

ene.field project



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# **Grid Connection of fuel cell based micro-CHPs: Standards, legislations, issues and lessons learned**

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## EXECUTIVE SUMMARY

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This position paper is part of the ene.field project (European-wide field trials for residential fuel cell micro-CHP). Europe's largest demonstration project for FC- based micro-CHP (fuel cell based micro combined heat and power) systems. The aim is to give an insight in the current status of grid connections; to the power and the natural gas grids as well as connections to building for a number of European countries. This includes standards, legislations, connection guidelines and issues. A micro-CHP produces both heat and power to supply a single household up to small commercial buildings with all or parts of their heat and power demand.

Three installation modes have been identified;

1. Stand-alone installation: This means that the unit is installed without any connection to the power grid, meaning that all the produced electricity will be consumed at site.
2. Sell surplus electricity: This is the most common installation mode in which the surplus electricity will be exported to the grid
3. Sell all electricity: When this installation is performed none of the produced electricity will be consumed (no connection to any building is required), but all of the produced electricity will be exported to the grid.

The second alternative is the most frequently used/considered installation mode. The three above mentioned grid connections are described for Denmark, France, Germany, Italy and the United Kingdom. The installation procedure is similar in most countries, but with national supplements, such as if there is need for an additional electric breaker and if this should be installed indoors or outdoors so that the network operator has constant access.

Also, connections to the gas grid as well as electrical connections to households are described. Furthermore, special requirements/demands on the technical installer for power grid connections, gas grid connections as well as electrical connections to the buildings are considered and explained.

Even though only a few FC- based micro-CHP units have been installed in Europe (in previous and ongoing field trials) a number of grid connections related issues have been observed. The most frequently observed issue relate to the inverter which is sensitive to disturbances on the grid, such as variable power input as well as power outages due to weather and grid maintenance. This often leads to a sudden stop of the micro-CHP as an inverter failure will trigger the safety system and thereby shut down the whole system. Furthermore, future possible grid connections are briefly discussed.

As a consequence of the fact that only a few units have been installed an updated version of this report will be published by the end of the ene.field project. The updated version will include more specific grid connection issues and sharper suggestions for political policy.

# 1. INTRODUCTION AND AIM

## Summary box of chapter 1

This position paper is part of the ene.field project (European-wide field trials for residential fuel cell micro-CHP). Europe's largest demonstration project for FC- based micro-CHP (fuel cell based micro combined heat and power) systems. It introduces its aim and the scope. Namely, to give an insight in the current status of connections to the power and the natural gas grid, including standards, legislation and issues. Furthermore, the concept of fuel cell and the FC- based micro-CHP is introduced. A fuel cell converts chemical energy into electricity, heat and water and a FC-based micro-CHP is a small scale power and heat production plant typically dimensioned to supply heat and electricity for one building.

## 1.1. Introduction

This position paper is a part of Europe's largest demonstration project for fuel cell based micro-CHP (micro combined heat and power) systems called ene.field (*European-wide field trials for residential fuel cell micro-CHP*), grant no. 303462 [1]. The aim of the project is to demonstrate small stationary fuel cell systems for residential and commercial applications. The project will deploy up to 1000 micro-CHP units in 12 EU member states. This is a step change in the volume of fuel cell micro-CHP deployment in Europe and an important step to push the technology towards commercialization. The project involves 26 partners. Several research institutes as well as utilities are also involved as partners in the project.

### 1.1.1. Fuel cells

A fuel cell is an electrochemical device that directly converts chemical energy into electricity, heat and water. Typical fuels are hydrogen (either derived from water or a hydrocarbon fuel such as natural gas, gasoline or diesel) and oxygen (supplied from the air).

Fuel cell operates without combustion and is therefore not limited by the Carnot cycle, leading to higher theoretical efficiency. There are several classes of fuel cells; these are often based on the electrolyte materials that are used in the cells. The most common classes are polymer electrolyte membrane (PEM) based fuel cell and solid oxide fuel cells (SOFC). Figure 1, below, shows the operating principle for a solid oxide fuel cell.

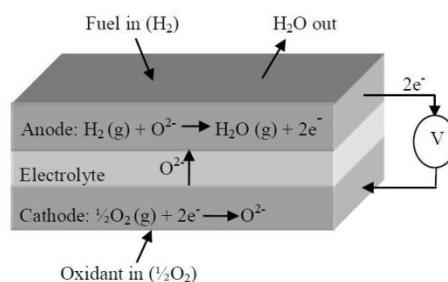


Figure 1. Working principle of an SOFC including electrode reactions, using hydrogen as the anode fuel.

To make a whole system, several fuel cells are combined into a stack which is combined with a large number of external components and help systems such as reformer, inverters, water supply, etc.

### 1.1.2. Fuel cell based micro-CHP systems

Micro-CHP systems produce both electricity and heat. Their electrical efficiency is higher than standard turbines and boilers, and the high utilization of the produced heat is a big advantage for fuel cell based micro-CHP technology. They can be connected directly to separate buildings, but also export excess electricity to the grid. This can potentially increase the power security in a future electricity grid as many other renewable energy technologies are intermittent and can thereby cause a lack of electricity when for example the wind is weak or the sun is absent [2].

The European definition of a micro-CHP system is that it must be a cogeneration (heat and electricity) system with a maximum output below 50 kW<sub>e</sub> [3]. The ene.field project involve, as mentioned previously, several manufacturers who all distribute fuel cell based micro-CHP systems. Table 1 below gives technical characteristics of the systems being deployed within the ene.field project.

Table 1. Technical characteristics of systems deployed within ene.field. \* based on the lower heating value, \*\* PEM = Polymer Electrolyte Membrane Fuel Cells, SOFC = Solid Oxide Fuel Cells, LT = low temperature, HT = high temperature and IT = intermediate temperature [4].

Technical characteristics	Summary table of products	
Fuel cell technology	LT-PEM / HT-PEM **	SOFC / IT-SOFC**
kW electrical	1 - 5 kW	0.8 - 2.5 kW
kW thermal	1.4 - 10 kW	1.4 - 25 kW
System efficiency (LHV*)	58 - 90 %	80 - 95 %
Electrical efficiency (LHV)	35 %	35 - 40 %
System type	Floor	Wall or Floor
Certification	CE	CE

A micro-CHP unit needs to be connected to the gas grid (or a separate gas supply) and to the electricity grid. Gas is required for operation of the fuel cell. The micro-CHP unit can at times when the electricity consumption in the building (that it supplies with heat and power) is low produce more electricity than needed. It is, in those cases, beneficial if the surplus electricity can be exported to the electricity grid and when the residential consumption exceeds the production of the micro-CHP, this creates a need to import additional electricity from the grid. It is therefore important to know the current status and any potential issues that regard to grid connection of fuel cell based micro-CHP units. Figure 2 shows a sketch of a micro CHP unit installed in a residential house.

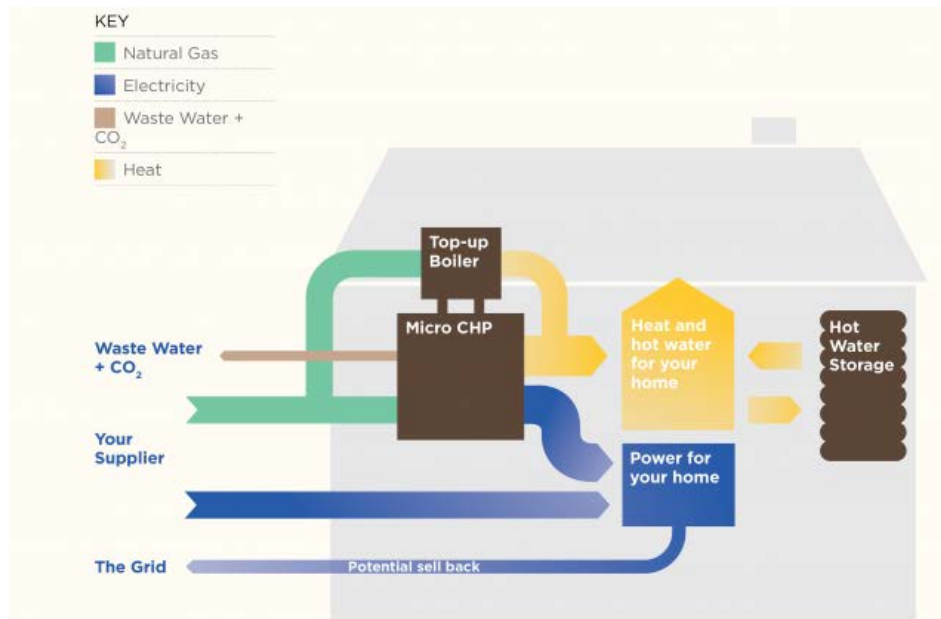


Figure 2. Sketch showing a micro-CHP installed in a residential house. [5]

## 1.2. Aim

The aim of this position paper is to identify and summarize current standards that are of importance for grid connections as well as to identify already observed and potential future issues that concerns connection to the gas- and electricity grid. The focus of this report is on technical grid connections and not on economy.

In general, the following connection aspects must be considered when installing a micro-CHP to a residential building:

- Connection to the natural gas grid (or stand-alone gas supply)
- Connection to air supply (needed for the fuel cell to run)
- Connection to the electrical network (in cases where electricity will be exported to the grid, this aspect may need installation of additional connections).
- Electrical connections between the micro-CHP and the building
- Connection of water supply
- Connection to the households heat and hot water system
- Internet connection (in case of remote controlled, smart grid operation)
- Exhaust connection, both chimney and ventilation

Apart from connection of the unit must also the building (site), usage of appropriate installation personnel as well as permits and technical documentation be verified and signed. The unit size (electrical and thermal output) needed for a certain dwelling is dependent on the operating mode and the demand for the specific dwellings and must be worked out with the end-user and the distributor/manufacturers of the units and is not taken into account in this report.

However, economy plays a vital role for the dissemination of micro-CHP and fuel cells, and the fuel cell economy for private and commercial fuel cell customers in most countries are based upon national political decisions. For some countries no special conditions have been decided to promote fuel cells, whereas other countries do have beneficial subsidies to help the promotion of FC micro-CHP.

Due to this rather confusion picture it has been quite difficult to create a complete picture of the European politically decided support systems and related calculations of the economic consequences for the user of fuel-cells. This task will, therefore, be executed later on in the Ene.field project.

