilation systems of apartments and individual residential areas and areas which have a similar purpose (e.g., residential units in hotels or hostels).</p>

### Heating and hot water system

Standard	Explanation
<p><b>ÖNORM H 5151-1 (2010):</b> Planung von zentralen Warmwasser-Heizungsanlagen mit oder ohne Warmwasserbereitung - Teil 1: Gebäude mit einem spezifischen Transmissionsleitwert über <math>0,5 \text{ W}/(\text{K}\cdot\text{m}^2)</math> - Ergänzungsnorm zu ÖNORM EN 12828 (<i>Planning of central hot water heating systems with or without hot water - Part 1: Buildings with a specific transmission conductance of about <math>0.5 \text{ W} / (\text{K m}^2)</math> - Collateral standard of ÖNORM EN 12828</i>).</p>	<p>This ÖNORM applies to the design of heating systems and is valid for water heat carriers and frost proof heat transfer up to a maximum operating temperature of <math>110^\circ \text{C}</math> (safety temperature).</p>
<p><b>ÖNORM H 5155 (2013):</b> Wärmedämmung von Rohrleitungen und Komponenten in haustechnischen Anlagen (<i>Thermal insulation of pipes and components in technical systems</i>).</p>	<p>This standard refers to the thermal insulation of all heating system and water heating system components.</p>
<p><b>ÖNORM M 7550 (2002):</b> Heizkessel mit Betriebstemperatur bis <math>100^\circ \text{C}</math> - Begriffe, Anforderungen, Prüfungen, Kennzeichnungen (<i>Boilers with operating temperatures of up to <math>100^\circ \text{C}</math> - Definitions, requirements, tests, markings</i>).</p>	<p>This ÖNORM contains the requirements for the design and manufacture, and the operational parameters of boilers and gives rules on testing and marking.</p>
<p><b>ÖNORM M 7780 (1997):</b> Blockheizkraftwerke - Benennungen mit Definitionen (<i>Combined heat and power units - Terms with definitions</i>).</p>	<p>This standard gives definitions on combined heat and power unit components.</p>

## Belgium

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but all European (EN) standards are usually automatically valid inside the EU countries. If not specified, these standards can be found at <http://shop.nbn.be>.

### Interconnection to natural gas and water networks

Standard	Explanation
<p><b>NBN D 51-003 (2010):</b> Installations intérieures alimentées en gaz naturel et placement des appareils d'utilisation - Dispositions générales (<i>Indoor installation pipework for natural gas and the placing of consumer appliances - General prescriptions</i>).</p>	<p>This standard specifies the general technical and security conditions that apply to:</p> <ul style="list-style-type: none"> <li>- new indoor facilities, or new parts of indoor facilities fed by natural gas, with a maximum operating pressure (MOP) of 100 mbar and nominal diameter lines lower than or equal to DN 50;</li> <li>- the placement and commissioning of appliances.</li> </ul> <p>The placement of devices includes: compliance of the device; verification of the planning and equipment installation spaces, and it includes resistance to high temperatures; the realization and / or verification of combustion air supply; the production and / or verification of the evacuation of combustion products; connection to the indoor facility.</p>
<p><b>NBN D 51-004 (1992):</b> Installations alimentées en gaz combustible plus léger que l'air distribué par canalisations - Installations particulières (<i>Installations for combustible piped gas, lighter than air - Special installations</i>).</p>	<p>The standard specifies the technical and security conditions that apply to:</p> <ul style="list-style-type: none"> <li>- new indoor facilities, or new parts of installations: a) whose maximum allowable working pressure (MAWP) is 100 mbar and whose: 1) nominal pipe diameter is greater than DN 50, 2) or pipelines are buried. b) whose PMSA is greater than 100 mbar and less than 15 bar;</li> <li>- Placement and connection of relaxation devices;</li> <li>- Connection of domestic gas installations to the distributor network;</li> <li>- Connection of devices to lower installations.</li> </ul>

**BELGAQUA** is the **Belgian Federation for the Water Sector**(<http://www.belgaqua.be>) which deals with water regulations in Belgium. It groups the three regional trade associations together: AQUABRU for the Region of Brussels-Capital, AQUAWAL for the Walloon Region and AQUA FLANDERS for the Flemish Region.

As an important feature, BELGAQUA participates in both national and international standardization work and it has been designated as an operator for the following areas (only the national ones are listed here):

- **E164:** Water supply;
- **E165:** Waste Water engineering;
- **E308:** Characterisation of sludges.

*Interconnection to the electrical grid*

Standard	Explanation
<p><b>NBN 18-300 (1989):</b> Code de bonne pratique pour la protection des installations électroniques et électriques à basse et à très basse tension contre la foudre (<i>Code of practice for the protection of electronic and electric installations of low and very low voltage against lightning</i>).</p>	<p>This standard defines the general principles for the protection of equipment against the effects of a lightning in buildings or on sites as well as against surges introduced by external links (telephone cables, cable, electric power ... ).</p>
<p><b>NBN C 73-335-01 (1989):</b> Sécurité des appareils électrodomestiques et analogues - Partie 1: Exigences générales (<i>Safety of household and similar electrical appliances - Part 1 : General requirements</i>).</p>	<p>No description available.</p>
<p><b>RGIE (<a href="http://www.emploi.belgique.be">http://www.emploi.belgique.be</a>):</b> Le Règlement général des Installations électriques (<i>Belgian general regulations on electrical installation</i>).</p>	<p>RGIE was introduced by the Royal Decree of 10 March 1981. It applies to electrical installations that were put into operation after 1 October 1981. It gives a series of preventive measures against the effects of electricity and also includes the requirements for the selection and use of lines, electrical machinery and apparatus.</p>
<p><b>C 10/11 - 06.2006:</b> Prescriptions techniques spécifiques de raccordement d'installations de production décentralisée fonctionnant en parallèle sur le réseau de distribution (<i>Specific technical requirements for the connection of distributed generation facilities operating in parallel on the distribution network</i>).</p>	<p>This is the Belgian version of the European standard EN 50438. These technical requirements apply to facilities that generate electrical energy connected to low or medium voltage distribution networks, covering power ranges of up to plus or minus 25 MVA. <a href="http://www.synergrid.be/">http://www.synergrid.be/</a>.</p>

### Building and safety

Standard	Explanation
<p><b>NBN D 50-001 (1991):</b> Dispositifs de ventilation dans les bâtiments d'habitation (<i>Ventilation devices in residential buildings</i>).</p>	<p>This standard applies to buildings, or parts of new buildings for housing. It also applies to buildings, or parts of new construction, or major undergoing interior renovation and used as dwellings.</p> <p>This standard provides general guidance, and not specific data, relating to fresh air inlets and exhaust stale air necessary for devices with non-sealed combustion (eg. boiler appliances that produce hot water, etc.).</p>

### Heating and hot water system

Standard	Explanation
<p><b>NBN D 30-041 (1992):</b> Chauffage central, ventilation et conditionnement d'air - Conditions communes à tous les systèmes - Calorifuge (<i>Central heating, ventilation and air conditioning – Conditions Common to all systems - Thermal insulation</i>).</p>	<p>This standard deals with the insulation of central heating systems, ventilation and air conditioning. More in general, standards belonging to series D 30 show the common requirements of all central heating systems, ventilation and air conditioning, that is regardless of which heating or cooling fluid (water, steam, refrigerant, air, ...) carries the heat energy from the generators to the premises.</p>
<p><b>NBN B 61-002 (2006):</b> Chaudières de chauffage central dont la puissance nominale est inférieure à 70 kW - Prescriptions concernant leur espace d'installation, leur amenée d'air et leur évacuation de fumée (<i>Central heating boilers with a nominal heat output of less than 70 kW - Prescriptions concerning their installation space, air supply and evacuation of the flue gases</i>).</p>	<p>This standard specifies the technical conditions and safety of a central heating boiler, with or without the production of hot water, with a rated power of less than 70 kW in the premises where these boilers must be placed in a new or renovated building (where renovation means a thorough adaptation of the flue) and air supply and exhausts from these boilers.</p> <p>This standard does not apply to combustion appliances intended exclusively for the heating of the rooms in which they are installed.</p>

## Denmark

The Danish national administration drew up **Building Regulations (2010)** (<http://bygningsreglementet.dk/>) in order to establish the rules for the construction of building in Denmark. These Regulations refer to all forms of domestic, industrial, commercial and institutional buildings. The aim is to design buildings that have satisfactory operational conditions, in terms of safety, health, accessibility and use by all, and in terms of cleaning and maintenance.

In relation to the installation of heating appliances, the most relevant sections of these Regulations are:

- **Section 6 - Indoor climate.** This section deals with all the aspects that are connected to the comfort of inhabitants, such as ventilation and acoustics.
- **Section 7 - Energy consumption.** The energy performance of buildings is discussed in this section.
- **Section 8 - Services.** This is about the services which supply a building with power, gas, heating, cooling, drainage and water for heating, cooling, ventilation, water consumption, waste disposal and equipment with the aim of making buildings accessible. This is the most relevant section: *Article 8.4*, which deals with water installations and drainage systems, *Article 8.5.1*, which deals with combustion plants (*Article 8.5.1* is focused on small-scale CHP plants) and *Article 8.5.3*, which deals with exhaust systems, are of particular interest.

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://webshop.ds.dk>.

## *Interconnection to natural gas and water networks*

As far as gas regulations are concerned, the **Danish Gas Code** (<http://www.sik.dk>) is in force in Denmark. This code is composed of three sections. The most relevant parts are listed below:

- **Section A.** This gives general installation guidelines for gas installations for common consumers. The gas installations include the service line from the connection to the main line, house entries, regulators, gas meters, house wiring and gas appliances, ventilation and exhaust systems.
- **Section B-4 with Chapter 5 (revised in January 2011).** This contains installation instructions for large gas-fired plants (even greater thermal input than 135 kW). Chapter 5 instead focuses on chimneys and flue systems.

- **Section C-1.** This is about guidelines for the conformity assessment, sale, marketing and commissioning of gas equipment with a maximum allowable operating pressure of less than or equal to 16 bar.
- **Section C-2.** This regulation includes provisions for gas equipment, its design, functioning and labelling.
- **Sections from C-3 to C-8.** These sections contain provisions concerning conformity assessment elements.
- **Section C-10.** This section includes provisions for gas suppliers. These provisions include city gas, natural gas and F-gas suppliers, and can also be applied to companies that distribute biogas or household gas to more than one consumer.
- **Order no. 1674, 14/12/2006 (supersedes Section C-11).** This order pertains to the authorization and operation of businesses such as a plumbing, water and sanitation masters, approved competent companies or sewer contractors.
- **Section C-12.** This contains requirements relating to the quality of combustible gases supplied by transmission or distribution network for town gas, natural gas, liquefied petroleum gas, biogas or hydrogen for use in gas installations and gas equipment that have been constructed properly and maintained under the Gas Regulations.

Apart from this Danish Code, there are also other relevant standards related to this topic.

Standard	Explanation
<b>DS 141 (1934):</b> Gasmålerforskrninger ( <i>Couplings for gas meters</i> ).	This standard describes the construction and sizes of pipe connections to gasmeters.
<b>Sikkerhedsstyrelsens vejledning for installation af brint forbrugende anlæg (Revideret 20. juni 2011.)</b> ( <i>Security Agency guidelines for the installation of hydrogen-consuming appliances (Revised on 20 June 2011)</i> ).	The Safety Agency guidelines for the installation of hydrogen-consuming appliances deal with: <ul style="list-style-type: none"> <li>- which laws and regulations are applicable for the installation of hydrogen-consuming appliances;</li> <li>- information about the various supply options;</li> <li>- the 5 main categories for hydrogen installation requirements for the installation of small fuel cells with a rated power of less than 10 kW.</li> </ul>
<b>Consolidation Act No. 1331 of 25/11/2013</b> <b>Governing:</b> Bekendtgørelse af lov om naturgasforsyning ( <i>Act on Natural Gas Supply</i> )( <a href="http://www.retsinformation.dk/">http://www.retsinformation.dk/</a> ).	This Act applies to the transmission, distribution, supply and storage of natural gas, including liquefied natural gas (LNG). The law also applies to adjacent natural gas supply systems.

As far as water supply is concerned, it is important to point out standard "**DS 439 (2009):** Norm for vandinstallationer(*Code of Practice for domestic water supply installations*)". This Code of Practice applies to water supply installations connected to public or private water supply systems, or to smaller private systems. The functional requirements of this Code also apply to rainwater

installations, which are part of the pipe system that supplies toilets and washing machines with rainwater from tanks or a similar containers.