### **1.3. Focus and content**

This report focuses on the connection to the natural gas grid, to the electrical grid and the electrical connection between the micro-CHP and the building (site). Three types of operating modes are considered; sell (export) all the produced electricity to the grid, sell surplus electricity to the grid and consume all the produced electricity in the building where it is produced (self-consumption). In all cases it is assumed that all the produced heat is being consumed by the dwelling in which the unit is installed, e.g. no export of heat.

The content of this position is divided into sections: section 2 gives some input from previous projects as well as related topics within the ene.field project. Section 3-6 explains current standards, legislation, how grid connections are performed and if there are any special specifications needed for fuel cell based systems in Denmark, France, Germany, Italy and United Kingdom. Additional sections try to identify already observed and potential future issues. An appendix (A) including relevant national regulations, codes and standards for; Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Slovenia, Spain and the United Kingdom is added. This appendix is directly taken from the ene.field deliverable 3.5 "Regulations, Codes and Standards".

*\*NOTE: The number of installed fuel cell based micro-CHP units is currently limited and thereby is also the data regarding grid connection issues also limited. Due to this the position paper will be updated in the end of the ene.field-project. This update will be to ensure a more rigid base and thereby also more solid suggestions on areas that need further improvements.*

### **1.4. Partners**

This position paper has been written by the Technical University of Denmark, Dong Energy AS, Dolomiti Energia SPA, GDF SUEZ and British Gas Trading Limited; additional input has been given from several other partners within the ene.field project.

## 2. PREVIOUS, ON-GOING AND RELATED WORK

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### Summary box of chapter 2

This chapter gives a short update on previous and ongoing European projects carried out in the same or closely related areas. It also gives an insight in related ene.field tasks. Two work tasks within ene.field are related to this work. Namely, a regulation codes and standards (RCS) work group that have carefully analysed the current status on RCS in Europe and all the way down to a national level. Looking at various aspect of RCS useful in the installation process of an micro-CHP. Another related task is the field support arrangement that have reviewed the current status on field support arrangements, training and certification.

### 2.1 Previous and on-going European projects

A large number of projects have been carried out on the topic of regulation, codes and standards. However, only limited attention has been taken to grid connections. Below is a short summary of some of the previous projects that have been carried out and where grid connections have been assessed. A more extensive summary of RCS- projects can be found in the “position paper on regulation, codes and standards” that have been published as Deliverable 3.5 within the ene.field project or through webpages, reports and other documents supplied by the projects stated below.

HarmonHy, Harmonization of Standards and Regulations for a Sustainable Hydrogen and Fuel Cell Technology, project that took place in 2005-2006 and was funded by the 6<sup>th</sup> Framework Programme of the European Commission [6]. Apart from assessing and defining needs for harmonization and development of standards and regulations this project prepared a priority list with issues/barriers to solve in order to help fuel cell technologies to the market. “Low voltage grid connection” was here pointed out as one important topic to help the technology to reach market penetration.

Another project funded by the 6<sup>th</sup> Framework Programme of the European Commission was the HYPER project carried out 2006- 2009. This project aimed to develop an installation permitting guide for stationary hydrogen and fuel cell applications [7]. Below are to citations from the outcome of the project:

*“Interconnectivity: Manufacturers of equipment intended to be connected to networks should construct such equipment in a way that prevents networks from suffering unacceptable degradation of service when used under normal operating conditions. National standards exist covering the connection of small scale generators to local power distribution networks, e.g. in the UK: technical Note G83/1-1. These standards address issues such as safety of network personnel and quality of exported power.” [8]*

*“National legislation: Installations that are connected to the electrical distribution network, for exporting surplus electricity back to the grid, will need to meet electrical regulations for interconnectivity of supplies.” [9]*

On the HYPER-projects webpage are a number of lists published including national regulations for natural gas systems as well as international regulations, codes and standards.

An ongoing project where the outcome can be of interest is the Hyindoor project, funded by the Fuel Cells and Hydrogen Joint Undertaking. This project aims to improve and close gaps in already existing RC&S. However the focus is on safety aspects in closed environments (indoors) and might therefore be more relevant for other parts of the ene.field project.

Finland has prepared the “Finnish handbook of the SOFC System in Buildings” which was published in 2009 as a part of their fuel cell technological program [10]. This handbook is divided into sections where both Finnish and international regulations on natural gas interfaces as well as electrical interconnections are evaluated.

## **2.2 Related work within ene.field**

### 2.2.1 Work task 3.1: review of field support arrangements

The ene.field work task 3.1 aimed to evaluate and describe the current state of the art with respect to field support arrangements, training and certification, this work task was led by ENVIPARK (Parco Scientifico e Tecnologico per L’ambiente – Environment Park Spa). The report raise the awareness on lessons learned from previous and on-going projects. The work was carried out in collaboration with the JTI-FCH project; Hyprofessionals. The outcome of the report highlight that there is a need for specific courses, at both European and international level, on micro-CHP systems. It is suggested that the following topics could be covered by such courses:

- General information about CHP technology (electricity generation as a by-product of heat);
- Advantages on CHP technology:
- *Carbon savings*: by generating electricity on-site you could be saving carbon dioxide compared with using grid electricity and a standard heating boiler),
- *Easy installation*: if you already have a conventional boiler then a micro-CHP unit should be able to replace it as it’s roughly the same size.
- *Servicing costs and maintenance*: estimated to be similar to a standard boiler
- Financial income;
- Certification for installers

### 2.2.2. Work task 3.5: RCS Working group

Ene.field work task 3.5 called *Regulations, Codes and Standards working group* (RCS- working group, led by Politecnico de Torino) is established to be a clear and joint sound from European manufacturers regarding regulations, codes and standards. The aim of this working group is to analyse European (and country specific) legislations, codes, permits and standards including application procedure, construction and planning permits. It will also support the development of standards and quality management in sales, design, installation and operation, in order to protect end-users and increased customer confidence and to support preparation and application of legislative measures. Furthermore, it will prepare commitments with industry and stakeholders for the development of standards, labelling and certification system.

This working group has prepared an extensive position paper on RCS within Europe. The report includes European and country specific regulations, codes and standards on seven main topics that regard installation of a fuel cell based micro-CHP, see bullet list below. The following countries have

been considered: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Slovenia, Spain and the United Kingdom.

- Inlet fluids: for example, natural gas, air and water
- Electrical system: for example, connection to electrical grid
- Heat and hot water: heating and hot water systems in the building
- Exhaust: chimney and ventilation etc.
- Construction and siting
- People: installers and other involved staff
- Administration: permits and technical documentation

Especially the two first points are of great importance for this report as they directly relate to grid connections.

The main interesting point on codes and standards were that there is a large non-homogeneity within Europe. Most countries base their codes and standards on European standards, but with country specific supplements creating a need for the manufacturers to change and adopt when trying to penetrate the market throughout more European countries. Concerning European regulations were the main finding that micro-CHPs are labelled in an unfair/unbalanced way compared to other energy technologies. This raises the necessity to understand the exact opinion of the European commission regarding policies on the energy labelling. Relevant national regulations, codes and standards for the above mentioned countries can be found either in Deliverable 3.5 or in appendix A.

#### 2.2.3. Work task 3.6.2: Smart-grid and active control

One additional task of interest is a position paper that is being prepared with focus on smart-grids and active control. This position paper is currently in the process of being finalized and is expected to be finished in the first quarter of 2015.

The main focus of this position paper is to evaluate the capabilities of fuel cell based micro-CHP system in a future smart-grid. This will include suggestion on preferred operation modes for the units, e.g. if the shall be load-following, heat-following, operated at constant load and so forth. This will also reflect how and when units shall export excess electricity to the power grid and who will be allowed to take decisions on this.

## 3. CONNECTION TO THE ELECTRICITY GRID

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### Summary box of chapter 3

This section aims to explain the connections to the electrical grid for a micro-CHP system. A micro-CHP can be installed to serve different purposes, for example; sell (export) all the produced electricity to the grid, sell surplus electricity to the grid and consume all the produced electricity in the building where it is produced (self-consumption). Standards, legislation and different installation scenarios are described for Denmark, France, Italy and UK in section 3.1-3.4. A comprehensive list of grid-connection relevant regulations, codes and standards can be found in the ene.field deliverable 3.5: *Position paper on regulations, Codes and Standards*. This position paper compile of RC&S information for the following countries: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, The Netherlands, Slovenia, Spain and the United Kingdom.

### 3.1. Connection to the Danish electricity grid

#### 3.1.1. Standards and Legislation

The technical requirements which have to respect the production installations to be connected to the electricity networks are based on the "Teknisk Forskrift" (Technical Direction) 3.2.1 for power producing plants with nominal current below 16 A (11 kW) and its implementing decrees [11]. This Technical Direction refers to the EU norm EN 50438 ("Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks")

For the grid connection, the electric production installation follows the steps given in Figure 3. Figure 4 illustrates the connection to the electric grid. For all installations:

- In Denmark the installation contains: 1. Fuse in an outdoor cabinet (no switch) 2. Branch conducting line. 3. Accounting Meter 4. Fuse 5. Pulsating RCD and fuse (installation by authorized personnel)
- Only electronic meter is used (electromechanical meter is forbidden).
- Agreement between the TSO (Energinet.dk) and the local power distributor and the electric producer. The power distributor is responsible for registration of metering data and reporting of plant data to the TSO.

Additional regulations, codes and standards for Denmark can be found in Appendix A.

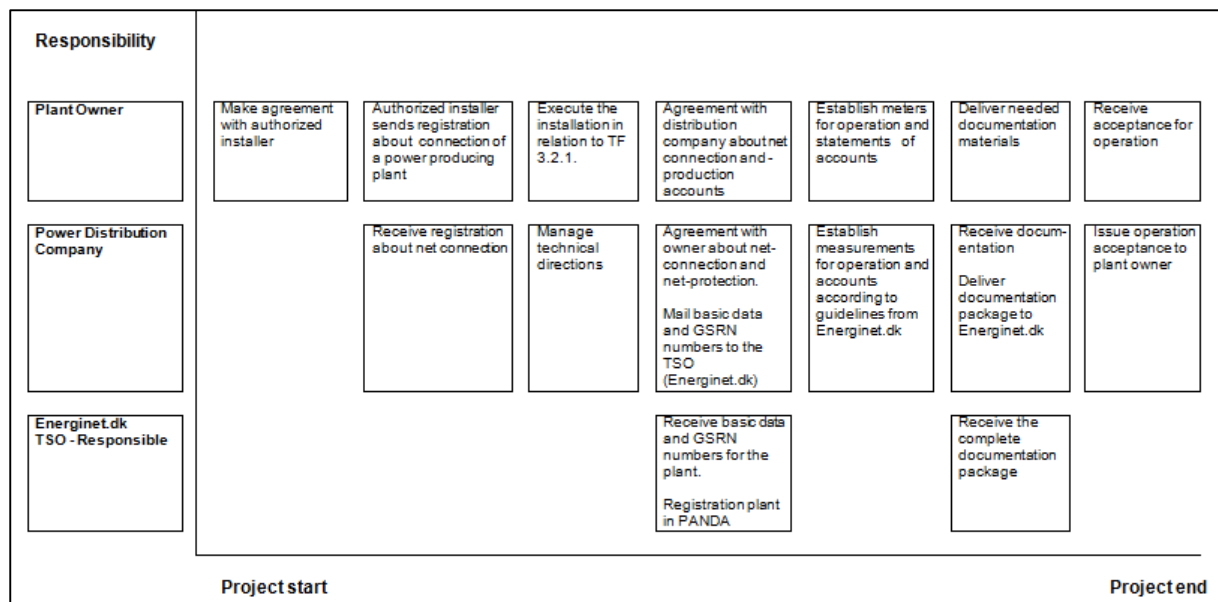


Figure 3. Installation procedure for single power producing plants of less than 11 kW in Denmark.

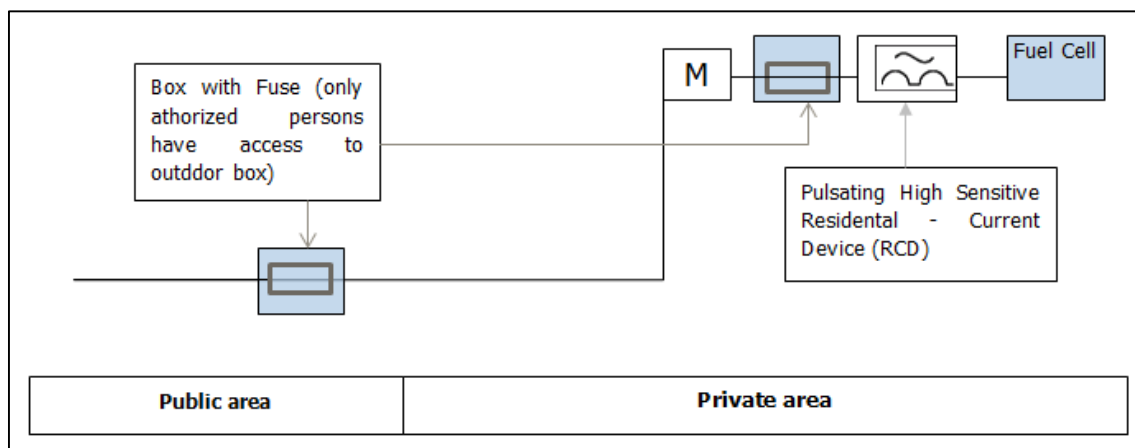


Figure 4. Illustration of a Danish connection between a private area and the public area (the grid).

### 3.1.1.1. Different electric connections

There are as mentioned previously three different scenarios to consider when a power producer is connected to the power grid, namely: 1) sell (export) all the produced electricity to the grid, 2) sell surplus electricity to the grid and 3) consume all the produced electricity in the building where it is produced (self-consumption). In the case of self-consumption no modifications of the electric installation is required.

No remarkable bureaucracy is involved in the application for the installation as already known guidelines known from PV panels will be followed. However with one major exception concerning Danish installations, as tariffs for solar PV is much higher than tariffs for electricity from natural gas feed fuel cells. Duration process for the paper work is normally 1 - 2 weeks.

When all the produced electricity or the surplus electricity will be sold to the grid a new electric line is required as the delivery to the network might exceed the dimension for the internal house cabling.

There is also a need for an electric meter with two counting trains, e.g. one for electricity in and one for electricity out.

### 3.1.2. Agreements between partners

The producer has to sign agreements with both the DSO and TSO, see Figure 3.

### 3.1.3. Who can do the work?

The electric work must be performed by an electrician who has the adequate qualifications, minimum a certified electrician or an educated electrician working for a certified electrician. No immediate problems with sufficient qualified personnel are foreseen here.

## **3.2. Connection to the French electricity grid**

### 3.2.1. Standards and Legislation

The technical requirements which have to respect the productions to be connected to the electricity grids are based on Decree No. 2008-386 of 23<sup>rd</sup> of April 2008, and its implementing decrees. For the grid connection, the electric production depends on two important standards:

1. NF C 14-100 of March 2008 which defines the electric conception for the grid connection.
2. NF C 15-100 which regards the electric installation.

Figure 5 illustrates the connection to the electric grid. The following three points are required for all French installations:

- An electric breaker with a public access (standard NF C 14-100).
- Electronic meters must be used, e.g. electromechanical meters are forbidden.
- An agreement between the DSO (ErDF, Est, GEG,...) and the producer is needed.

Additional regulations, codes and standards for France can be found in Appendix A.

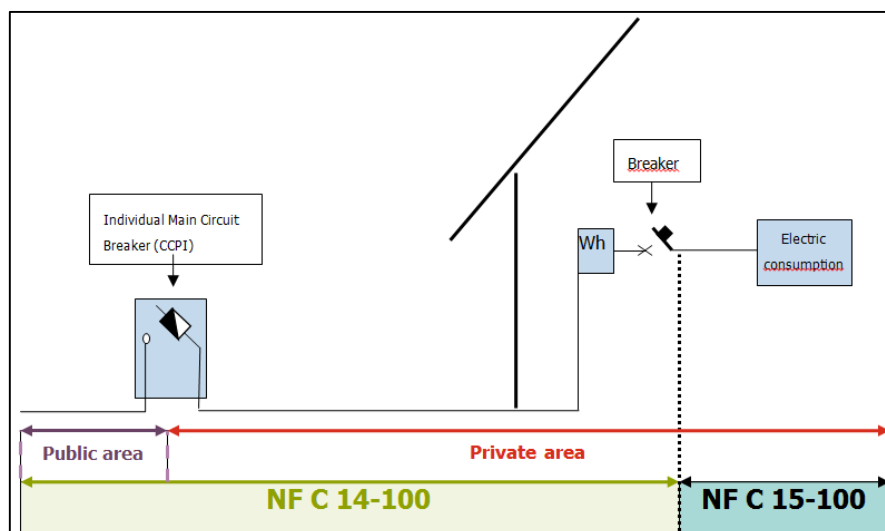


Figure 5. Illustration of a French connection between a private area and the public area (the grid), based on NF C 14-100 and NF C 15-100.

### 3.2.1.1. Different electric connections

In cases where the aim is to sell all produced electricity a new electric line with individual main circuit breaker (CCPI) which is in the public area, 2 electric meters and an electric security breaker (D1) in the private area must be created, see Figure 6 (top). The electric production system must have an electric decoupling protection which respects the DIN VDE 0126 V1.1.

When only surplus electricity will be sold an additional electric meter have to be installed, assuming that an electric breaker, CCPI, is installed in the public area (Standard NF C 14-100), See Figure 6 (middle). This installation is realized by the DSO.

No particular modification is required in the case where all produced electricity will be consumed without using the grid (self-consumption), see Figure 6 (bottom). This is of course under circumstances that Standard NF C 14-100 is fulfilled, e.g. that an electronic electric meter is used and an electric breaker, CCPI is installed in the public area.

The DSO gets the energy consumption / production of the end user electric meter once or twice a year and sends the information to the electric supplier of the customer.

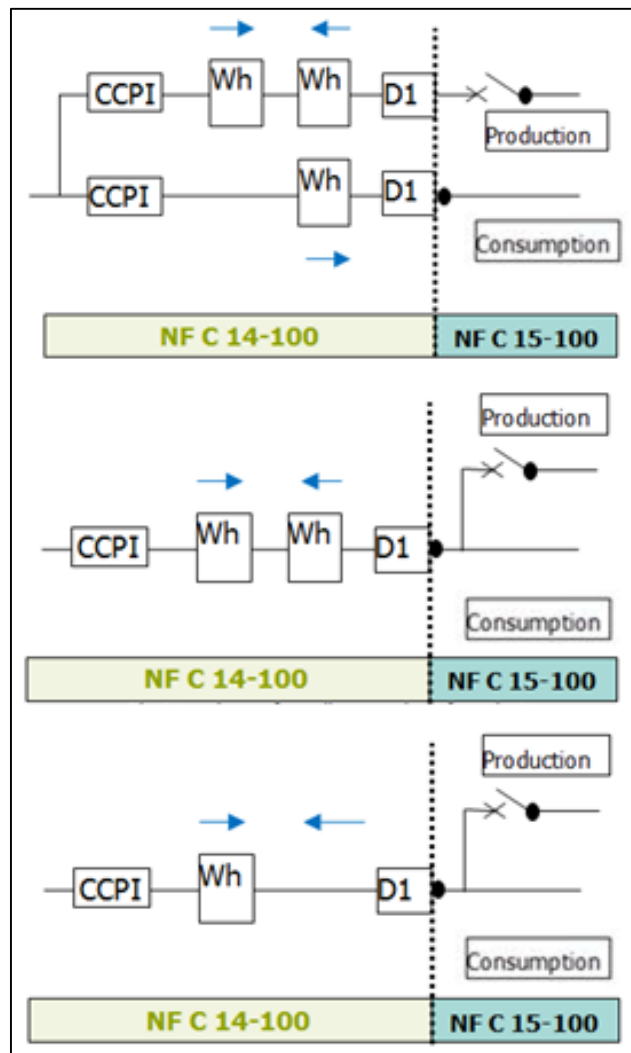


Figure 6. Illustrates different grid connections. Top: All of the produced electricity will be exported to the grid. Middle: Surplus electricity will be exported to the grid. Bottom: All electricity will be self-consumed.

### 3.2.2. Agreements between partners

The producer and the DSO have to sign an agreement. The following two links give examples of such agreements:

- [http://www.erdfdistribution.fr/medias/DTR\\_Racc\\_Prod/ERDF-FOR-RAC\\_22E\\_Formulaire.pdf](http://www.erdfdistribution.fr/medias/DTR_Racc_Prod/ERDF-FOR-RAC_22E_Formulaire.pdf)
- <http://www.es-reseaux.fr/Producteurs/Declarer-une-production-en-autoconsommation-de-puissance-inferieure-ou-egale-a-3-kVA>

The agreement (including signing of documents) between the producer and the DSO is usually realized within month.

### 3.2.3. Who can do the work?

An electrician with a qualification is needed, for example a BR qualification. The DSO and the producer need to sign an agreement. The commissioning of the micro CHP has to be done after the signature of the agreement.