### Interconnection to the electrical grid

Standard	Explanation
<b>Technical regulation 3.2.1 for electricity-generating facilities of 16 A per phase or lower</b> <a href="http://www.energinet.dk/">(http://www.energinet.dk/)</a> .	This technical regulation comprises provisions for electricity-generating facilities connected to the Danish public electricity supply network, which have a maximum output current of 16 A per phase. The regulation includes provisions regarding the properties that the electricity-generating facilities must have, and continue to have, throughout their service life. The operating conditions are regulated by other regulations.
<b>Consolidation Act No. 1329 of 25/11/2013</b> <b>Governing:</b> Bekendtgørelse af lov om elforsyning ( <i>Order of the Electricity Supply Act</i> ) <a href="http://www.retsinformation.dk/">(http://www.retsinformation.dk/)</a> .	This Act applies to the production, transport, trade and supply of electricity. It also applies to biogas, gas from biomass and other types of gas on land, territorial sea, in the exclusive economic zone and on the Danish continental shelf area.

### Building and safety

Standard	Explanation
<b>DS 447 (2013):</b> Ventilation i bygninger - Mekaniske, naturlige og hybride ventilationssystemer ( <i>Ventilation of buildings - Mechanical, natural and hybrid ventilation systems</i> ).	This standard specifies the requirements for the ventilation of buildings intended for human occupancy. The purpose of this standard is to ensure that ventilation systems are designed, constructed and can be maintained in a responsible technical and hygienic way, while considering comfort and energy efficiency. It comprises provisions for the design, construction, testing and operation of ventilation systems.
<b>DS 468 (1990):</b> Dansk Ingeniørforenings norm for automatiske reguleringsystemer til VVS-tekniske anlæg ( <i>Code of Practice for automatic control systems for heating, airconditioning and sanitary systems</i> ).	The code covers control systems installed in buildings which have the purpose of keeping the controlled variables within a desired range.

### Heating and hot water system

Standard	Explanation
<b>DS 452 (2013):</b> Termisk isolering af tekniske installationer ( <i>Thermal insulation of technical service and supply systems</i> ).	The standard applies to the thermal insulation of building systems, such as heating, ventilation, cooling, solar and water systems, as well as to the thermal insulation of industrial plants, including process and supply facilities. The standard also applies to outdoor installations. It

	<p>includes all the parts of an installation, including planar and curved surfaces, such as ducts and piping, valves, fittings, installation units, aggregates, fans and tanks.</p> <p>The standard does not apply to the insulation of boilers or heat pumps.</p> <p>Furthermore, it is designed for installations that operate at temperatures from - 40 ° C to + 650 ° C.</p>
<p><b>DS 469 (2013):</b> Varme- og køleanlæg i bygninger <i>(Heating and cooling systems in buildings).</i></p>	<p>This standard specifies the requirements of heating and cooling systems. The requirements are intended to give a correct technical quality level, with the required thermal indoor climate maintained at the lowest possible energy consumption. The standard applies to all types of heating- and cooling systems, that have the purpose of supplying rooms, buildings and connected systems with heating or cooling. The heating or cooling media in the system can be water, air or electricity.</p>

## France

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://www.boutique.afnor.org>.

### Interconnection to natural gas and water networks

The standards that refer to natural gas installation can be found at <http://www.ocie.free.fr>.

Standard	Explanation
<b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 1: Terminologie ( <i>Building works - Gas installation in domestic premises - Part 1: Terminology</i> ).	This document has the aim of providing a list of terms and definitions related to combustible gas and liquefied hydrocarbons located inside residential buildings or their outbuildings.
<b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 2: Cahier des clauses techniques- Dispositions générales ( <i>Building works - Gas installation in domestic premises - Part 2: Technical specifications - General dispositions</i> ).	This document applies to the feeding and equipment of fuel gas and liquefied hydrocarbons for residential buildings or their outbuildings. These supplies and equipment are located downstream from the general building cut-off connection element, (e.g., valves or taps). This kind of element is also covered by the standard. In particular, this part defines the technical requirements that have to be met during gas installation work.
<b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 3: Cahier des clauses techniques- Dispositions particulières hors évacuation des produits de combustion ( <i>Building works - Gas installation in domestic premises - Part 3: Technical specifications - particular dispositions, with the exception of combustion product evacuation</i> ).	The field of application is the same as that of the Part 2. However, this document defines the specific provisions that have to be met during gas installation work.
<b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 4: Cahier des clauses techniques- Dispositions particulières à l'évacuation des produits de combustion ( <i>Building works - Gas installation in domestic premises - Part 4: Technical specifications - particular dispositions</i>	This section defines the requirements for the supply of combustion air and the evacuation of combustion products from gas appliances.

<p><i>pertaining to combustion product evacuation).</i></p>	
<p><b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 5: Aménagements généraux (<i>Building works - Gas installation in domestic premises - Part 5: General installations</i>).</p>	<p>This document defines the requirements for the management of structures that surround gas installations. It supplements the provisions established in NF DTU 61.1 P2, NF DTU 61.1 P3 and NF DTU 61.1 P4, and determines the environment in which a gas system can be designed and constructed.</p>
<p><b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 6: Cahier des clauses spéciales (<i>Building works - Gas installation in domestic premises - Part 6: Contract bill of special clauses</i>).</p>	<p>This document has the purpose of providing the special administrative clauses of the work steps for the installation of fuel gas and liquefied hydrocarbon systems in the field of application established in NF DTU 61.1 P2, NF DTU 61.1 P3 and NF DTU 61.1 P4.</p>
<p><b>NF DTU 61.1 (2006):</b> Travaux de bâtiment - Installations de gaz dans les locaux d'habitation- Partie 7: Règles de calcul (<i>Building works - Gas installation in domestic premises - Part 7: Calculation rules</i>).</p>	<p>This Part sets the calculation rules for the dimensioning of pipelines for the supply of fuel gases and liquefied hydrocarbons to devices installed in residential buildings and their outbuildings. It also lays down rules for the calculation of the dimensioning of combustion product evacuation systems of combustion products operating under natural draw in type B1 and B2 appliances with a nominal heat input that does not exceed 85 kW.</p>

Some relevant water supply standards are listed hereafter.

Standard	Explanation
<p><b>NF P 52-305-1 DTU 65.10 (1993):</b> Canalisations d'eau chaude ou froide sous pression et canalisations d'évacuation des eaux usées et des eaux pluviales à l'intérieur des bâtiments - règles générales de mise en oeuvre Partie 1: cahier des clauses techniques (<i>Building works - Piping used for hot and cold pressure water and piping for evacuation waste water and rain water inside buildings - General rules of execution - Part 1: Technical specifications</i>).</p>	<p>This document has the purpose of defining the terms of implementation of hot and cold pressurized water pipes, and pipes for sewage and rainwater inside buildings, whatever the final destination.</p>

<p><b>NF P 52-305-2 DTU 65.10 (1993):</b> Canalisations d'eau chaude ou froide sous pression et canalisations d'évacuation des eaux usées et des eaux pluviales à l'intérieur des bâtiments - règles générales de mise en oeuvre Partie 2: cahier des clauses spéciales (<i>Building works - Private contracts - Piping used for hot and cold pressure water and piping for evacuation waste water and rain water inside buildings - General rules of execution - Part 2: Special clauses</i>).</p>	<p>This document has the purpose of defining the special administrative clauses for work contracts related to water pipes inside buildings, that is covered by DTU 65.10 (General Rules - Technical Specification clauses).</p>
---	---

### Interconnection to the electrical grid

Low-voltage electrical installations are regulated in France by standard **NF C 15-100 "Installations électriques à basse tension (Electrical installations at low voltage)"**. This is the official standard for the relative safety of low voltage electrical installations. It specifically deals with the protection of electrical installations and people, as well as with the management of comfort, use and scalability of the system. It covers the design, implementation, verification and maintenance of electrical installations supplied with a voltage that does not exceed 1000 volts (rms value) AC or 1500 volts DC.

### Exhaust and environment

The following standards can be found at <http://www.ocie.free.fr>.

Standard	Explanation
<p><b>NF DTU 24.1 Part 1 (2006):</b> Travaux de fumisterie - Systèmes d'évacuation des produits de combustion desservant un ou des appareils Partie 1: Cahier des clauses techniques - Règles générales (<i>Building works - Chimney specialist work - Systems for the evacuation of combustion products equipping one or more appliances - Part 1: Contract bill of technical clauses -General rules</i>).</p>	<p>This document contains the technical specification clauses that apply to the realization of individual and collective ducts, smoke, tubing, liners, flues, and connecting pipes for the discharging of the products of combustion devices that use conventional fuels, and for space heating, that produce domestic hot water, as well as other individual or collective uses. It also covers maintenance, sweeping and the diagnosis of conduits. It also concerns the flues of fireplaces, appliances and open fire inserts.</p>
<p><b>NF DTU 24.1 Part 2 (2006):</b> Travaux de fumisterie - Systèmes d'évacuation des produits de combustion desservant un ou des appareils Partie 2 : Cahier des clauses techniques - Règles spécifiques d'installation des systèmes d'évacuation des produits de combustion desservant un ou des appareils raccordés dits de type B utilisant des combustibles gazeux</p>	<p>In addition to the employment area cited in NF DTU 24.1 P1, this document defines the specific installation rules, in residential areas, of discharge pressure systems operating under natural draw or low mechanical extraction , for appliances that use gaseous fuels:                      - for types B11, B11BS, B11AS, B22, B23, (see Appendix A in this document);                      - for a nominal heat input that does not exceed</p>

<p><i>(Building works - Chimney work - Combustion product evacuation systems that serve one or more appliances - Part 2 : Contract bill of technical clauses - Specific installation rules for combustion product evacuation systems that serve one or more of the so-called gaseous fuel fired type B connected appliances).</i></p>	<p>85 kW (expressed relative to the net calorific value). This document only deals with installation rules pertaining to disposal systems for aforementioned combustion products, whether individual or collective, that operate under in natural draw or low pressure mechanical extraction.</p>
<p><b>NF DTU 24.1 Part 3 (2006):</b> Travaux de fumisterie - Systèmes d'évacuation des produits de combustion desservant un ou des appareils Partie 3: Cahier des clauses spéciales <i>(Building works - Chimney work - Combustion product evacuation systems that serve one or more appliances - Part 3: Contract bill of special clauses).</i></p>	<p>This standard has the purpose of providing the special administrative clauses of contracts for the construction and rehabilitation of flues, within the scope defined in NF DTU 24.1 P1 and NF DTU 24.1 P2.</p>

### Building and safety

Standard	Explanation
<p><b>NF DTU 65.11 P1-1 (2007):</b> Travaux de bâtiment - Dispositifs de sécurité des installations de chauffage central concernant le bâtiment - Partie 1-1: Cahier des Clauses Techniques <i>(Building works - Safety systems for central heating installations in buildings - Part 1-1: Technical specifications).</i></p>	<p>This document has the purpose of providing provisions concerning the implementation of heating systems, in terms of personal safety, and of maintaining the equipment installed in these facilities in good condition. It applies to all the equipment of the facilities (generators, containers, pipes) that are not subject to Decree no. 99-1046 of 13 December 1999 (concerning pressure equipment), and its subsequent amendments.</p>
<p><b>Arrêté du 2 août 1977 (version consolidée):</b> Règles techniques et de sécurité applicables aux installations de gaz combustible et d'hydrocarbures liquéfiés situés à l'intérieur des bâtiments d'habitation ou de leurs dépendances <i>(Technical and safety rules applicable to combustible gas and liquefied hydrocarbons located inside residential buildings, or their outbuildings).</i>  Available at <a href="http://www.legifrance.gouv.fr/">http://www.legifrance.gouv.fr/</a>.</p>	<p>The provisions of this Order apply to all gas facilities, including the pipelines and accessory organs of power boilers for domestic hot water and the heating of residential buildings, which are located downstream from a general cut-off element (provided for in Article 13 (1), such as valves or taps) as well as to the general cut-off elements themselves. The following are excluded from this Order: generator heating, singly or in groups, with a total nominal installed capacity in the boiler of more than 70 kW, or approximately 85 kW total heating capacity installed, and the premises where these devices work.</p>

<p><b>RT 2012</b> (<a href="http://www.rt-batiment.fr">http://www.rt-batiment.fr</a>): La réglementation thermique (<i>Thermal Regulation</i>).</p>	<p>This regulation sets a maximum limit to the energy consumption of new buildings as far as heating, ventilation, air conditioning, hot water production for and lighting are concerned. It imposes three requirements for new buildings:</p> <ul style="list-style-type: none"><li>- they must maximize the energy efficiency;</li><li>- minimize the energy consumption;</li><li>- permit summer comfort without having to resort to an active cooling system.</li></ul>
---	---

### Germany

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://www.beuth.de> and <http://www.dvgw.de>.