## **3.3. Connection to the German electricity grid**

### 3.3.1. Standards and legislation

Installations of a micro-CHP unit in Germany must apply with German laws: either the “German Renewable Energy Act” (EEG, Erneuerbare-Energien-Gesetz) or the “Combined Heat and Power Act” (KWK-G, Kraft-Wärme-Kopplungsgesetz). A CHP system does always have the right to be connected to the German electricity grid, meaning that the does not have the right to reject connection of a CHP system to the grid unless it is believed to have a negative influence on the grid stability. Several forms must be filled in, see section 3.3.3. Additional regulations, codes and standards can be found in Appendix A.

Regulation VDE-AR-N 4105:2011-08 (a regulation on technical connection conditions) [12] sets the course for how to improve the integration of distributed generation sources (such as photovoltaics and micro-CHP units) in the German electricity grid. Its most essential statements are communicated in the following list:

- It aims to facilitate network integration of distributed power generation.
- The core of the VDE-AR-N 4105 form grid-supporting functions to ensure safe and reliable operation of the network, with the highest possible integration to the low-voltage grid.
- VDE-AR-N 4105 is a part of the TAB (technical connection requirements) for network operators.

DIN VDE V 0126-1-1 (2013) “Selbsttätige Schaltstelle zwischen einer netzparallelen Eigenerzeugungsanlage und dem öffentlichen Niederspannungsnetz” (Automatic disconnection device between a generator and the public low-voltage grid) This regulation instructs that an automatic disconnection device must be installed (if not already installed) to ensure safe control and operation of the electrical grid.

Additional regulations, codes and standards for Germany can be found in Appendix A.

### 3.3.2. Different electric connections

A CHP unit can be installed in several different ways. Figure 7 shows three examples on how a micro-CHP unit can be installed in Germany. The unit must be installed in accordance with the German “Verband der Elektrizitätswirtschaft Messkonzepte”, (VDEW measurement concepts). Figure 7a illustrates an installation where all of the produced electricity is sold back to the electricity grid whereas Figure 7b and c refer to installations where only excess electricity is exported to the grid. The difference between the two latter installations is that in the case of Figure 7c is an additional electric meter ( $Z_2$ ) installed to allow for measuring of the total electricity production from the micro-CHP unit. The electric meter  $Z_1$  does only measure the electricity that is exported to the grid. The installation shown in Figure 7c is the most common and probable installation mode.

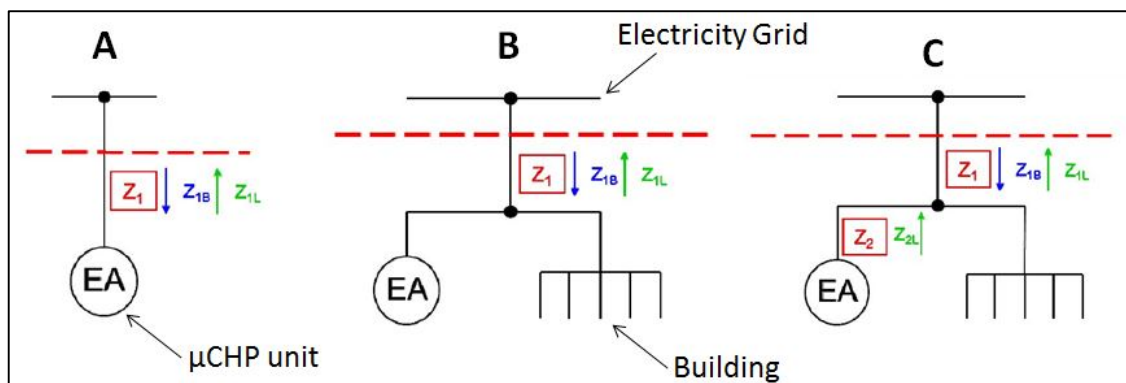


Figure 7. Illustration of the installation modes that is available in Germany. A: All of the produced electricity will be exported to the grid. B and C: Surplus electricity will be exported to the grid, with one difference, installation C includes a second electricity meter ( $Z_2$ ) which allows monitoring of all produced electricity and not only the exported electricity which is measured with  $Z_1$ .

### 3.3.3. Agreements between partner and how to apply for a new active connection

The DSO is responsible for the agreements / forms. These forms are based on a number of “Verband der Elektrotechnik, Elektronik und Informationstechnik” (VDE, association for Electrical, Electronic and Information Technologies) forms which are published as an annex of VDE AR N 4105. The following forms must be filled: [13]

#### Forms before commissioning:

- G.1 Antragsstellung für Erzeugungsanlagen am Niederspannungsnetz  
(Applying for production systems on the low voltage network)
- F.2 Datenblatt – Erzeugungsanlagen am Niederspannungsnetz  
(Data sheet - generating systems on the low voltage network)
- G.2 Konformitätsnachweis  
(Proof of conformity)
- G.3 Konformitätsnachweis NA-Schutz  
(Proof of conformity NS protection)
- Schemaplan  
(Scheme plan)

#### Forms after commissioning:

- F.1 Inbetriebsetzungsprotokoll – Erzeugungsanlage Niederspannung  
(Initial start-up - generation plant low voltage)

This process is very time consuming, due to several reasons. For example since documents must be filled by the house owner, the installer and the electrician both before and after the installation and start-up of the system.

The German Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch e.V. (ASUE) has submitted a guideline for registration and tax treatment of micro-CHP units up to 5 kW. This detailed report (only available in German) can be found:

[http://asue.de/cms/upload/broschueren/2014/bhkw/06\\_05\\_14\\_asue\\_steuerleitfaden\\_bhkw.pdf](http://asue.de/cms/upload/broschueren/2014/bhkw/06_05_14_asue_steuerleitfaden_bhkw.pdf)

#### 3.3.4. Who can do the work?

An installer with admission from the government to install electrical devices can perform the installation after special training on the specific type of electrical grid connection.

### **3.4. Connection to the Italian electricity grid**

#### 3.4.1. Standards and legislation

The reference technical rule for the connection of active and passive users to the Low Voltage (LV) electrical utilities is the CEI 0-21. This normative has the purpose to define the technical criteria for the connection of the users to the distribution networks with the nominal alternate voltage up to 1kV. Apart from what can be seen in Figure 8 it also gives input to the producers, see the list below:

- Defines the start-up, the use and the disconnection of a production system;
- Avoids unwanted voltage islands on the distribution LV networks;
- Define some provisions to regulate the generation systems that work in stand-alone mode on the user network.

The technical rule CEI 64-8 is the reference for electrical installation in domestic, commercial and industrial use. It defines the design and the installation criteria and how to draw-up the compliance certificate for an electrical installation.

Additional regulations, codes and standards for Italy can be found in Appendix A.

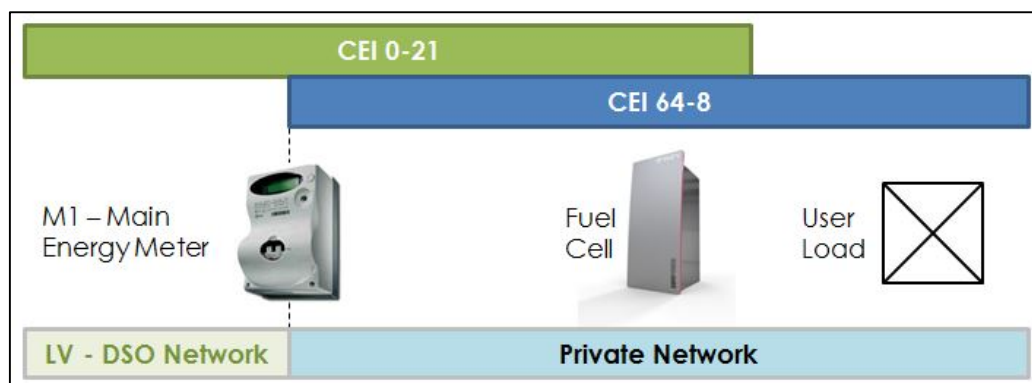


Figure 8. Brief description of the installation scheme for installation of an micro-CHP in Italy.

### 3.4.2. Different electric connections

Before different electrical connections/operation modes are discussed, it is important to introduce the protection devices that are required according to CEI 0-21. These are the same for all connection configurations. General user Device (GD or GDL): security electric breaker, it assures the separation between DSO network (Distribution System Operator) and the private network in case of fault on the private network. The DG must not open in case of a fault upstream the PdC. Interface Device (DDI): it assures the separation between DSO network and the private network in case of fault or problems on the DSO network. Point of Connection (PdC) identifies the border between DSO network and the user network, e.g. after the main energy meter (M1).

#### *3.4.2.1 Active and Passive users*

Figure 9 shows a passive connection as described in CEI 0-21. Possible active connections are described below in accordance with CEI 0-21. In case of an active user there is at least one bi-directional smart energy meter (M1) placed in correspondence of the PdC. Four different active connections are of interest for micro-CHP, namely: sell all the production, sell the surplus production, stand-alone system connected to the user network and sell the surplus production combined with storage. These modes are presented in the following paragraphs and in Figure 10 and Figure 11. Figure 10 (A) explain a electric grid connection for an installed micro-CHP installed to export all the produced electricity and Figure 10 (B) shows the electric grid connections for a micro-CHP installed to sell only the surplus electricity. This configuration is the most frequently used one, it requires to install a second smart meter (M2) to measure the generated energy as defined in the deliberation: AEEG n.578/2013/R/EEL, Art. 10. The smart meter (M2) can also, if needed, be used for tax purposes (declaration to “Agenzia delle Dogane”).

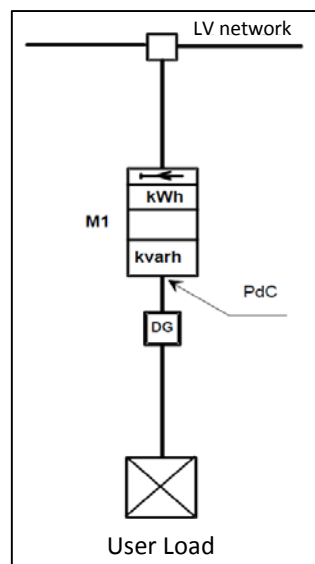


Figure 9. Connection of the energy meter for a passive user.