### Interconnection to natural gas and water networks

Standard	Explanation
<b>DVGW G 260 (2013):</b> Gasbeschaffenheit ( <i>Gas quality</i> ).	This standard deals with the quality designation of the gas used for supply purposes.
<b>DVGW G 640 (2002):</b> Aufstellung von Klein-BHKW ( <i>Preparation of microCHP units</i> ).	This standard applies to the design, creation, modification and maintenance of motor-driven microCHP units operated by gas according to DVGW Code of Practice G 260. It describes the procedural and safety requirements for the establishment of microCHP units, and in particular for gas connectors and the removal of combustion gases.
<b>DVGW G2000 (2011):</b> Mindestanforderungen bezüglich Interoperabilität und Anschluss an Gasversorgungsnetze ( <i>The minimum requirements for interoperability and connection to gas supply networks</i> ).	This standard describes the technical requirements, in terms of interoperability and connection to gas supply networks, and has been formulated taking into account the provisions set out in the Energy Act.
<b>DVGW VP 601 (2007):</b> Gas- und Wasser-Hauseinführungen ( <i>Gas and water connections to houses</i> ).	This standard is the basis of the professional certification of common house entry systems, one-part solutions and multi-branch solutions.
<b>DVGW W 534 (2004):</b> Rohrverbinder und Rohrverbindungen in der Trinkwasser-Installation ( <i>Pipe connectors and pipe joints for drinking water installations</i> ).	This worksheet applies to pipe fittings and joints in pipes used for drinking water installations.
<b>DVGW W 544 (2007):</b> Kunststoffrohre in der Trinkwasser-Installation ( <i>Plastic pipes for drinking water installation</i> ).	This contains the requirements and tests for the application of plastic pipes for hot and cold water in house installations.

<p><b>DVGW W 570 (2013):</b> Armaturen für die Trinkwasser-Installation - Teil 1: Anforderungen und Prüfungen für Gebäudearmaturen (<i>Valves for drinking water installation - Part 1: Requirements and tests for building valves</i>).</p> <p><b>DVGW W 570 (2008):</b> Armaturen für die Trinkwasser-Installation - Teil 2: Anforderungen und Prüfungen für die Sicherungsarmaturen (<i>Valves for drinking water installation - Part 2: Requirements and tests for the fuse fittings</i>).</p> <p><b>DVGW W 574 (2007):</b> Sanitärarmaturen als Entnahmearmaturen für Trinkwasser-Installationen - Anforderungen und Prüfungen (<i>Sanitary fittings as off valves for drinking water installations - Requirements and tests</i>).</p>	<p>These standards regulate the requirements regarding hygiene and materials, define internal and external monitoring and the additional specific national product requirements for each type of typologies described in the standards.</p>
---	---

*Interconnection to the electrical grid*

Standard	Explanation
<p><b>VDE-AR-N 4105 (2011):</b> Erzeugungsanlagen am Niederspannungsnetz, Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz (<i>Power generation systems connected to a low-voltage distribution network – Minimum technical requirements for the connection to and parallel operation with low-voltage distribution networks</i>).</p>	<p>This standard includes topics that refer to system reactions (flicker, harmonics, voltage unbalance, etc.), connection criteria, three-phase network, behaviour of power generation systems on the network (active and reactive power, network support, etc.), the construction of systems and protection, metering, system operation (connection characteristics and synchronization, reactive power compensation) and the verification of the electrical properties.</p>
<p><b>DIN VDE V 0124-100 (2012):</b> Netzintegration von Erzeugungsanlagen - Niederspannung - Prüfanforderungen an Erzeugungseinheiten vorgesehen zum Anschluss und Parallelbetrieb am Niederspannungsnetz (<i>Grid integration of generator plants: Low-voltage – Test requirements for generator units to be connected to and operated in parallel with low-voltage distribution networks</i>).</p>	<p>DIN VDE V 0124-100 pertains to the verification of the electric requirements of the generator units fixed in VDE AR N 4105. In addition to design and testing, this standard provides relevant data to network operators, such as plant constructors, which could be important as planning documents and for decision support as well as - as a result - during operation.</p>
<p><b>DIN VDE V 0126-1-1 (2013):</b> Selbsttätige Schaltstelle zwischen einer netzparallelen Eigenerzeugungsanlage und dem öffentlichen Niederspannungsnetz (<i>Automatic disconnection device between a generator and the public low-voltage grid</i>).</p>	<p>The automatic disconnection device is used as a safety interface between a generator and the public low-voltage distribution network and serves as a substitute for a disconnecting switch which is accessible at all times by the distributing network operator. It prevents the unintentional supply of electrical energy from the generator to a sub-network disconnected from the rest of the distribution grid (islanding), thereby offering</p>

	<p>additional protection to the measures specified in DIN VDE 0105-100 (VDE 0105-100), 6.2 concerning:</p> <ul style="list-style-type: none"> <li>- operational staff, against voltage in the disconnected sub-network;</li> <li>- equipment, against inadmissible voltages and frequencies;</li> <li>- consumers, against inadmissible voltages and frequencies;</li> <li>- equipment, against the feed of faults by the generator.</li> </ul>
--	---

**Exhaust and environment**

Standard	Explanation
<b>DIN V 18160-1 (2006):</b> Abgasanlagen - Teil 1: Planung und Ausführung ( <i>Chimneys – Part 1: Design and performance</i> ).	This standard provides a comprehensive overview of the requirements necessary to comply with the planning and construction of exhaust systems.
<b>DIN V 18160-1 Beiblatt 1 (2006):</b> Abgasanlagen - Teil 1: Planung und Ausführung ( <b>Supplement 1:</b> <i>Chimneys - Part 1: Design and performance</i> ).	This is a national supplement, for metal chimneys, according to DIN EN 1856-1, for flues and connecting flues, according to DIN EN 1856-2, and for allowed materials and corrosion resistance classes.
<b>DIN V 18160-1 Beiblatt 2 (2006):</b> Abgasanlagen - Teil 2: Planung und Ausführung ( <b>Supplement 2:</b> <i>Chimneys - Part 1: Design and performance</i> ).	This is a national supplement, according to DIN EN 1457, for the use of clay or ceramic flue liners and the allocation of the classification system for custom built chimneys.

**Building and safety**

Standard	Explanation
<b>DVGW G 110 (2003):</b> Ortsfeste Gaswarneinrichtungen ( <i>Fixed gas detection equipment</i> ).	<p>This DVGW Code of Practice applies to stationary gas warning equipment in facilities that are operated with gases from public gas supply systems according to DVGW Code of Practice G 260 (Gas Quality).</p> <p>The installations that can be complemented with gas detection systems, the requirements imposed on these gas warning devices and which outputs have to be processed further are indicated in this document.</p>

<p><b>DVGW G 280-1 (2012):</b> Gasodorierung (<i>Gas odorization</i>).</p>	<p>This standard serves as a basis for the odorisation of gases that are distributed to households and similar customers. The user is informed about the odorisation, the safety measures, the odorisation technology and its control. Furthermore, the DVGW worksheet contains an overview of the applicable regulations, standards and regulations that have to be considered during the transport and handling of odorants.</p>
<p><b>DVGW G 442 (2011):</b> Explosionsgefährdete Bereiche an Ausblaseöffnungen von Leitungen zur Atmosphäre an Gasanlagen (<i>Potentially explosive atmospheres at venting line exhaust openings of gas plants or systems</i>).</p>	<p>The instructions on how to perform blow-out type A side entry and on the preparation and documentation of blowouts are specified in this standard.</p>
<p><b>DVGW G 600 (2008):</b> Technische Regeln für Gasinstallationen (DVGW- TRGI) (<i>Technical rules for gas installations (DVGW TRGI)</i>).</p>	<p>This contains the requirements for Use and Maintenance. This standards also refers to (or contains some parts) (of) G 624 pertaining to the sealing of existing internal gas lines and to G 670 pertaining to gas installations and devices used for mechanical ventilation.</p>
<p><b>VDI 4655 (2008):</b> Referenzlastprofile von Ein- und Mehrfamilienhäusern für den Einsatz von KWK-Anlagen (<i>Reference load profiles for single-family and multi-family houses concerning the use of CHP systems</i>).</p>	<p>This guideline applies to combined heat and power systems (CHP systems) with a fuel input of up to 70 kW (referring to the net calorific value), designed for use in residential buildings. It covers single-family houses with up to 12 occupants and multi-family houses with up to 40 flats. The guideline supplies reference load profiles as a basis and tool for the designing of combined heat and power systems in residential buildings and for their cost-effectiveness analysis. The test conditions for the determination of the system efficiency, design criteria and testing procedures may be also derived from this guideline. Furthermore, the guideline can be used for simulations and design calculations. Operating times and operating cycles can be used to determine service lives and maintenance intervals.</p>
<p><b>VDI 4656 (2013):</b> Planung und Dimensionierung von Mikro-KWK-Anlagen (<i>Design and dimensioning of micro-combined heat and power-plants</i>).</p>	<p>Special requests are made to the planners and installers of the plants regarding design and dimensioning. The design of the electrical and thermal performance of the micro CHP module, and the supplementary heater, as well as the size of the heat storage unit and any other components that are required have to be considered in particular. The methods developed in this guideline are</p>

	<p>based on guideline VDI 4655 pertaining to the use of reference load profiles for the standard application case. This enables one to make a comparison of different micro CHP technologies and different dimensions of the components with the same framework conditions that are found in the planning and dimensioning process. The necessary calculations, including the generation of reference load profiles, are supported with a calculation programme which is enclosed as a CD in the guideline. The standard heating load of an object, in object-related planning, is determined for the design of the heat generator performance according, to DIN 12831.</p>
--	---

*Heating and hot water system*

Standard	Explanation
<p><b>DVGW W 551 (2004):</b> Trinkwassererwärmungs- und Trinkwasserleitungsanlagen; Technische Maßnahmen zur Verminderung des Legionellenwachstums; Planung, Errichtung, Betrieb und Sanierung von Trinkwasser-Installationen (<i>Drinking water heating and drinking water piping systems; technical measures to reduce the risk of Legionella growth; design, construction, operation and rehabilitation of drinking water installations</i>).</p>	<p>This worksheet applies to the planning, construction, operation, maintenance, hygienic-microbiological monitoring and rehabilitation of drinking water installations in public and private buildings.</p>
<p><b>DVGW VP 201 (2004):</b> Strömungsmengenregeleinrichtungen mit Doppelmembran und Sicherheitsarmatur (<i>Flow rate controller with double diaphragm and a safety valve</i>).</p>	<p>This standard applies to the testing of flow rate control devices for domestic pressure-controlled hot water heaters (water heaters) with proportional amounts of coordination between primary and secondary circuits (heating water and DHW side).</p>
<p><b>DVGW G 640-2 (2005):</b> Aufstellung von Brennstoffzellen - Heizgeräten (<i>Installation of fuel cells – heaters</i>).</p>	<p>This worksheet applies to the design, installation, modification and maintenance of fuel cell heaters (BZ heaters) with a maximum rated heat input (based on the fuel performance) of up to 70 kW (SOFC and PEM), and gases, according to DVGW worksheet G 260.</p>
<p><b>VDI 2035:</b> Vermeidung von Schäden in Warmwasserheizanlagen Blatt 1 (2005): Steinbildung in Trinkwassererwärmungs- und Warmwasser-Heizungsanlagen Blatt 2 (2009): Wasserseitige Korrosion Blatt 3 (2000): Abgasseitige Korrosion (<i>Prevention of damage to water heating</i>)</p>	<p>Part 1: This part is limited to damage caused by scale formation, where it was, but is also extended to include statements on stone formation and its prevention in water heating installations. The latter achievement is of special interest since, due to the expected higher hot water temperatures, there is often an increasing risk of damage caused by stone formation, in the</p>