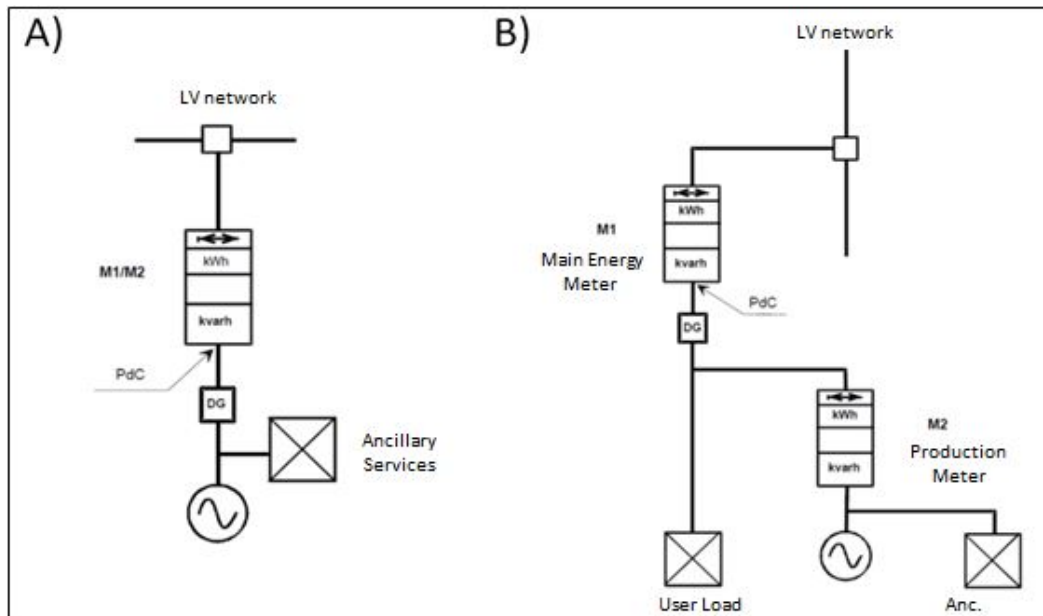


Figure 10. A) Connection of the energy meter for an active user that sells all the production, net of ancillary services B) Connection of the energy meters for an active user that sells only the surplus production.

Figure 11 (A) shows a system connected as a stand-alone unit but still connected to the grid. This possibility is mentioned only for knowledge. In this case the user loads are supplied alternatively from the DSO network or from the local generator, not in parallel mode. This means that the fuel cell has to support all the user loads. A fourth alternative, namely a system where parts of the surplus energy are sold to the grid and other parts are stored, is presented in Figure 11 (B). This type of connection requires a third electric meter (M3) for the storage.



### 3.4.3. Agreements between partner and how to apply for a new active connection

Firstly, a request of a new active connection to the local DSO is required. A new connection does also include the installation of a new smart energy meter, this according to: Del ARG/elt n°99/08 e s.m.i (TICA). In the TICA is specified also the maximum time required by the DSO and the active user for the procedures to activate a new active connection:

- 20 working days after the request for emit the quotation for the connection costs at the expense of the user;
- 45 working days for the user to accept the quotation;
- 30 working days for the DSO to install the new energy meter or 90 working days if a more complex work is needed;
- 10 working days from the end of works to activate the new active connection.

However on the average of the cases the time required to complete the activation process is around 20 days.

If the local DSO is SET Distribuzione S.p.A it is possible to do the request of a new active connection through the web portal:

- <http://www.set.tn.it/content/portale-produttori>

Additional information is available in the document MCC (Modalità e condizioni tecniche contrattuali) which can be downloaded at the following link:

- <http://www.set.tn.it/content/produttori>

and in the document “Guida alle connessioni alla rete di SET Distribuzione SpA”:

- <http://www.set.tn.it/content/guida-per-la-connessione-degli-impianti-di-produzione>

No more communications or reports are required on the DSO side after the end of the activation process; all the measures are managed remotely.

### 3.4.4. Who can do the work

DSO personnel are the only ones who are allowed to install and manage a smart meter directly connected with the electrical network.

Only qualified electricians and electrical technicians are allowed to realize electrical installation connection between generators and energy meters according to: D.M. n°37 22/01/2008

## **3.5. Connection to United Kingdom's electricity grid**

In the United Kingdom, the connection of SSEG (small scale embedded generation) is an established simple and straightforward process and is completed on a ‘fit & inform’ basis when installing one or more power generating units. The process is called G83 notification. [14]

To fall under G83 notification the plant has to be capable of producing power no greater than 16 A per phase and in a typical single phase UK home the size of generator will typically not exceed 3.6 kWp. [14]

### 3.5.1. Standards & Regulations

The safety requirements for DG connections are set out in the relevant Engineering Recommendation, EREC G83/2. This document references the Regulation that informs these requirements, the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002, and also lists the relevant British Standards.

Health and Safety aspects of DG connections on the following websites:

- The Electrical Safety Council (ESC):  
<http://www.esc.org.uk>
- The Energy Networks Association (ENA):  
[www.energynetworks.org/electricity/she/overview.html](http://www.energynetworks.org/electricity/she/overview.html)

Additional regulations, codes and standards for the United Kingdom can be found in Appendix A.

### 3.5.2. Feed-in Tariff Scheme & Customer Benefits

Feed-In Tariffs were introduced on 1 April 2010 and replaced UK government grants as the main financial incentive to encourage uptake of renewable electricity-generating technologies. Most domestic technologies qualify for the scheme, including:

- solar electricity (PV) (roof mounted or standalone)
- wind turbines (building mounted or free standing)
- hydroelectricity
- anaerobic digesters
- micro combined heat and power (CHP).

The UK Government's Department for Energy and Climate Change (DECC) makes the key decisions on FITs in terms of government policy. The energy regulator Ofgem administers the scheme.

Your energy supplier will make the FITs payments to you. The large energy suppliers are required by law to provide them; smaller suppliers are not, but many have opted to offer them anyway.

### 3.5.3. Different electric connections

The power generated is recorded via a generation meter, this measures the kWh's that are produced and it is on this figure that the FiT payment is made, for micro-CHP below 2 kWp the payment is 12.89p / kWh. As well as FiT, an export payment is paid per kWh at 4.8p per kWh, this is a deemed figure and is 50% of the total amount of kWh's that the power generator produces. Figure 12 illustrates a grid connection set-up in UK.

There is no requirement to record exported power via an export meter.

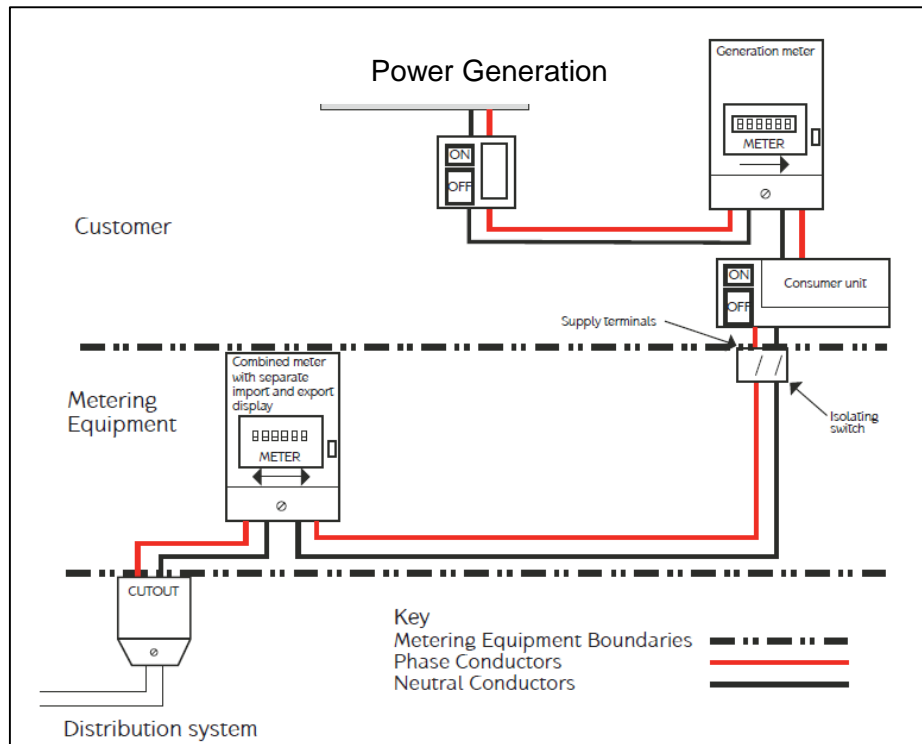


Figure 12. Illustrates the power grid connection in UK.

#### 3.5.4. Agreements between partners

The consumer must notify their DSO that the micro-CHP micro-generation product has been connected to the grid to claim the feed in tariff. For you to qualify for FITs, the installer and the products you use must both be certified under the Microgeneration Certification Scheme (MCS).

## 4. CONNECTION TO THE GAS GRID

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### Summary box of chapter 4

This section explains the connections to the gas grid for a micro-CHP system. Installed micro-CHP units can either be connected to a national/regional gas grid or to a separate gas supply (for example a gas bottle). Connection to a separate gas supply can be important for installations that are far away from a gas grid or in cases where another fuel than what is supplied by the gas-grid (e.g. pure hydrogen instead of natural gas) is used as a fuel. This section is only explaining the first case, e.g. how a fuel cell based micro-CHP is connected to an existing gas grid. Just as in section 3 are standards, legislation and different installation scenarios described for Denmark, France, Italy and UK in section 4.1-4.4. A comprehensive list of grid-connection relevant regulations, codes and standards can be found in the ene.field deliverable 3.5: *Position paper on regulations, Codes and Standards*. This position paper compile of RC&S information for the following countries: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, The Netherlands, Slovenia, Spain and the United Kingdom.

### 4.1. Connection to the Danish gas grid

#### 4.1.1. Standards and legislation

The installation to a natural gas line and the exhaust line follow the same rules as for a normal boiler, e.g. it has to respect the Danish “gasreglementet” [15].

#### 4.1.2. Who can do it?

A traditional certified plumber with dedicated training can do the gas grid installation/connection.

### 4.2. Connection to the French gas grid

#### 4.2.1. Standards and legislation

The installation to a natural gas line and the exhaust line follow the same rules as for a normal boiler, e.g. it has to respect the standard: arête du 2 aout 1977; Arrêté du 30 novembre 2005.

#### 4.2.2. Who can do it?

A traditional certified plumber (PGN) with dedicated training can do the gas grid installation/connection.

### 4.3. Connection to the German gas grid

#### 4.3.1. Standards and legislation

The installation to the natural gas grid must agree with DVGW G2000 (2011) “Mindestanforderungen bezüglich Interoperabilität und Anschluss an Gasversorgungsnetze” (The minimum requirements for interoperability and connection to gas supply networks). 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.