<p><i>installations</i>  <i>Part 1: Scale formation in domestic heating and hot water heating systems;</i>  <i>Part 2: Water-side corrosion;</i>  <i>Part 3: Gas-side corrosion.)</i></p>	<p>context of measures to prevent the risk of Legionella infection.</p> <p>Part 2: The purpose of this Directive is to summarize the recommendations of actions necessary to reduce the likelihood of heating water side corrosion in water-based heating systems.</p> <p>Part 3: Deals with the exhaust gas side corrosion of metallic materials in hot water heating systems, immediately heated water heating systems and the associated exhaust systems.</p>
<p><b>VDI 2077 Blatt 3.1:</b> Verbrauchskostenerfassung für die Technische Gebäudeausrüstung - Ermittlung der umlagefähigen Wärmeerzeugungskosten von KWK-Anlagen - Berichtigung zur Richtlinie VDI 2077 Blatt 3.1:2010-12 (<i>Energy consumption for the building services - Determination of reimbursable costs of heat generation by CHP systems - Corrigendum Concerning guideline VDI 2077 Part 3.1:2010-12</i>).</p>	<p>This guideline is applied to cogeneration systems (CHP generation systems) subject to the German heating-cost ordinance (HeizkostenV), where only heat is used (excluding emergency cooling), and it describes the methods adopted to bill the costs of heat generation that can be apportioned. The guideline is not applicable to systems in which the costs are billed under the German AVBFernwärmeV (contracting, commercial heat supply).</p>
<p><b>VDI 4682 (2006):</b> Brennstoffzellen-Heizgeräte - Gestaltung von Serviceverträgen (<i>Fuel cell heating appliances - Drafting of service contracts</i>).</p>	<p>Fuel cell heating appliances (FCHA) are combined heat and power plants (CHP) that use a fuel cell to generate electrical energy. The present guideline is restricted to domestic heating applications in buildings in which the FCHA consumes up to 70 kWth (with respect to the net caloric value <math>H_i</math>). In addition to the purchase order for the complete FCHA, an independent definition of its scope is also necessary. The service contract will be linked to this definition since the service contract may have a different scope to that of the sales contract. This document is effective after completion of the commissioning of the FCHA.</p>
<p><b>DIN V 4701-10 (2003):</b> Energetische Bewertung heiz- und raumluftechnischer Anlagen - Teil 10: Heizung, Trinkwassererwärmung, Lüftung (<i>Energy efficiency of heating and ventilation systems in buildings - Part 10: Heating, domestic hot water supply, ventilation</i>).</p>	<p>This standard offers system designers and planners the opportunity of quantifying the losses of the used plant technology and of demonstrating the benefits of efficient technology.</p>

<p><b>DIN V 4701-12 (2004):</b> Energetische Bewertung heiz- und raumluftechnischer Anlagen im Bestand - Teil 12: Wärmeerzeuger und Trinkwassererwärmung (<i>Energetic evaluation of heating and ventilation systems in existing buildings - Part 12: Heat generation and domestic hot water generation</i>).</p>	<p>No description available for this standard.</p>
<p><b>DIN 4708-1 (1994):</b> Zentrale Wassererwärmungsanlagen; Begriffe und Berechnungsgrundlagen (<i>Central heating waterinstallations – Part 1: Terms and calculation basis</i>).</p>	<p>No description available for this standard.</p>
<p><b>DIN 4708-2 (1994):</b> Zentrale Wassererwärmungsanlagen; Regeln zur Ermittlung des Wärmebedarfs zur Erwärmung von Trinkwasser in Wohngebäuden (<i>Central heatwaterinstallations – Part 2: Rules for the determination of the water heat demand in dwelling houses</i>).</p>	<p>This standard can be considered a valid basis for the uniformdetermination of the heating requirement in centraldrinking water heating systems in residential Constructions, wherethe water heaters are heated heater directly or indirectly. They can be combined withheat generators to supply heat or can be used exclusively for the heating of drinking water.</p>
<p><b>DIN 4708-3 (1994):</b> Zentrale Wassererwärmungsanlagen; Regeln zur Leistungsprüfung von Wassererwärmern für Wohngebäude (<i>Central heating waterinstallations – Part 3: Rules for the testing of the efficiency of water heaters in dwelling houses</i>).</p>	<p>The determination of the following quantities is described in this standard:</p> <ul style="list-style-type: none"> <li>-storage volume;</li> <li>- thermal power that can continuously be delivered;</li> <li>- thermal storage capacity;</li> <li>- performance figure NL (this is a kind of "performance figure" that describes how many standard dwellings (NL=1) can be supplied with the same storage performance).</li> </ul>

## Ireland

The Irish **Building Regulations** (<http://www.environ.ie>) were established with the aim of providing for the health, safety and welfare of people in and around buildings. In general, they apply to the construction of new buildings and to extensions and material alterations of existing buildings and to certain changes of use of existing buildings. These Regulations apply to all types of construction.

The Building Regulations are composed of Parts A to M. The Technical Guidance Documents offer help on how to comply with each of these Parts. The most relevant Parts concerning the installation of heating appliances are listed below:

- **Part E - Sound.** This deals with dwelling requirements in order to reduce the transmission of sound between different dwellings and within the same dwellings.
- **Part F - Ventilation.** This Part establishes that a good quality of the air has to be reached inside buildings by means of an adequate ventilation.
- **Part H - Drainage and waste water disposal.** This deals with drainage systems that have to fulfil certain requirements, that mostly concern the health of people.
- **Part J - Heat producing appliances.** This part deals with all the requirements that lead to the correct and safe functioning of a heat producing appliance.
- **Part L - Conservation of fuel and energy.** The aim of this Part is to limit the use of fossil fuel energy and the related carbon dioxide (CO<sub>2</sub>) emissions that arise from the operation of buildings. In this way it is possible to limit losses and increase the efficiency. This Part refers to both dwellings and buildings other than dwellings.

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://www.nsai.ie/>.

### *Interconnection to natural gas and water networks*

Standard	Explanation
<b>IS 265 (2000):</b> Installation of Gas Service Pipes - Parts 1 and 2 (Fourth Edition).	This standard specifies the design, installation, testing, commissioning and record keeping of gas service pipes for the supply of manufactured gas, natural gas and liquefied petroleum gas, at operating pressures that do not exceed 5 bar.

<p><b>IS 813 (2002) + Amd 2 (2005):</b> Domestic Gas Installations (Second Edition).</p>	<p>This standard provides a Code of Practice for the installation of natural gas or liquefied petroleum gas, in domestic premises, from the point of delivery to the gas appliance.</p>
--	---

*Interconnection to the electrical grid*

Standard	Explanation
<p><b>DTIS-230206-BRL (2009):</b> Conditions that govern the connection and operation of micro-generation.</p>	<p>This standard constitutes the Irish version of European standard EN 50438 (2007). It contains the requirements for the connection of micro-generators in parallel with public low-voltage distribution networks.</p>
<p><b>ESBN NC6:</b> Micro-generation installation notification form.</p>	<p>This is a form that has to be filled in if someone wants to communicate with the ESB (Electricity Supply Board) Networks to inform them that he plans to connect a micro-generator to the electricity network.</p>
<p><b>ET101 (2008):</b> National Rules for Electrical Installations.</p>	<p>This summary of the Rules, which is based on the Fourth Edition, lays down the requirements for the design, mounting and proper functioning of electrical installations in order to ensure the safety of persons, livestock and property against danger and damage that may arise from the reasonable use of electrical installations. These Rules apply to electrical circuits supplied at nominal voltages of up to and including 1000V a.c. or 1500V d.c.</p>
<p><b>ET 210 (2003):</b> Code of Practice for the Installation of Low Voltage Generators.</p>	<p>This Code of Practice gives details on the installation of low voltage generator sets, and includes details on protection pertaining to safety, earthing and bonding, operation, maintenance and verification processes.</p>
<p><b>ET 213 (2007):</b> Guide to the Basic Principles of Electrical Safety.</p>	<p>The purpose of this Guide is to raise the awareness of the uses a electrical safety and to describe protective measures that are available to reduce the risk of being injured by electricity.</p>

*Heating and hot water system*

Standard	Explanation
<b>IS 288 (1987):</b> Thermal performance requirements for water and space heaters.	This standard gives the minimum thermal performance requirements for heat generators (space heaters, water heaters and combined appliances) for space heating and/or the production of hot water in non-industrial buildings.
<b>IS 289 (1987):</b> Thermal insulation of pipes, ducts and storage vessels.	This describes the thermal insulation requirements for pipes, ducts and storage vessels used for space heating and hot water supply in non-industrial buildings.

## Italy

The national regulations regarding the installation of heating appliances in Italy are based on **Ministerial Decree no.37, published on 12th of March, 2008** (available at <http://www.energia.provincia.tn.it>). This decree applies to heating appliances located within buildings. If the plant is connected to the distribution networks, it applies from the point of delivery of the supply. The national decree also provides the professional and technical requirements concerning activities on the plant, which the technical expert must have. A design is required for the installation, extension or modification of the plant, a design is requested and it must be elaborated in accordance with current standards. One of the most important aspects of the document is the declaration of conformity, which must be provided by the installation company, when the activities have been completed. Furthermore, the national decree contains information about: the owner's and client's obligations, as well as about fines incurred for violations and attachments for the declaration of conformity.

Heating systems in buildings (the design, installation, operation and maintenance of heating systems in buildings), with the objective of energy savings, are regulated by **Decree no.412 (amended by Decree no.551/99)**.

The reference document concerning the production of materials, appliances, machinery, installations and electrical and electronic systems, is **Regulation no.186/68** (<http://www.normattiva.it>). This document refers to the current technical standards developed by the IEC.

The subsequent sections contain the most important national regulations and standards concerning FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://store.uni.com>.

### *Interconnection to natural gas and water networks*

**Ministerial decree no. 37/2008** also deals with aspects related to the connection of plants to different kinds of distribution networks, but only from the point of delivery of the supply, with reference to the connection to natural gas networks, it is also possible to consider other standards that have been listed in the following Table.

Standard	Explanation
<b>Decreto Ministeriale 16/04/2008:</b> Regola tecnica per la progettazione, costruzione, collaudo, esercizio e sorveglianza delle opere e dei sistemi di distribuzione e di linee dirette del gas naturale con densità non superiore a 0,8 <i>(Ministerial Decree 16/04/2008: Technical rule</i>	This technical rule has the aim of guaranteeing the safety, the possibility of interconnection and the interoperability of the systems.

<p>for the design, construction, testing, operation and monitoring of works and distribution systems and of direct natural gas lines with a density of up to 0.8).  <a href="http://www.cti2000.it">http://www.cti2000.it</a></p>	
<p><b>UNI 7129-1 (2008):</b> Impianti a gas per uso domestico alimentati da rete di distribuzione - Progettazione, installazione e manutenzione. Parte 1: Impianto interno (<i>Gas plants for domestic use supplied by a distribution network - Design, installation and maintenance. Part 1: Internal plant</i>).</p>	<p>This standard establishes the design, installation and testing requirements for domestic plants and the like that are fed by fuel gases belonging to the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> families and which come from a distribution network. Reference is made to UNI 9165 and UNI 10682.</p>
<p><b>UNI 7129-2 (2008):</b> Impianti a gas per uso domestico alimentati da rete di distribuzione - Progettazione, installazione e manutenzione. Parte 2: Installazione degli apparecchi di utilizzazione, ventilazione e aerazione dei locali di installazione (<i>Gas plants for domestic use supplied by a distribution network - Design, installation and maintenance. Part 2: Installation of gas appliances, ventilation and aeration of premises</i>).</p>	<p>The Standard defines the criteria for the installation of gas appliances with a nominal heat input of up to 35 kW, as well as ventilation and /or aeration of premises.</p>
<p><b>UNI 7129-3 (2008):</b> Impianti a gas per uso domestico alimentati da rete di distribuzione - Progettazione, installazione e manutenzione. Parte 3: Sistemi di evacuazione dei prodotti della combustione (<i>Gas plants for domestic use supplied by a distribution network - Design, installation and maintenance. Part 3: Systems for the discharge of combustion products</i>).</p>	<p>The standard defines the criteria of combustion products in flue systems connected to gas appliances with a nominal heat input of up to 35 kW.</p>
<p><b>UNI 7129-4 (2008):</b> Impianti a gas per uso domestico alimentati da rete di distribuzione - Progettazione, installazione e manutenzione. Parte 4: Messa in servizio degli impianti/apparecchi (<i>Gas plants for domestic use supplied by a distribution network - Design, installation and maintenance. Part 4: Gas plants and their appliances: commissioning</i>).</p>	<p>The standard defines the commissioning criteria of: gas appliances with a nominal heat input of up to 35 kW, new domestic gas plants, substitution of gas appliances, and modification of gas plants.</p>
<p><b>UNI 7140 (2013):</b> Apparecchi a gas per uso domestico - Tubi flessibili non metallici per allacciamento di apparecchi a gas per uso domestico e similare (<i>Gas appliances for domestic use - Non metallic flexible pipes for connection of gas appliances for domestic use and the like</i>).</p>	<p>This standard establishes the construction requirements and test methods for flexible pipes (A1, A2, B and C-types) used to connect domestic appliances and the like with a thermal power of up to 35 kW and fed by fuel gases belonging to the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> families.</p>

<p><b>UNI 9165 (2004):</b> Reti di distribuzione del gas - Condotte con pressione massima di esercizio minore o uguale a 5 bar - Progettazione, costruzione, collaudo, conduzione, manutenzione e risanamento (<i>Gas distribution networks - Pipelines with a maximum operating pressure of up to and including 5 bar - Design, construction, testing, operation, maintenance and reconditioning</i>).</p>	<p>This standard provides the design, construction, testing, operation, maintenance and reconditioning requirements for pipelines that supply gases belonging to the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> families, with a maximum operating pressure of up to and including 5 bar.</p>
<p><b>UNI 11071 (2003):</b> Impianti a gas per uso domestico asserviti ad apparecchi a condensazione e affini - Criteri per la progettazione, l'installazione, la messa in servizio e la manutenzione (<i>Gas plants for domestic use connected to condensing appliances and the like - Criteria for the design, installation, operation and maintenance of such appliances</i>).</p>	<p>This standard offers criteria for the design, installation, operation and maintenance of gas plants for domestic use connected to condensing appliances and the like with a nominal input that does not exceed 35 kW.</p>

No regulations have been found concerning interconnection to water networks.