#### 4.3.2. Who can do it?

Only a company with the following infrastructure is allowed to work on the gas grid in a house:

- The company needs to have an employee who is a “Meister” (top level of professional education for a craftsman) in the gas craftsmanship.
- This employee needs to be registered as the “technical operational manager”
- This employee, even if he is not creating the gas connection himself, is responsible that the work is done according to rules and regulations
- The employee needs to register himself with the gas grid operator who operates the grid where the installation is to be done. To register he has to provide his diploma and has to confirm that the company owns a list of tools, safety equipment and documentation on standards, rules and regulations.
- If he has to do an installation outside the grid for that he is registered, he has to register again with the other grid operator. For some grid operators, a simplified registration based on the existing registration is sufficient. For some the complete registration has to be repeated. In Germany there are 730 different gas grid operators and 890 different power grid operators. Fees for registration vary.

### **4.4. Connection to the Italian gas grid**

#### 4.4.1. Standards and legislation

The reference standards that are used for installation of a domestic micro-CHP to the natural gas grid are essentially:

- Design and installation - due to a lack of dedicated technical rules covering electricity DOMESTIC power generation (fed by natural gas), up to now, we have to consider as applicable the UNI 7129/08 Gas systems for domestic use and similar fed by the natural gas distribution network
- Groups of measurement UNI 9036:2001 - diaphragm metering systems.
- Resolution AEEGSI n° 40/04 - Adoption of the regulation of the activities of assessment of the safety of facilities for gas users

#### 4.4.2. Installation diagrams

Below are two figures showing examples of connection to the Italian natural gas grid, Figure 13 (diagram 1) shows the gas metering system for a dedicated internal feeding line to the micro-CHP system and Figure 13 (diagram 2) shows the installation for an off-taken natural gas feeding line.

#### 4.4.3. Who can do it?

It is required that the installation is carried out by professionally qualified and trained installer, in accordance with the requirements of UNI and CEN in the existing legislation and according to good practice.

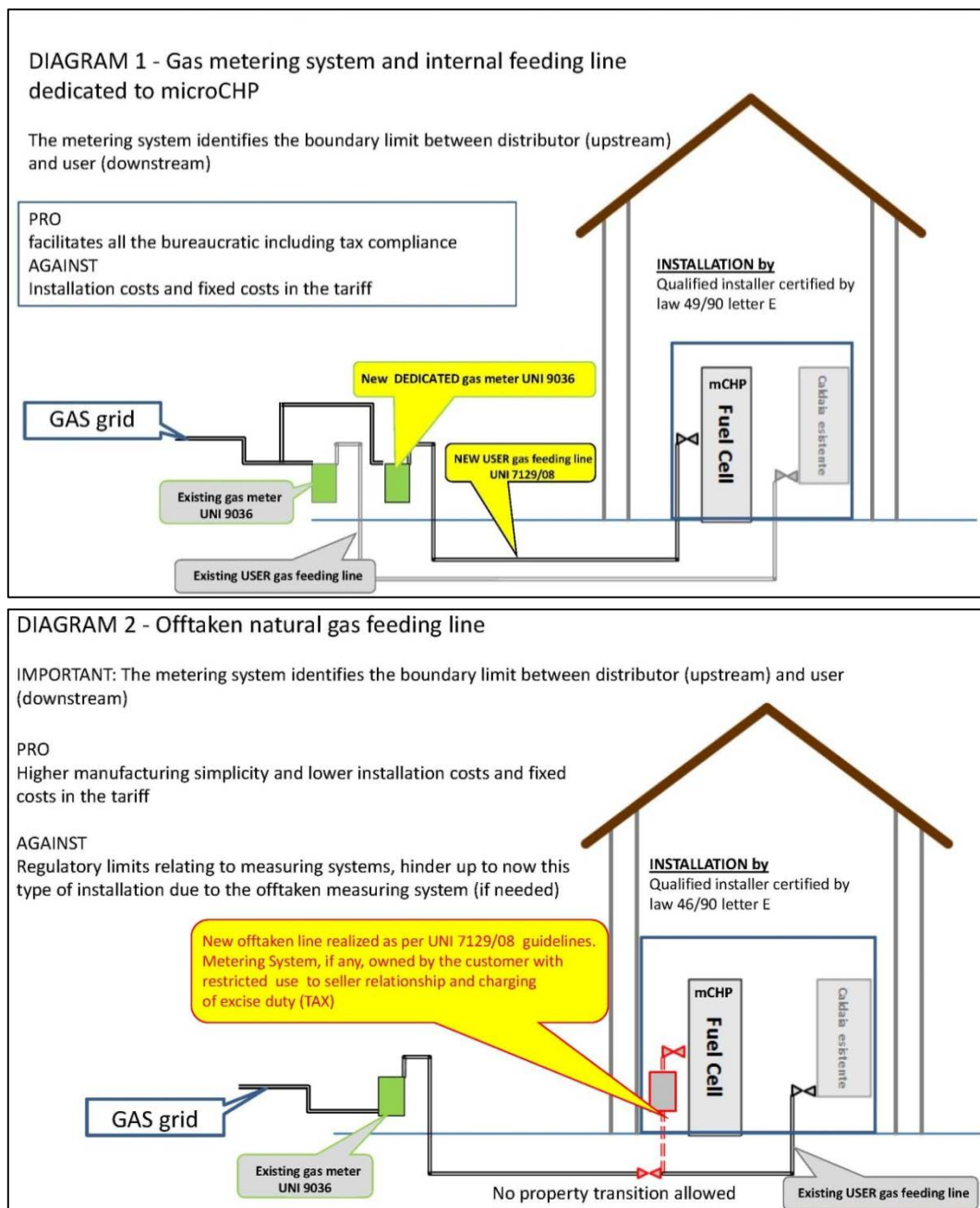


Figure 13. Diagram 1 shows the gas metering system for a dedicated internal feeding line to the micro-CHP system and diagram 2 shows the installation for an off-taken natural gas feeding line.

#### 4.4.3. Who can do it?

Installations can be deployed by qualified installers certified by law 46/90 letter E ; the installer have to issue a dedicated Declaration of Conformity according to: D.M. 37/08 *Regulations concerning activities of installation of the equipment inside the buildings*.

### 4.5. Connection to United Kingdom's gas grid

The ACS scheme delivers a certificate of competence that is required by operatives who must be legally registered to undertake gas work. Certification is available for a wide range of gas work including:

- Domestic Natural Gas Installations
- Commercial Installations (including heating, catering and laundry)
- Liquefied Petroleum Gas (LPG) Installations
- Emergency Service & Meter Installation

#### 4.5.1. Safety & Regulations

It is a requirement of the Gas Safety Regulations (1998) for individuals to be competent in the areas of gas work they carry out and registered with a body recognised by the Health and Safety Executive (HSE).

CCN1 Gas Safety Assessment is designed to test the gas safety competence of an operative in core domestic gas work using both practical and knowledge based understanding and assessment. This Gas Safety Assessment comprises of 15 Core Competencies:

#### 4.5.2. Who can do it?

The Gas Safe Register is the official gas registration body for the United Kingdom, Isle of Man and Guernsey, appointed by the relevant Health and Safety Authority for each area. By law all gas engineers must be on the Gas Safe Register [16].

Gas Safe Register replaced CORGI as the gas registration body in Great Britain and Isle of Man on 1 April 2009 and Northern Ireland and Guernsey on 1 April 2010.



## 5. ELECTRIC CONNECTION TO BUILDINGS

### Summary box of chapter 5

This chapter describes electrical connections to buildings (when installing a FC-based micro-CHP) for Denmark, France, Germany Italy and the United Kingdom. The focus is on standards and legislation that are relevant for the connection procedure as well as special requirements needed by the installers.

### 5.1. Electric connection to buildings, Denmark

#### 5.1.1. Standards and legislation

The standard Technical Direction 3.2.1 gives the rules to install electric system of a building. A specific electric line is necessary (1 electric line for Fuel Cell, without anything on it).

#### 5.1.2. Who can do it?

For a new house, Electrician with needed qualification can make the net-connection. For a replacement of a boiler, generally a plumber does it because there is no electric modification on the building. But it is better if the plumber receives training from the manufacturer (The majority of manufacturer allows the sale of their product if installer has done a training course).

### 5.2. Electric connection to buildings, France

#### 5.2.1 Standards and legislation

The standard NF C 15-100 gives the rules on how to install an electric system to a building. The electric connection of a fuel cell is the same as for a boiler. A specific electric line is necessary, e.g. one electric line that is connected to the fuel cell and nothing else. The fuel cell has to respect to NF C 15-100. Figure 14 show an example of an electric connection to a building.

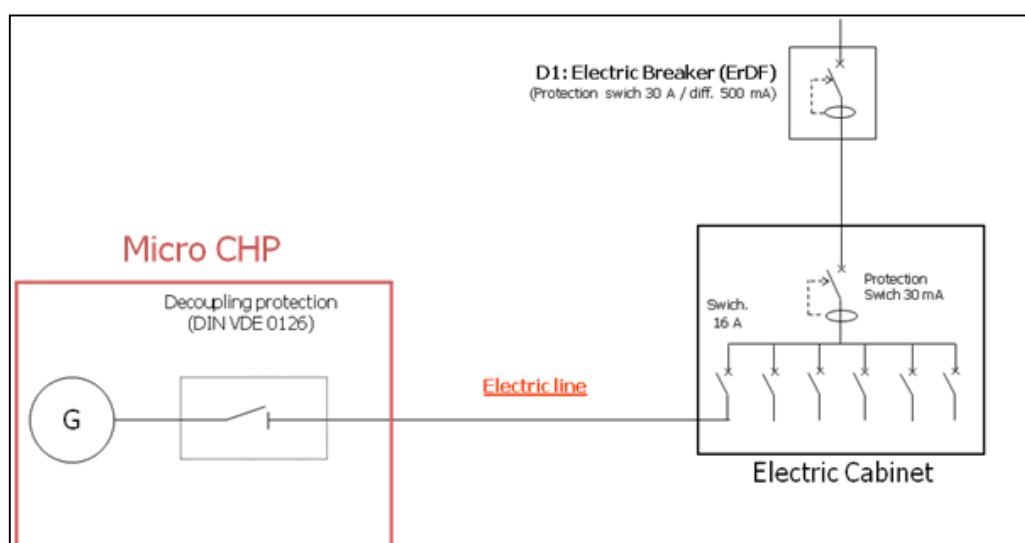


Figure 14. A schematic sketch for an electric connection to a building in France.