### *Interconnection to the electrical grid*

Besides the standards that regulate the connection to electrical grids, two regulations that establish methods for the payment of taxes for the production and consumption of electricity are also reported. The entity of the taxes depends on the technology that is used, the purpose of the production and the size of the considered plant.

Standard	Explanation
<p><b>CEI 0-21 (2011):</b> Regola tecnica di riferimento per la connessione di Utenti attivi e passivi alle reti BT delle imprese distributrici di energia elettrica (<i>Technical Reference rules for the connection of active and passive users to the LV electrical Utilities</i>).</p> <p><a href="http://webstore.ceiweb.it">http://webstore.ceiweb.it</a></p>	<p>This standard defines the technical criteria necessary for the connection to electricity distribution grids with a nominal voltage AC of up to and including 1 kV.</p>
<p><b>CEI 11-20 (2000):</b> Impianti di produzione di energia elettrica e gruppi di continuità collegati a reti di I e II categoria (<i>Electrical energy production systems and uninterruptable power systems connected to the 1<sup>st</sup> and 2<sup>nd</sup> network classes</i>).</p> <p><b>CEI 11-20 V2 (Annex C) (2007):</b> Prove per la verifica delle funzioni di interfaccia con la rete elettrica per i micro generatori (<i>Test for the verification of the interface functions with the electrical network for micro-generators</i>).</p> <p><a href="http://webstore.ceiweb.it">http://webstore.ceiweb.it</a></p>	<p>Standard CEI 11-20 defines the installation criteria necessary for distributed production facilities of electricity working with alternating currents, in isolated or parallel modes, connected to systems belonging to 1<sup>st</sup> and 2<sup>nd</sup> categories. It also considers uninterruptable power supply (UPS) systems.</p> <p>The 2<sup>nd</sup> modification of this standard (V2) was made in order to add Annex C, which introduces electrical tests for electrical generators and cogenerators with a power output of up to 50 kW which are connected to Low Voltage networks.</p>

<p><b>Dlgs 504/95</b> (<a href="http://www.normattiva.it">http://www.normattiva.it</a>): Testo Unico delle disposizioni legislative concernenti le imposte sulla produzione e sui consumi e relative sanzioni penali e amministrative (<i>Consolidated Text of the laws concerning production and consumption taxes, and the related criminal and administrative fines</i>).</p> <p><b>Ministerial Decree 27/10/2011</b> (<a href="http://www.cnel.it">http://www.cnel.it</a>): Semplificazioni per impianti di microgenerazione ad alto rendimento (<i>Simplified procedures for high efficiency micro-cogeneration plants</i>).</p>	<p>The first decree contains an article that offers information on taxes regarding the production and consumption of electricity.</p> <p>The second decree focuses on taxes pertaining to the production and consumption of electricity, for the case of high efficiency microcogeneration plants.</p>
---	--

### Exhaust and environment

Both aspects of the topic have been covered, that is, the environmental problem and the standardization of chimneys.

Standard	Explanation
<p><b>D.lgs n. 152/06</b> (<a href="http://www.energia.provincia.tn.it">http://www.energia.provincia.tn.it</a>): Norma in materia ambientale (<i>Environmental Laws</i>).</p>	<p>This is a general decree in which the standards for the protection of the environment can be found. The most interesting Part is the fifth, in which the standards concerning the protection of air and the reduction of polluting emissions are discussed.</p>
<p><b>UNI 10640 (1997)</b>: Canne fumarie collettive ramificate per apparecchi di tipo B a tiraggio naturale. Progettazione e verifica (<i>Branched chimneys for B-type appliances with natural draft. Design and verification</i>).</p>	<p>This standard establishes the criteria for the design and verification of the internal dimensions of branched chimneys.</p>

### Building and safety

The regulations listed in this section, which deal with all the aspects concerning plants located in buildings, also contain references to issues concerning some of the other areas that have been mentioned.

Standard	Explanation
<p><b>D.P.R. n. 412/93</b>  <a href="http://www.energia.provincia.tn.it">(<a href="http://www.energia.provincia.tn.it">http://www.energia.provincia.tn.it</a>):</a>                      Regolamento recante norme per la progettazione, l'installazione, l'esercizio e la manutenzione degli impianti termici degli edifici ai fini del contenimento dei consumi di energia, in attuazione dell'art. 4, comma 4, della L. 9 gennaio 1991, n. 10 (<i>Regulation for the design, installation, operation and maintenance of building heating systems in order to control the energy consumption, as put with effect by art. 4, paragraph 4, Regulation of the 9<sup>th</sup> January 1991, no. 10</i>).</p>	<p>This Regulation concerns heating systems in buildings (design, installation, maintenance) with the objective of saving energy. This decree was amended by the subsequent D.P.R. no. 551/99.</p>
<p><b>Ministerial Decree 37/08:</b> Regolamento concernente l'attuazione dell'articolo 11-quaterdecies, comma 13, lettera a) della legge n. 248 del 2005, recante riordino delle disposizioni in materia di attività di installazione degli impianti all'interno degli edifici (<i>Regulation concerning the fulfilment of the article 11-quaterdecies, paragraph 13, letter a) of Regulation no. 248 (2005), which lays down the reorganization of provisions for the installation of plants inside buildings</i>).</p>	<p>This decree offers the requirements for the installation activity of the heating plants inside buildings.</p>
<p><b>UNI 9463 (2012) series:</b> Impianti di odorizzazione e depositi di odorizzanti per gas combustibili impiegati in usi domestici o similari (<i>Odorization plants and odorant deposits for fuel gases employed in domestic uses and the like</i>).</p>	<p>Part 1: Terms and definitions.                      Part 2: Odorization plants - Design, construction, testing and monitoring.                      Part 3: Odorant deposits - Design, construction and operation.                      Part 4: Odorant supply modes.</p>

### Other RC&S

Standard	Explanation
<p><b>UNI 8887 (1987):</b> Sistemi per processi di cogenerazione. Definizioni e classificazione (<i>Systems for cogeneration processes. Definitions and classification</i>).</p>	<p>The purpose of this standard is to: define and classify the different cogeneration systems and introduce specific definitions for particular components of the system as well as the limits (even conventional) in its chain of interconnection; define the characteristic parameters and indices designed to detect the quality and the performance, in terms of energy, as covered by this standard; define the performance under nominal conditions, and</p>

	<p>other significant terms and conditions of CHP systems.</p> <p>It applies to all cogeneration systems, regardless of: the energy source, the size of energy flows and their relationships, the producers and users from the industrial, services, residential, agricultural, etc.sectors.</p>
--	---

### The Netherlands

In The Netherlands, anyone who plans to refurbish, build, demolish or occupy a building must comply with **Buildings Decree 2012** (<http://vrom.bouwbesluit.com/>). This contains technical regulations that represent the minimum requirements for all structures in the Netherlands. These requirements relate to safety, health, usability, energy efficiency and the environment.

**Practice Book Decree 2012** (<http://www.rijksoverheid.nl/>), which represents a sort of guidance to have a better understanding of building regulations is also available.

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://www.nen.nl>.

### Interconnection to natural gas and water networks

Standard	Explanation
<b>NEN 1078 (2004):</b> Voorziening voor gas met een werkdruk tot en met 500 mbar - Prestatie-eisen - Nieuwbouw ( <i>Provision for gas with an operating pressure of up to 500mbar - Performance requirements</i> ).	This standard provides a set of building-related provisions for gas with an operating pressure of up to 0.05 MPa (500 mbar).
<b>NEN 7244-1 (2003):</b> Gasvoorzieningsystemen - Leidingen voor maximale bedrijfsdruk tot en met 16 bar - Deel 1: Algemene functionele eisen ( <i>Gas supply systems - Pipelines with a maximum operating pressure of up to 16 bar - Part 1: General functional requirements</i> ).	This standard provides the general functional recommendations for piping systems that distribute first and second gas family fuels, in accordance with EN 437:1994, with an operating pressure of up to 1.6 MPa (16 bar). The standard applies to the piping from the point of gas purchase to the point of gas delivery. The standard is applicable to the design, construction, commissioning and decommissioning, operation, maintenance and renovation of pipelines and all the related services.
<b>NEN 7244-6 (2005):</b> Gasvoorzieningsystemen - Leidingen voor maximale druk tot en met 16 bar - Deel 6: Specifieke functionele eisen voor aansluitleidingen ( <i>Gas supply systems - Pipelines for maximum pressure of up to 16 bar - Part 6: Specific functional requirements for connecting pipes</i> ).	This standard provides the functional requirements for gas connecting pipes with an operating pressure of up to 1.6 MPa (16 bar), subject to the maximum allowable working pressures for each material (see NEN 7244 Part 1 Section 4.2 "Pipe Materials"). The standard is applicable to the design, construction and operation, maintenance and refurbishment of connection cables and any associated tasks.

<p><b>NPR 3378-43 (1999):</b> Praktijkrichtlijn gasinstallaties - Deel 43: Aansluiten van gastoestellen op de voorziening voor afvoer van rookgas (<i>Practice Guideline gas installations - Part 43: Connecting gas appliances for the provision of exhaust ducts</i>).</p>	<p>The procedure in this section shows the implementation of the discharge connecting pipe of a gas appliance. The transfer tube connects the unit outlet to the drain opening of a device in order to discharge combustion gas.</p>
--	--

A relevant standard concerning water supply networks is "**NEN 1006 + A3 (2011):** Algemenevoorschriftenvoorleidingwaterinstallaties (*General requirements for water supply installations*)". This standard specifies the requirements that a water system must comply with, from the health, safety and efficacy point of view. Temporary water systems also fall under the scope of this standard.