#### 5.2.2. Who can do it?

In the case of a new house, the installation of the fuel cell must be performed by an electrician with an adequate qualification, for example BR qualification. For replacement of an old boiler, generally a plumber is allowed to do it as it does not include any modification of the electrics. The majority of the fuel cell manufacturers allows to sell their product if the installer has received a training course.

### **5.3. Electric connection to buildings, Germany**

#### 5.3.1 Standards and legislation

Standard rules of electric craftsmanship needs to be respected

#### 5.3.1. Who can do it?

Companies registered for electric installations are allowed to perform the electrical installation. If a new electricity counter needs to be installed and which is going to be used to collect the feed-in tariff, the counter needs to be requested to the electrical grid operator. The grid operator will typically install the counter himself. In some cases he allows a registered craftsmanship (see above for registration with gas grid operator, section 4.3.2), and with which he has a contract, to install the counter.

### **5.4. Electric connection to buildings, Italy**

#### 5.4.1 Standards and legislation

The technical rule CEI 64-8 is the reference for electrical installation in domestic, commercial and industrial buildings. It defines the design and the installation criteria and how to draw-up the compliance certificate for an electrical installation.

#### 5.4.2. Who can do it?

Installation, transformation, extension and maintenance of the facilities must be entrusted to qualified companies, in according to: D.M. n°37 22/01/2008.

### **5.5. Electric connection to buildings, United Kingdom**

#### 5.5.1 Standards and legislation

The micro-CHP installation must comply with Engineering Recommendation G83/1 (Recommendations for the connection of small scale embedded generators (up to 16A per phase) in parallel with public low voltage distribution networks). The micro-CHP incorporates the necessary grid connection hardware for compliance with Engineering Recommendation G83/1. Figure 15 shows an illustration of the connection.

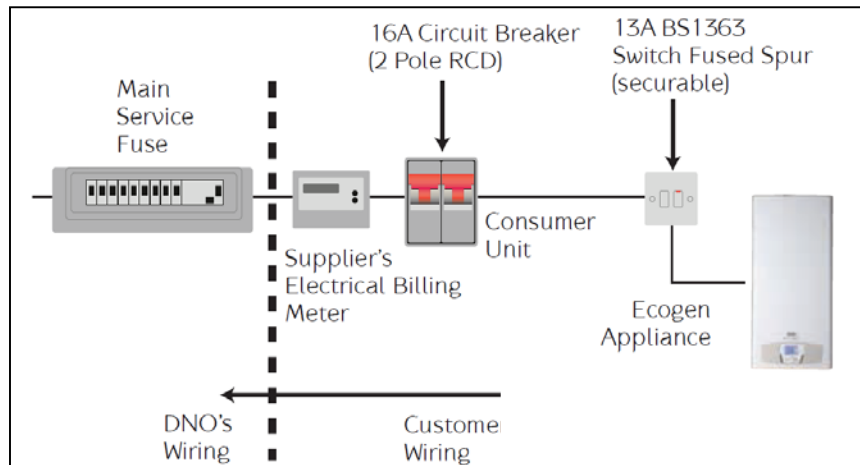


Figure 15. Illustration of the connection to a building in the United Kingdom.

### 5.5.2 Who can do it?

The electrical regulation that must be adhered to is G83 / 1 and installers will be 17<sup>th</sup> Edition standard registered electricians.

## 6. FUEL CELL SPECIFICATION/ LABELLING

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### Summary box of chapter 6

This section briefly describes the discrepancy in the fuel cell certification/labelling. CE- marking is the most commonly required certification of a unit. This is often combined with an addition of country specific certifications. It also contains additional considerations with respect to labelling of hydrogen and in-directly hydrogen operated systems, especially in France.

Different countries require different labelling and specifications of installed fuel cells. In **Denmark**, CE-marking of the unit is required and if the producer of the inverter (same as the inverter used for photovoltaic plants) cannot guarantee that all DC fault current will be less than 6mA, a type B, RCD device is needed. Also **France** requires a CE-marking and that the unit compile with the gas security standard (2009/142/CE9) and the electric standards: UTC C 15-400 and NF C 15-100. The unit does need to be equipped with an electric decoupling protection which fulfils the requirements stated in DIN VDE 0126 V1.1. **Germany** does also require CE- marking of an installed FC-based micro-CHP. The labelling of German EnEV (Energieeinsparverordnung), which is obligatory for new built houses, is not adopted for fuel cells yet. This regulation is still under preparation. In order to get funding for the systems a registration at the German BAFA is required. In **Switzerland** a fuel cell system must be labelled as a gas appliance, e.g. CE-certified in the flue system class. In Also in **Italy** fuel cells micro-CHPs are certified according to a number of directives: Gas Appliances Directive, GAD, (2009/142/EC), Electromagnetic Compatibility Directive, EMC-D, (2004/108/EC) and the Low Voltage Directive (2006/95/EC).

The specification for fuel cell being installed in the **United Kingdom** still needs final clarification. However, if the fuel cell is to be eligible for trials and support via feed-in tariff where it will be a requirement for both CE-marking and also MCS accreditation.

In France, all systems which produce or store hydrogen (even if the hydrogen is used as an internal by-product of natural gas to feed the fuel cell stack) shall be concerned by the French regulation "ICPE" (Facility classified for environmental protection). The French ministry considers even a residential fuel Cell as being an industrial hydrogen production based on the European Directive IED (Industrial Emission) because there is the possibility to sell on-site electricity produced from hydrogen. Therefore Fuel Cell could be considered classified installation with complex declaration procedure. GDFSUEZ is working on the improvement of the regulation. For example, field trials within ene.field are undertaken an exception by the French Industrial Ministry, a modification of this regulation is necessary for the commercial development of fuel cell based micro-CHP systems in France.

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## 7. ISSUES AND LESSONS LEARNED FROM FIELD TRIALS

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### Summary box of chapter 7

This section compiles the findings from section 3 - 6, discussing differences from the investigated countries with respect to grid connections, national differences and fuel cell labelling. Included is also a section on issues and lessons learned from previous field trials, most of this section compile of input received from manufacturing companies. The main conclusions are that the inhomogeneity's with respect to installations in different countries cause barriers for companies as they try to expand into other countries. Also, the level of documentation and forms are issues that hinder fast deployment of units. The most common technical issue appear to be related to shut-downs of the inverter units due to variations in the current (e.g. spikes) that cause the inverter to stop. Furthermore, a number of potential future issues are mentioned.

### 7.1 Differences between countries

#### 7.1.1 Differences in electrical- and gas- grid connections

The analysis of installations carried out in section 3 to 5 goes well in line with the main conclusion from deliverable 3.5 (regulations codes and standards) described briefly in section 2.2.2, namely: that most countries have the same main regulations codes and standards, but all having their own supplements. The same holds for installations of fuel cell based micro-CHPs: most countries have methodologies for the installation procedure and for different installation modes (sell all produced electricity, sell the surplus electricity or self-consumption), but they all have country specific requirements. This leads to issues and difficulties once companies try to expand outside their host country. For example, as pointed out by one manufacturer, there are problems with respect to differences in amplitude the DC current. Some countries require a certain DC injection (for example 5 mA in UK) whereas other requires a smaller or larger. This is not a big technical problem as it can easily be solved by the addition of an additional transformer in the inverter, but it leads to a considerable cost increase.

Furthermore, the variety of regulations, codes and standards with respect to grid connections for different countries leads to the need for different inverters (or at least different settings of the inverters) throughout Europe. The regulations can also differ within different regions in the same country, some regions in Germany require that the electric meter is inside the micro-CHP whereas other regions require the meter to be placed easy accessible outside the unit. Also gas quality certification is different in different countries, for example Germany has I2E certification whereas France has I2E+, I2Esi and I2Er certification of the natural gas.

Another difference is the difference in documentation, agreements and other forms. The large variety of documents cause unnecessary costs as it takes a considerable amount of time to find out the exact procedure for each country/region. In general, there are very different and partially complex regulations for the technical and economical part, e.g. in Germany the end-user has to deal with the involved utilities (gas and electricity suppliers) for technical documentation, billing issues and the custom office for tax refunding. The lack of clear and straight forward procedures for this makes it hard for end-users to foresee all documentation and this leads to unnecessary delay.

The requirements for an installation of a micro-CHP is often not in relation to the requirements for installation of a large system (>100 kW), this leads to non-proportional costs.

### 7.1.2 Labelling

As described in section 6 are the requirements for certification and labelling of fuel cell based micro-CHPs different for different European countries. This can lead to confusion and additional work for manufacturers. Most countries base their certification on CE- marking, but this is most commonly supplemented with national additions forcing the manufacturer to adjust their units in order to get allowance for installation in more countries. This ultimately leads to an increased production cost and it does thereby become harder to attract customers.

### 7.1.3 Network codes

The new network CODE for generators places requirements on generators connected to the power grid right down to the 700 kW level. In these codes a micro-CHP operator is defined as a generator (along with large power stations). While it is in the manufacturer's interest to make sure that the product conforms to the codes it is ultimately the householder's responsibility to make sure that their product complies with the new codes and future versions of the code.

Instead of setting micro-CHPs along with large scale power stations, micro-CHP and other small scale power producing technologies should, with favour, be allowed to be classified in their own class. It is as mentioned above in the manufacturer's interest to make their products to fulfil the requirements, but it is not easy for end-users (customers) to take on the ultimate responsibility for this, especially not in a new field where things can change often and fast.

## **7.2 Issues observed in previous field trials**

### 7.2.1 Issues observed in European field trials

#### 7.2.1.1. Electrical connections

The most common and outspoken issue that concern the electrical grid connections relates to the installed inverters. Influence of anything that lowers the quality of the surrounding electrical network or the electrical wave quality can create problems, such as an automatic security switch-off of the micro-CHP inverter and thereby the whole fuel cell micro-CHP unit. This has for example been observed when a fuel cell is installed close to a Stirling micro-CHP. It have also been observed when fuel cell micro-CHPs have been installed next to large heat pumps or other kinds of high power motor regulators, the reason for this can for example be a distortion of the grid impedance or electrical current phase.

Several manufacturers have observed problems during power outages and other electrical grid disturbances, such as maintenance of the grid, monthly routine controls of the grid or weather events. Once again these events cause the inverter to be disconnected. This can most often be solved by restarting the system. The same issue have been observed from electric disturbances in the household. For example have electrical errors in washing machines caused RCD- tripping (residual current device).