**Interconnection to the electrical grid**

Standard	Explanation
<p><b>NEN 1010 (2007) + C1 (2008)/A1 (2011) + C1 (2011):</b> Veiligheidsbepalingen voor laagspanningsinstallaties (<i>Safety requirements for low-voltage installations</i>).</p>	<p>This standard has the purpose of giving the minimum requirements for the construction of safe low voltage installations. It is also used for control and inspection upon completion of projects. NEN 1010 is widely applied in residential and commercial construction and industry.</p>
<p><b>NPR 5310 (2007) +A5 (2013):</b> Nederlandse Praktijkrichtlijn bij NEN 1010 (<i>Practices in Dutch NEN 1010</i>).</p>	<p>This standard offers the installer a guide to NEN 1010, clarifies standard texts and provides additional information. Furthermore, it explains how to verify whether the correct equipment is being used.</p>

**Exhaust and environment**

Standard	Explanation
<p><b>NEN 2757-1 (2011):</b> Bepalingsmethoden voor de geschiktheid van systemen voor de afvoer van rookgas van gebouwgebonden installaties - Deel 1: Installaties met een belasting kleiner dan of gelijk aan 130 kW op bovenwaarde (<i>Methods to determine the suitability of systems for the installation of exhaust ducts in buildings. Part 1: Systems with a load less than or equal to 130 kW as the upper value</i>).</p>	<p>This standard specifies the methods that should be used to determine the provisions for the discharge of flue gases.</p>

<p><b>NEN 8757 (2005):</b> Afvoer van rook van verbrandingstoestellen in gebouwen - Bepalingsmethoden voor bestaande bouw (<i>Discharge of smoke from combustion appliances in buildings - Calculation methods for existing buildings</i>).</p>	<p>This standard provides the methods that should be used to determine the provisions for the discharge of smoke.</p>
---	---

### Building and safety

Standard	Explanation
<p><b>NEN 1087 (2001):</b> Ventilatie van gebouwen - Bepalingsmethoden voor nieuwbouw (<i>Ventilation in buildings - Determination methods for new estate</i>).</p>	<p>This standard provides assessment methods for buildings: a) the nominal ventilation capacity of a provision for ventilation (provision for the supply of fresh air and the removal of indoor air) and a drainage device, b) the establishment of a provision for ventilation, related to thermal comfort, the direction of the air flow, the controllability and the location of a supply opening for the supply of outside air and a discharge opening for the removal of indoor air.</p>
<p><b>NEN 7120 + C2 (2012):</b> Energieprestatie van gebouwen - Bepalingsmethode (<i>Energy performance of buildings - Calculation method</i>).</p>	<p>This standard gives the terms, definitions and methodology used for the determination of energy and the derived indicators of a building or part of a building. It covers both new and existing houses, as well as residential buildings and commercial buildings.</p>
<p><b>NPR 1088 (1999):</b> Ventilatie van woningen en woongebouwen - Aanwijzingen voor en voorbeelden van de uitvoering van ventilatievoorzieningen (<i>Ventilation of dwellings and residential buildings - Instructions and examples of the performance of ventilation systems</i>).</p>	<p>The code of practice provides guidance on the implementation of ventilation facilities so that they meet specified performance requirements. The code of practice should be applied to the provision of ventilation to house or a residential building.</p>
<p><b>NTA 8025 (2005):</b> Periodieke beoordeling van de veiligheid van technische installaties en technische voorzieningen in woningen (<i>Periodic assessment of the safety of technical installations and technical equipment in houses</i>).</p>	<p>NTA applies to the assessment of the safety of existing installations (that is, electrical installations, gas appliances, water plants) and technical facilities in houses and outbuildings. This standard also contains:</p> <ul style="list-style-type: none"> <li>- a method that can be used to determine whether an existing technical installation or an existing technical provision meets the minimum socially acceptable level of safety;</li> <li>- a method to determine the necessary frequency of reviews.</li> </ul>

*Heating and hot water system*

Standard	Explanation
<b>NEN 3028 (2011):</b> Eisen voor verbrandingsinstallaties ( <i>Requirements for fuel combustion installations</i> ).	NEN 3028:2011 gives the applicable requirements for the design, construction and installation of buildings and it is also related to industrial furnaces, which are fired with solid, liquid or gaseous fuels from the second and third families. This standard is intended for use for: -the drafting of combustion appliances; -the implementation of the sided process protections of combustion appliances for which a conformity assessment is required, according to the Decree on equipment; -the management, maintenance and inspection of boiler rooms, heating appliances and incinerators.

### Slovenia

Additional national requirements (national standards), apart from those covered by EN standards, are not present in this Country, as far as heating installations are concerned.

In the present context, "**Technical guideline TSG-N-002 (2008):** Low-voltage electrical installations" and "**Technical Guideline TSG-1-001 (2009):** Fire Safety in Buildings" should be mentioned. Both were put into practice under Directive 98/34/EC and their texts are available on the TRIS database:

- <http://ec.europa.eu/enterprise/tris/pisa/app/search/index.cfm?fuseaction=getdraft&inum=1398661>
- <http://ec.europa.eu/enterprise/tris/pisa/app/search/index.cfm?fuseaction=getdraft&inum=1507591>

## Spain

The Spanish national administration has established a **building code** in which several important issues regarding heating systems and appliances are regulated. The building code, named “**Código Técnico de la Edificación**” (CTE) in Spanish, has been developed as several laws and amendments over the years, but all the information can be found at [www.codigotecnico.org](http://www.codigotecnico.org). The framework of CTE was created in Ley 38/1999 de Ordenación de la Edificación (LOE) and the current version was approved in 2006 in **Real Decreto 314/2006**. CTE is developed in six reference documents called “**Documento Básico**” (DB) (literally Basic Document) that give the technical and legal requirements pertaining to different aspects in the process of designing and constructing a building. The most important ones regarding the installation of heating appliances are:

- **DB HE Ahorro de Energía:** This is about energy efficiency in buildings. This is the most important document, since section 2 (HE2), called “Rendimiento de las Instalaciones Térmicas” (literally Efficiency of Heating Installations), contains specific information about heating appliance and system installations. HE2 is developed in Real Decreto 1027/2007 (amended in 2009 and 2013) which is called “Reglamento de Instalaciones Térmicas en los Edificios” (RITE) (literally Regulation for Heating Systems in Buildings) and it contains a first part which establishes a legal framework and a second part which sets out the technical requirements.
- **DB HS Salubridad:** This is about health and water quality.
- **DB HR Protección frente al Ruido:** This is about noise protection.

Furthermore, all the CTE DBs contain information about reference standards (some European (EN) and some national (UNE)) that comply with the regulations.

Additionally, electrical installation is regulated by **Real Decreto 842/2002** “Reglamento electrotécnico para baja tensión” (literally Regulation for Low Voltage Electrical Installations). This document contains a first part which sets out the legal framework and a second part which gives 51 “Instrucciones Técnicas Complementarias” (ITC) (literally Complementary Technical Instructions) that suggest the necessary technical requirements for several issues pertaining to low voltage electrical installations. This document also contains a section in which reference standards (UNE and EN) for electrical installations are given. Another law (**Real Decreto 1699/2011**) exists, which specifically regulates the interconnection of small power generators to the electrical grid.

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1. Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at [www.en.aenor.es](http://www.en.aenor.es).

**Interconnection to natural gas and water networks**

CTE and RITE are the main regulations that have to be followed for natural gas networks. However, regarding natural gas appliance interconnection with the network, standard **UNE 60670 “Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar”** (literally “Gas installation pipeworks supplied at a maximum operating pressure (MOP) up to and including 5 bar”) supplies additional and detailed technical requirements. Among its different parts, the following ones have been identified as the most interesting for the Ene.field project:

Standard	Explanation
<p><b>UNE 60670-3.</b> Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar. Parte 3: Tuberías, elementos, accesorios y sus uniones (<i>Gas installation pipeworks supplied at a maximum operating pressure (MOP) of up to and including 5 bar. Part 3: Pipeworks, elements, fittings and their unions</i>).</p>	<p>The UNE 60670 series standards all regulate different aspects of natural gas reception systems up to 5 bar. UNE60670-3 deals with pipework elements, fittings and unions. It specifies the material properties, technical characteristics and which types of connections can be realized and how.</p>
<p><b>UNE 60670-4.</b> Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar. Parte 4: Diseño y construcción (<i>Gas installation pipeworks supplied at a maximum operating pressure (MOP) of up to and including 5 bar. Part 4: Design and construction</i>).</p>	<p>The 4<sup>th</sup> part of UNE 60670 defines the design and installation guidelines for the abovementioned gas reception systems.</p>
<p><b>UNE 60670-6.</b> Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar. Parte 6: Requisitos de configuración, ventilación y evacuación de los productos de la combustión en los locales destinados a contener los aparatos a gas (<i>Gas installation pipeworks supplied at a maximum operating pressure (MOP) of up to and including 5 bar. Part 6: Configuration, ventilation and evacuation of the combustion products requirements for gas appliances premises</i>).</p>	<p>This standard regulates the characteristic of the appliance premises, the ventilation requirements and the exhaust outlets for appliances &lt;70kW. It is cited as a reference standard in RITE.</p>
<p><b>UNE 60670-7.</b> Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar. Parte 7: Requisitos de instalación y conexión de los aparatos a gas (<i>Gas installation pipeworks supplied at a maximum operating pressure (MOP) of up to and including 5 bar. Part 7: Installation and connection requirements for gas appliances</i>).</p>	<p>This standard deals with the requirements for the interconnection between gas appliances and the gas reception system.</p>

<p><b>UNE 60670-9.</b>Instalaciones receptoras de gas suministradas a una presión máxima de operación (MOP) inferior o igual a 5 bar. Parte 9: Pruebas previas al suministro y puesta en servicio (<i>Gas installation pipeworks supplied at a maximum operating pressure (MOP) of up to and including 5 bar. Part 9: Pre-supply testing and commissioning</i>).</p>	<p>UNE 60670-9 specifies the tests that should be carried out during the pre-supply testing and commissioning of a gas reception system.</p>
--	--

Furthermore, another standard: **UNE 60715“Tubos flexibles para unión de instalaciones a aparatos que utilizan gas como combustible. Conjuntos de conexión flexible con enchufe de seguridad y rosca”**, specifically addresses the technical requirements of flexible pipes for the connection of gas installations to gas appliances (assemblies of a flexible connection with a security socket and thread).

CTE is the regulation that has to be followed, as far as water supply is concerned. DB HS Salubridad specifically addresses water supply requirements.

### Interconnection to the electrical grid

The interconnection to the electrical distribution network is regulated by several laws and certain reference standards. Electrical energy distribution companies are allowed to set additional requirements to connect small generators to their networks (in accordance with Reglamento Electrotécnico para Baja Tensión).

The current regulations that have to be complied with are (Unión Fenosa Distribución, 2013):

Regulation	Explanation
<p><b>Ley 54/1997</b>, de 27 de noviembre, del Sector Eléctrico (<i>Electrical Sector</i>).</p>	<p>This law sets out the electrical energy activities in Spain</p>
<p><b>Ley 48/1998</b> de 30 de diciembre sobre procedimientos de contratación en los sectores del agua, la energía, los transportes y las telecomunicaciones, por la que se incorporan al ordenamiento jurídico español las directivas 93/38 CEE y 92/13 CEE (<b>Law 48/1998</b> on the procurement procedures in the water, energy, transport and telecommunications sectors, which are incorporated in Spanish law directives 93/38 EEC and 92/13 EEC).</p>	<p>This law sets the contracting procedures for the water, energy, transport and telecommunication sectors. It incorporates Directives 93/38/EEC and 92/13/EEC in Spanish legislation.</p>
<p><b>Real Decreto 1955/2000</b>, del 1 de diciembre de 2000, por el que se regulan las Actividades de Transporte, Distribución, Comercialización, Suministro y Procedimientos de Autorización de Instalaciones de Energía Eléctrica (<b>Royal Decree 1955/2000</b> which establishes the Transportation, Distribution, Marketing, Supply and Authorization Procedures for Electric Power Installations).</p>	<p>This Royal Decree regulates the transport, distribution, commercialization, supply and authorization procedures for electrical energy installations. Sections “Título III”, “Título IV” and “Título VII” contain information about the distribution network interconnection requirements and procedures.</p>

<p><b>Real Decreto 1454/2005</b> del 2 de diciembre de 2005, por el que se modifica parcialmente el Real Decreto 1955/2000, del 1 de diciembre de 2000 (<i>Royal Decree 1454/2005 which partially amends Royal Decree 1955/2000</i>).</p>	<p>Amendment of Real Decreto 1955/2000.</p>
<p><b>Reglamento Electrotécnico para Baja Tensión</b> aprobado por <b>Real Decreto 842/2002</b> de 2 de agosto, publicado en el BOE nº 224 del 18 de septiembre de 2002 (<i>Low Voltage Electrotechnical Regulation approved by Royal Decree 842/2002 and published in the Official Gazette No. 224, 18/09/2012</i>).</p>	<p>The Spanish Low Voltage Electrotechnical Ordinance contains 51 technical instructions that regulate several aspects pertaining to low voltage electrical installations. ITC-BT-40 specifically addresses the low voltage generator installation requirements.</p>
<p><b>Real Decreto 661/2007</b> de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial (<i>Royal Decree 661/2007 on the activity of electricity production under a special regime</i>).</p>	<p>This Royal Decree regulates electrical energy production for special regimes. The special regimes include certain types of electrical energy generators defined in Ley 54/1997. Cogeneration systems are also included in the Special Regimes category (Category a), and fuel cell microCHP systems are part of subgroup a.1.1 (high efficiency cogeneration systems that use natural gas). This document regulates the procedures that must be followed to register a generator in the Special Regime sector, sets the economic framework (retribution, incentives, etc.) and establishes certain requirements (efficiency, fuel, etc.) for the generators.</p>
<p><b>Real Decreto 1699/2011</b> de 18 de noviembre, por el que se regula la conexión a red de instalaciones de producción de energía eléctrica de pequeña potencia (<i>Royal Decree 1699/2011 on the regulation of the networking of small power facilities that produce electricity</i>).</p>	<p>This law defines the administrative, contractual, economic and basic technological conditions for small generators (&lt; 100kW) connected to the electrical grid.</p>
<p><b>Real Decreto 1110/2007</b> de 24 de Agosto de 2007 por el que se aprueba el reglamento unificado de puntos de medida del sistema eléctrico (<i>Royal Decree 1110/2007 on the approval of the unified regulations that deal with electrical system measurement points</i>).</p>	<p>This ordinance regulates energy metering activities in the electrical system. It covers different aspects, ranging from the physical situation of the measurement activities to the characteristics of the energy meters.</p>
<p><b>Código Técnico de la Edificación (CTE)</b> (<i>Technical Building Code</i>).</p>	<p>CTE regulates certain electrical interface topics through RITE.</p>

### Exhaust and environment

RITE regulates exhaust and environmental issues. Specific mention is made to **EU chimney standards** (**EN 13384**, **EN 1443**, etc.) and to two Spanish standards:

Standard	Explanation
<p><b>UNE 123001 (2012):</b> Cálculo, diseño e instalación de chimeneas modulares (<i>Calculation, design and installation of chimneysystems</i>).</p>	<p>This standard sets the requirements for the calculation, design and installation of chimneys (metallic or plastic) that have to be connected to the exhaust outlet of any appliance in buildings, including boilers, CHP and microCHP systems, stoves and so on.</p>
<p><b>UNE 123003 (2011):</b> Cálculo, diseño e instalación de chimeneas autoportantes (<i>Calculation, design and installation of free-standing chimneys</i>).</p>	<p>Like UNE 123001, this standard defines the requirements necessary for the calculation, design and installation of chimneys. In this context, it is specific for metallic free-standing chimneys.</p>

### Building and safety

All the safety and building requirements are defined in CTE. Two documents are of specific importance for heating systems and appliances:

- **DB HE Ahorro de Energía (RITE)** is about energy efficiency in buildings. This is the most important document, since section 2 (HE2), called “Rendimiento de las Instalaciones Térmicas” (literally Efficiency of Heating Installations), contains specific information about heating appliance and system installations. HE2 was developed in Real Decreto 1027/2007 (amended in 2009 and 2013) called “Reglamento de Instalaciones Térmicas en los Edificios” (RITE) (literally Regulation for Heating Systems in Buildings), and it contains the first part which lays out a legal framework, and a second part which shows the technical requirements.
- **DB HR Protección frente al Ruido** is about noise protection. It defines the noise limits and soundproofing requirements for buildings.

**Heating and hot water system**

RITE is the document that has to be followed in order to know all requirements pertaining to heating and hot water systems. There are two other important standards that should be considered:

Standard	Explanation
<p><b>UNE 60601.</b> Salas de máquinas y equipos autónomos de generación de calor o frío o para cogeneración, que utilizan combustibles gaseosos (<i>Machinery rooms and gas fired self contained apparatus for heating or cooling generation, or for cogeneration</i>).</p>	<p>This standard only applies to systems &gt; 70kW (considering all the installed power together).</p>
<p><b>UNE 100030.</b> Guía para la prevención y control de la proliferación y diseminación de legionela en instalaciones (<i>Guide on the prevention, control and dispersion of Legionella in buildings</i>).</p>	<p>The standard provides guidelines concerning the prevention, control and dispersion of Legionella in buildings. It suggests measures that should be taken for AC, ventilation and hot water systems during both the design and operation processes.</p>

## The United Kingdom

There are three Regulations in the UK that deal with all the aspects related to the design and construction of buildings, which apply throughout England and Wales, Scotland and Northern Ireland, respectively. Their aim is to ensure the health and safety of people in and around buildings, and they also deal with energy conservation and access to and use of these buildings.

The **Building Regulations of England and Wales** are established under powers provided by the **Building Act 1984**. They are currently composed of 14 sections, each of which is accompanied by an *Approval Document* (available at <http://www.planningportal.gov.uk/>). These documents first state the legislation and then provide a number of means which are deemed necessary to satisfy the Regulations. Among these sections, some are relevant for the installation of heating appliances:

- **Part E - Resistance to the passage of sound** is about the requirements that are needed to guarantee protection against sound from outside and within buildings.
- **Part F - Ventilation** is about the ventilation and air quality requirements of all buildings.
- **Part G - Sanitation, hot water and water efficiency** is about the requirements for the supply of water and its different uses within buildings.
- **Part H - Drainage and waste disposal** this deals with internal sanitary pipeworks, foul drainage, rainwater drainage and final disposal, wastewater treatment and discharges, cesspools, building over or close to 'public' and 'private' sewers and refuse storage. **Part H1 - Foul water drainage** is of particular interest.
- **Part J - Combustion appliances and fuel storage systems**. This part is concerned with the construction, installation and use of boilers, chimneys, flues, hearths and fuel storage installations. It deals with the control of the safety of installations: the suitability of materials / non-combustibility, pollution and carbon monoxide poisoning.
- **Part L - Conservation of fuel and power** this part deals with the energy efficiency requirements of buildings. In particular, **Parts L1A** and **L1B** focus on dwellings while **Parts L2A** and **L2B** focus on buildings other than dwellings.
- **Part P - Electrical safety – Dwellings** this contains new rules for electrical safety in house, the garden and outbuildings. This part only applies to dwellings (in some cases, buildings that would be exempt, but which take their electrical supply from a dwelling).

The **Scottish Building Regulations** are established by the Scottish Ministers according to the **Building (Scotland) Act 2003**. Two Technical Handbooks are issued by the Scottish Ministers in order to provide practical guidance with respect to the requirements of the provisions of the Building Regulations: one refers to domestic buildings and the other to non-domestic ones. The Technical Handbook that covers domestic building aspects (available at <http://www.scotland.gov.uk/>) is composed of 7 Sections. Those relevant for the installation of heating appliances are listed hereafter:

- **Section 3 - Environment**. The aim of this section is to ensure that buildings are not a threat to the environment and that people in or around buildings are not subjected to risks caused by certain aspects, such as the site conditions, inadequate drainage from a building, inadequate construction and installed combustion appliances, etc.

- **Section 4 - Safety.** This section supplies guidelines on the design of buildings to avoid the risk of accidents. It also takes into account safety concerning electrical installations and hot water systems.
- **Section 5 - Noise.** The aim of this section is to limit the transmission of sound from the outside or produced within the same dwelling. This section focuses on noise created by normal domestic activities.
- **Section 6 - Energy.** The intention of this section is primarily to lower carbon dioxide emissions by encouraging the use of low-carbon equipment (such as combined heat and power systems), and also to reduce the energy demand.

The **Northern Ireland Building Regulations 2012** (available at <http://www.dfpni.gov.uk/>) were drawn up by the Department of Finance and Personnel (DFP). These regulations are composed of 15 sections, each of which refers to a different aspect pertaining to the design and construction of buildings. DFP has published Technical Booklets to guide users in the comprehension of the Building Regulations. The topics that are dealt with are the same as for the other two Building Regulations versions. The most relevant sections are listed below:

- **Part F - Conservation of fuel and power.** This deals with energy efficiency requirements in buildings. It is composed of **Part F1**, which refers to dwellings and **Part F2**, which refers to buildings other than dwellings.
- **Part G - Resistance to the passage of sound.** This part deals with protection against sound from other parts of the building, and from adjoining buildings, as well as against sound produced within the same building.
- **Part K - Ventilation.** This is about the ventilation of buildings, including dwellings and buildings other than dwellings.
- **Part L - Combustion appliances and fuel storage systems.** This is about the installation of combustion appliances and fuel storage systems, and all the aspects related to the safe use of these devices.
- **Part N - Drainage.** This deals with the drainage of buildings, and it covers sanitary pipeworks, underground foul drainage and rainwater drainage.
- **Part P - Sanitary appliances, unvented hot water storage systems and reducing the risk of scalding.** This part is about water supply and distribution systems, and their safe use.

These Building Regulations make reference to both European (EN) and national standards that comply with the regulations.

The subsequent sections contain the most important national regulations and standards for FC-based microCHP systems installation, organized according to the five main areas mentioned in Section 4.1.

Only national level documents are mentioned, but generally all European (EN) standards are automatically valid inside EU countries. If not specified, these standards can be found at <http://shop.bsigroup.com/>.

*Interconnection to natural gas and water networks*

Standard	Explanation
<p><b>BS 5440 (2009):</b> Flueing and ventilation for gas appliances of a rated input that does not exceed 70 kW net (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> family gases) - Part 2: Specification for the installation and maintenance of ventilation provision for gas appliances</p>	<p>This standard specifies the requirements for the installation and maintenance of ventilation systems relating to gas appliances that utilize 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> family gases, with a rated heat input that does not exceed 70 kW, based on the net CV (net calorific value). It applies to provisions used for domestic or non-domestic purposes.</p>
<p><b>BS 6891 (2005) + A2 (2008):</b> Installation of low pressure gas pipeworks of up to 35 mm (R1 1/4) in domestic premises (2<sup>nd</sup> family gas). Specification.</p>	<p>The Standard specifies the design, installation and commissioning criteria for steel, copper or corrugated stainless steel semi-rigid pipe low pressure gas installation pipeworks. This standard applies to gas pipework for the supply of 2<sup>nd</sup> family gas from the meter to appliances in domestic dwellings.</p>
<p><b>GS(M)R 1996 :</b> Gas Safety (Management) Regulations.</p>	<p>The Gas Safety (Management) Regulations (GSMR) apply to the conveyance of natural gas (methane) through pipes to domestic and other consumers and cover four main areas:</p> <ul style="list-style-type: none"> <li>- The safe management of gas flow through a network, particularly those parts supplying domestic consumers, and a duty to minimise the risk of a gas supply emergency;</li> <li>- Arrangements for dealing with supply emergencies;</li> <li>- Arrangements for dealing with reported gas escapes and gas incidents;</li> <li>- Gas composition.</li> </ul>

The water supply **BS 8558 "Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages"** is the leading document in the domestic water supply area.

The "**Water Supply (Water Fittings) Regulations 1999**" (<http://archive.defra.gov.uk>) are the national requirements for the design, installation and maintenance of plumbing systems, water fittings and water-using appliances. Their purpose is to prevent the misuse, waste, undue consumption or erroneous measurement of water and, more importantly, to prevent contamination of drinking water. These Regulations are valid in England and Wales.

In Scotland, the "**Water Byelaws 2000**" document is roughly equivalent to the English and Welsh Water Supply (Water Fitting) Regulations, whereas the "**Water Supply (Water Fittings) Regulations 2009**" are used in Northern Ireland in order to be technically similar to England and Wales.

*Interconnection to the electrical grid*

Standard	Explanation
<p><b>BS 1362 (1997):</b> Specification for general purpose fuse links for domestic and similar purposes.</p>	<p>This standard deals with performance, dimensions, marking and tests for fuse links of any current rating not exceeding 13 A at 250 V a.c.</p>
<p><b>BS 7671 (2008) + A1 (2011) + A2 (2013):</b> Requirements for electrical installations.</p>	<p>This is the essential standard for electrical wiring and power systems in buildings. It outlines the testing and inspection procedure across a variety of locations and equipment including medical institutions and equipment, offices and computers, or maintenance gangways and electrical circuits. BS 7671 also provides a working guide to protecting against electromagnetic surges and using the correct electrical protection equipment. Working with the standard to achieve compliance, you can improve health and safety and emergency procedures.</p>
<p><b>ENA ER G83/2 (2012):</b> Recommendations for the connection of small-scale embedded generators (up to 16 A per phase) in parallel with public low-voltage distribution networks.</p>	<p>Specifies the technical requirements for connection of Small Scale Embedded Generators (SSEGs) for operation in parallel with a public low-voltage Distribution System, by addressing all technical aspects of the connection process from standards of functionality to site commissioning.</p>
<p><b>ENA Distributed Generation Connection Guides (2013).</b></p>	<p>There are three guides, two of which refer to ER G83/2 (single and multiple premises connections). The Guides are intended to help any user (whether it be an owner or a developer of Distributed Generation) to connect his generating plant to one of the UK's electricity distribution networks.</p>

*Exhaust and environment*

Standard	Explanation
<p><b>BS 5440 (2008):</b> Flueing and Ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases) – Part 1: Specification for installation of gas appliances to chimneys and for maintenance of chimneys.</p>	<p>This standard specifies requirements for the installation of gas appliances to chimneys, chimney installation work likely to be undertaken by gas engineers and operatives working under UK gas industry conditions and requirements for the maintenance of chimneys. It is applicable to open flue chimneys for Type B gas appliances and room-sealed chimney configurations for Type C gas appliances, each of rated input not exceeding 70 kW net family gases.</p>

*Building and safety*

Standard	Explanation
<p><b>BIP 2082 (2008):</b> Electrician's Guide to the Building Regulations Part P.</p>	<p>The Electrician's Guide to the Building Regulations will ensure that domestic installers not only comply with Part P (Electrical Safety), but also with other Building Regulations, including Fire Safety, Ventilation and Conservation of Energy.</p>
<p><b>GS(IU)R 1998 :</b> Safety in the installation and use of gas systems and appliances Gas Safety (Installation and Use) Regulations 1998. Approved Code of Practice and guidance.</p>	<p>This Approved Code of Practice (ACOP) and guidance gives practical advice on the Gas Safety (Installation and Use) Regulations. It is for anyone who may have a duty under the Regulations, including those who install, service, maintain or repair gas appliances and other gas fittings.</p>

*Heating and hot water system*

Standard	Explanation
<p><b>BS 1566 (2002) + A1 (2011):</b> Copper Cylinders for domestic purposes - Part 1: Open Vented Copper Cylinders – Requirements and Test Methods.</p>	<p>The standard discusses requirements for open vented, vertically mounted cylinders used to store hot water. The water is indirectly heated by primary (boiler) water circulating in an integral primary heater, or is directly heated via an external source or electric immersion heater. A look is also given at grades, materials, thickness, connections, tolerances, manufacture, corrosion resistance and product testing.</p>

<p><b>BS 5546 (2010):</b> Specification for installation and maintenance of gas-fired water-heating appliances of rated input not exceeding 70 kW net.</p>	<p>BS 5546 gives the requirements for the selection, installation, inspection, commissioning and maintenance of gas-powered hot-water supply systems. This includes water heaters with a rated power of not more than 70 kW, based on net calorific value.</p> <p>The standard also applies to water-heating devices using 1st, 2nd or 3rd family gases that supply hot water for domestic purposes – in either domestic or commercial dwellings. It covers current hot-water supply systems with a CE mark, as well as previously used appliances without this marking.</p>
<p><b>BS 5615 (1985):</b> Specification for insulating jackets for domestic hot water storage cylinders.</p>	<p>Specifies performance in respect of the maximum permitted heat loss, the materials, design and marking of jackets for cylinders to BS 1566.</p>
<p><b>BS 6798 (2009):</b> Specification for installation and maintenance of gas-fired boilers of rated input not exceeding 70 kW net.</p>	<p>This standard specifies requirements for the selection, installation, inspection, commissioning and maintenance of gas-fired boilers for central heating and other purposes, which have a total rated heat input not exceeding 70 kW, based on net calorific value. This includes cookers with integral boilers used to provide central heating. It applies to boilers utilizing 1st, 2nd or 3rd family gases designed to operate in the condensing or non-condensing mode for the heating of domestic dwellings or domestic dwellings in commercial premises by the circulation of heated water in open or closed systems. It applies both to boilers which carry a CE mark and also to previously used boilers which do not carry the CE mark.</p>
<p><b>BS 7074 (1989):</b> Application, selection and installation of expansion vessels and ancillary equipment for sealed water systems.</p>	<p>Part 1: Code of practice for domestic heating and hot water supply.</p> <p>Provides recommendations on the application of expansion vessels for use in individual domestic premises. It includes description, design considerations and types of application.</p> <p>Part 2: Code of practice for low and medium temperature hot water heating systems.</p> <p>It deals with vessels and systems for heating larger premises - commercial and industrial.</p>

<p><b>BS 7593 (2006):</b> Code of practice for treatment of water in domestic hot water central heating systems.</p>	<p>The purpose of BS 7593 is to ensure awareness of potential problems, and of the remedies required to maintain efficiency and maximize the life of the hot water central heating system. The standard also gives guidance on the preparation of the primary circuit of wet central heating systems prior to initial commissioning or re-commissioning following major remedial work (e.g. boiler replacement) and ongoing water treatment to ensure continued efficiency in operation. Although intended to cover domestic systems with up to 45 kW heat input, it is recognized that the recommendations are also applicable to similar systems of higher heat output.</p>
<p><b>BS 8580 (2010):</b> Water quality. Risk assessments for Legionella control. Code of practice.</p>	<p>This standard gives recommendations and guidance on the assessment of the risk of legionellosis presented by artificial water systems. It is applicable to any undertaking involving a work activity or premises controlled in connection with a trade, business or other undertaking where water is used or stored in circumstances that could cause a reasonably foreseeable risk of exposure to legionellae and contracting legionellosis.</p>

***Other RC&S: the Microgeneration Certification Scheme (MCS)***

The Microgeneration Certification Scheme (MCS) is an industry-led and internationally recognised quality assurance scheme (<http://www.microgenerationcertification.org/>), supported by the Department of Energy and Climate Change (DECC).

It certifies microgeneration products used to produce electricity and heat from renewable sources. MCS also certifies installation companies to ensure that the microgeneration products have been installed and commissioned to the highest standard for the consumer.

The certification is based on a set of installer standards and product scheme requirements. All the standards that refer to Micro Combined Heat and Power (CHP) technology are shown in the Table below.

Finally, MCS is linked to the Government's financial schemes and incentives. In order to access the Feed-In-Tariff (FiTs), Renewable Heat Incentive (RHI), or the Renewable Heat Premium Payment (RHPP), both the installed product and the installation company must be MCS certified.

Standard	Explanation
<p><b>MCS 001 (2013):</b> Installer Certification Scheme Requirements.</p>	<p>The scope of this scheme covers the requirements for companies undertaking the supply, design, installation, set to work, commissioning and handover of Microgeneration technologies (including CHP).</p>
<p><b>MCS 014 (2012):</b> Product Certification Scheme Requirements - CHP Heat Led.</p>	<p>This scheme provides ongoing independent, third party assessment and approval of heat-led micro-cogeneration packages intended for installation in single dwellings as the primary heating system, where the package:</p> <ul style="list-style-type: none"> <li>A) has a thermal and electrical output of less than 45 kWt or 50 kWe respectively;</li> <li>B) is fuelled by second and third family gas, gas from a bespoke source, hydrogen, mineral oil, other liquid fuels, principally bio-oils, other fuels including unconventional fuels and solid fuels.</li> </ul>
<p><b>MCS 015 (2012):</b> Product Certification Scheme Requirements - CHP Electricity Led.</p>	<p>This scheme provides ongoing independent, third party assessment and approval of electricity-led micro-cogeneration packages intended for installation in dwellings, where the package:</p> <ul style="list-style-type: none"> <li>A) has a thermal and electrical output of less than 45 kWt or 50 kWe respectively;</li> <li>B) is fuelled by second and third family gas, gas from a bespoke source, hydrogen, mineral oil, other liquid fuels, principally bio-oils, other fuels including unconventional fuels and solid fuels;</li> <li>C) is intended to maximise electricity production in response to an electrical demand.</li> <li>D) All the co-generated heat recovered will be made use of.</li> </ul>
<p><b>MIS 3007 (2013):</b> Heat led Micro CHP Systems.</p>	<p>This standard specifies the requirements of the Microgeneration Certification Scheme (MCS) for the approval and listing of Contractors undertaking the design, supply, installation, set to work, commissioning and handover of a heating system containing a micro-cogeneration package.</p>
<p><b>MIS 3007-2 (2013):</b> Electricity led Micro CHP Systems.</p>	<p>This standard specifies the requirements of the Microgeneration Certification Scheme (MCS) for the approval and listing of Contractors undertaking the design, supply, installation, set to work, commissioning and handover of a domestic hot water system containing a micro-cogeneration package.</p>

<p><b>Metering Guidance (2010)</b></p>	<p>This standard deals with the choice and installation of a meter and the possible application for the Feed-in Tariff.</p>
<p><b>PAS 67</b></p>	<p>This document deals with laboratory tests that have the aim of determining the heating and electrical performance of heat-led micro-cogeneration packages intended primarily for the heating of dwellings. Its use with the related MCS documents makes it possible to obtain access to the Feed-in Tariff.</p>

## References

- Bellerate, E., & Brusaglino, G. (2006). *HarmonHy WP4 deliverable: Report on industrial and societal needs*. Retrieved from <http://www.harmonhy.com/documents.php>
- Callux project. (2012, July 4). Callux: Field Test of Residential Fuel Cells. Background & Activities. Retrieved May 22, 2013, from <http://www.callux.net/home.English.html>
- Carter, D. (2013, February 27). Latest Developments in the Ene-Farm Scheme. *Fuel Cell Today*. Retrieved July 1, 2013, from <http://www.fuelcelltoday.com/analysis/analyst-views/2013/13-02-27-latest-developments-in-the-ene-farm-scheme>
- Conte, M. (2006, October). HarmonHy final conference: HarmoHy: Areas for Additional Pre-normative Research for RC&S. Brussels.
- FC-DISTRICT project, WP10 (2012, August 31). *Preliminary assessment on energy/cost reduction*.
- FCTESTNET WP2. (2006). *Stationary Fuel Cell Systems Test Programs and Test Modules*. Retrieved from <http://iet.jrc.ec.europa.eu/fuel-cells/downloads-0>
- FCTESTQA project. (2013, February 21). Retrieved May 6, 2013, from <http://iet.jrc.ec.europa.eu/fuel-cells/about-fctesqa-project>
- Fuel Cell Commercialization Conference of Japan. (2012, February). Ene-farm. Dissemination and General Specification. Retrieved July 1, 2013, from <http://www.fuelcellinsider.org/wp-content/uploads/2012/04/ENE-Farm-summary.pdf>
- Gandiglio, M., Lanzini, A., Santarelli, M., & Leone, P. (2014). *Design and optimization of a proton exchange membrane fuel cell CHP system for residential use*. *Energy and Buildings* 69, 381 – 393.
- HYPER. (2009). Installation Permitting Guidance for Hydrogen and Fuel Cells Stationary Applications. Retrieved from <http://www.hyperproject.eu/>
- Jordan, T. (2006, October 4). HarmonHy final conference. HySafe: Creating the knowledge base for regulatory processes. Brussels.
- Klobut, K., Vesanen, T., Pykälä, M.-L., Sipilä, K., Kiviaho, J., & Rosenberg, R. (2009). *Handbook of SOFC system in buildings: Legislation, standards and requirements*. VTT. Retrieved from <http://www.vtt.fi/inf/pdf/tiedotteet/2009/T2465.pdf>
- Nikkei. (2013, May 21). Tokyo Metropolitan Government to Subsidise Ene-Farm Home Fuel Cell System. Retrieved July 1, 2013, from <http://www.fuelcelltoday.com/news-events/news-archive/2013/may/tokyo-metropolitan-government-to-subsidise-ene-farm-home-fuel-cell-system>
- Pacific Northwest National Laboratory. (2004). *Hydrogen and Fuel Cells Permitting Guide. Module 1 - Permitting Stationary Fuel Cell Installations*. US Department of Energy. Retrieved from [http://www.pnl.gov/fuelcells/permit\\_guide.stm](http://www.pnl.gov/fuelcells/permit_guide.stm)

Panasonic Corporation. (2013, January 17). Launch of New 'Ene-Farm' Home Fuel Cell Product More Affordable and Easier to Install. Retrieved July 1, 2013, from <http://panasonic.co.jp/corp/news/official.data/data.dir/2013/01/en130117-5/en130117-5.html>

Steinberger-Wilkens, R. (2012). FC-Eurogrid: Evaluating the Performance of Fuel Cells n European Energy Supply Grids. Brussels.

Vergels, F. (2006, October 4). HarmonHy final conference. HarmonHy: Findings and recommendations. Brussels. Retrieved from <http://www.harmonhy.com/documents.php>