Furthermore, fuel cell systems are often more vulnerable to power outages than for example PVs. This is due to safety monitoring in the combustion process. This monitoring requires 230VAC and this is not the case in the event of a power outage.

In the initial phase of previous micro-CHP field trials (Opérations Pilotes Ecogénérateurs à Moteur Stirling/ Field trials of micro-CHPs using Stirling Engine) in France was a delay for getting the allowance of electricity export observed. It took on average 4 months for the DSO to authorize the household to export electricity from their micro-CHP system. This was probably as the micro-CHP technology was new on the French market. A communication campaign was started to inform and educate different actors (DSO, ministry of industry, etc.) about the new technology, especially about the security system (decoupling protection) which is the same as for a photovoltaic panel. This campaign led to a decrease of the delay to two weeks. Several points helped in explaining the situation for to the DSO, a few of these points are listed below:

- micro-CHPs does not modify existing electrical installation (which is not the case for a photovoltaic system).
- The produced power is mainly/most often self-consumed.
- Even if the customer asks for a feed-in tariff, the micro-CHP is allowed for temporal commissioning without an extra meter for power injection.
- No certification is needed for the installation.

Regarding the electric connection, the issues are particularly on the economics, especially for the existing buildings. As a matter of fact, an existing building is likely not to have the required electric breaker (required in France) with a public access and the meter may need to be changed. A substantial cost (several thousands of Euros) is often related to such an installation of the electric breaker. This is not an issue for new buildings in France as the breaker is promptly installed.

Another issue rely on the additional cost related to the additional electric meter. The annual fee in France for an additional meter is about 60€. This additional cost only make sense if the exported electricity via this meter is sold at a minimal value of 60€ every year. With the existing feed-in tariff for excess electricity of micro-CHPs, with is approximately 0.09 €/kWh, a minimal annual export of 666 kWh is required. This is not the case today for most of Stirling micro-CHP boilers, and may not be the case for fuel cell micro-CHPs. There is also a need to change the electric meters in Denmark for installations where the export amount of electricity is to be measured. If the failure current from the DC/AC Inverter in the installed Fuel Cell exceeds 6 mA (DC) - a type B HPFI circuit breaker (relay) is necessary. If the failure current is at 6 mA (DC) or lower it's only required to have a type A HPFI relay installed. The "Danish" HPFI (high pulsating failure-current indicator) is equal to the more known English RCD (residual current device) or RCCB (residual current circuit breaker). Price for the HPFI type A is in the range 25- 50 €, for the type B 300 – 600€. It is the fuel cell manufacturer that issues the needed guarantee for max failure current (DC) from the inverter.

#### *7.2.1.2. Connection to the gas grid*

Often a fuel cell micro-CHP is constructed for a certain inlet gas pressure, but in some single cases the inlet pressure is higher than the pressure for which the system is designed, observed in for example industrial areas and when installing a system to a laboratory. This is important to control before installation to the gas grid and to counteract by installing a pressure relief valve.

Installers need to pay attention, to not put extensive torsion to the gas connection tubes of the micro-CHP system as this has been observed to create gas leakages in the seals. Furthermore, often one-tube gas meters are sensitive and needs to be handles with extra care in order to avoid any undesired gas leakages.

#### *7.2.1.3. Other*

In France, many plumbers, especially independent ones, are not certified to work on the electric board of the house. So the installation requires two technicians: a plumber and an electrician, when installation of new breakers is needed. The issue increases the installation cost and possible delays to synchronize the interventions of the two technicians. However, big installation companies have technicians that are certified for gas and electric works.

In the Danish micro-CHP project (DkmKV,[17]) it was observed that it is not possible for a house owner to have both a natural gas micro-CHP and a photovoltaic panel feeding into the grid. It actually ended up with that the particular demonstration had to be terminated. This issue is related to the TSO Energinet.dk classification of system, where you can only be registered in one group and only switch groups once per year. The classification is described in the following document: “Retningslinjer for nettoafregning af egenproducenter” [18].

In for example Italy all fuel cell based installation so far and in the near future will be set up so that excess electricity can be exported to the grid, whereas in Denmark all three (standalone installation, sell all and sell surplus electricity) options are possible. Nevertheless the current feed in schemes does exclude the first two modes leaving only the “sell the surplus electricity” option as a real option.

The fact that many forms, for example tax schemes regarding export of excess electricity to the grid in Germany, must be filled prior to full utilization of an installed unit. The procedure for this is not really settled in all countries and causes a general uncertainty and barrier for many potential customers.

These last paragraphs clearly show that the bureaucratic procedures and the feed-in tariffs etc. must be made clearer, easier and more profitable in most countries in order to decrease these barriers in the market penetrations stage for fuel cell based micro-CHP systems.

### **7.3. Potential future issues**

So far only a small number of fuel cell based micro-CHP units have been connected to power and gas grids around Europe. One can easily foresee that other issues can rise when more units are connected. The difficult part is to find out which potential issues that will become reality and thereby have the possibility of preventing them by early actions. Below is a list containing a few potential issues that have been foreseen by FC- based micro-CHP manufacturers in Europe:

- Smart grid operation (virtual power plant): e.g. remote system control by energy suppliers to pre-control the micro-CHP based on previously tracked user heat consumption/demand profiles, enabling the micro-CHP systems to produce more electric power during the electrical peak load hours.
- In counties where it is standard to deliver 3 phase power to households there is a risk that it might come requirements of export balance on all three phases, alternatively the risk of having to coordinate which phase to export to with the DSO. Similar issues have been

observed for PV's with respect to grid voltage levels during peak production periods (system heat follows).

- ...

## 8. CONCLUSIONS

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Grid connections to the power and the electrical grid is in many ways performed similarly in several EU- countries, but most frequently with some national additions that eventually can increase the level of bureaucracy the FC-based micro-CHP manufacturers as they are entering the market in more than one country. This can for example be with respect to whom that is allowed to perform a certain type of installation and which type and how electric meters shall be installed, but also with respect to marking and labelling of the actual system in order to fulfil legislations and standards for a certain country.

Even if the number of units that have been installed so far around Europe is still small a few trends and more frequently upcoming issues have been observed. The most common issue is with respect to the inverter. A number of inverter shut downs have been registered within previous field trials when the grid impedance is disturbed (for example by other surrounding power production units), but also from power outages due to weather or maintenance of the power grid. This is an issue that must be solved as the grid impedance can be expected to vary as more and more small scale productions units enters as contributors to the electricity grid.

Other observed issues often relate to the increased cost due to requirements of new electric meters, differences in the inlet gas pressure when installing in different gas networks as well as the extensive amount of forms for feed in allowance and taxes that must be performed before export to the power grid is allowed.

Furthermore, a few examples of possible future grid connection related issues are brought up; these refer to the need for smart operation of the power grid, e.g. making sure that the power delivered to the different phases is controlled in the right manner and also to control and manage when and if the installed units export to the grid.

These last potential issues raise the need even further for a thorough investigation on smart grid operation and active control of the power grid. This is also the topic of the next position paper within W.T 3.6 (Utility working group) in the ene.field project.

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## APPENDIX A- NATIONAL REGULATIONS, CODES & STANDARDS

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The following appendix consists of national regulations, codes and standards in the field of “interconnection to natural gas and water networks” as well as “interconnections to the electric grid” for countries involved in the ene.field project. The information is directly collected from **chapter 4 in Deliverable 3.5 (work task 3.5) in the ene.field project**. To fit the scope of this positions paper a few sections have been removed from the original position paper, these areas are marked as with [...].

All sections in this appendix have been given a name starting with A instead of a 4 as in the original document to avoid confusion with chapter 4 in this document. The text in this appendix refer to several sections in the original document, these are in all cases, apart from when this section is the targeted section, left with the original section number used in the position paper; deliverable 3.5, “Regulations, Codes and Standards”.

### **A. Analysis of the RC&S status related to fuel cell micro-CHP installation in countries involved in the ene.field project.**

[...]

#### A.1.1. Installation issues

The installation issues for a micro CHP system, based on fuel cells, 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 fuel cell micro CHP 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 issues 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.

[...]

## A.2 Austria

The subsequent sections contain the most important national regulations and standards for fuel cell micro CHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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>.

### A.2.1. 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 ≤ 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 second gas family.

[...]

### A.2.2. Interconnection to the electrical grid

Different Regulations exist in Austria, concerning the electro-technical 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.

[...]

### A.3. Belgium

The subsequent sections contain the most important national regulations and standards for fuel cell micro CHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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>.

#### A.3.1. Interconnection to natural gas ~~and water~~ networks

Standard	Explanation
<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>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>
<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>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>

[...]

### A.3.2. Interconnection to the electrical grid

Standard	Explanation
<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> ).	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 ... ).
<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> ).	No description available.
<b>RGIE</b> ( <a href="http://www.emploi.belgique.be/">http://www.emploi.belgique.be/</a> ): Le Règlement général des Installations électriques ( <i>Belgian general regulations on electrical installation</i> ).	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.
<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> ).	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> .

[...]

## **A.4. 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 fuel cell micro CHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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>.

#### A.4.1. 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 gas meters.
<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: - which laws and regulations are applicable for the installation of hydrogen-consuming appliances; - information about the various supply options; - the 5 main categories for hydrogen installation requirements for the installation of small fuel cells with a rated power of less than 10 kW.
<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.

[...]

#### A.4.2. 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.

[...]

## A.5. France

The subsequent sections contain the most important national regulations and standards for fuel cell micro CHP appliance installation organized according to the five main areas mentioned in Section A.1.1.

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>.

### A.5.1. 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 pertaining to combustion product evacuation</i> ).	This section defines the requirements for the supply of combustion air and the evacuation of combustion products from gas appliances.

<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> ).	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.
<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> ).	This document has the purpose of providing the special administrative clauses of the work steps for the installation of fuel gas and liquefied hydrocarbons systems in the field of application established in NF DTU 61.1 P2, NF DTU 61.1 P3 and NF DTU 61.1 P4.
<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> ).	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.

[...]

#### A.5.2. 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.

[...]

### **A.6. Germany**

The subsequent sections contain the most important national regulations and standards for fuel cell micro CHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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>.

#### A.6.1. Interconnection to natural gas ~~and water~~ networks

Standard	Explanation
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<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.

[...]

#### A.6.2. Interconnection to the electrical grid

Standard	Explanation
<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> ).	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.
<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> ).	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><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 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>
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[...]

## A.7. 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 fuel cell microCHP appliance installation organized according to the five main areas mentioned in Section A.1.1.

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/>.

#### A.7.1. 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.
<b>IS 813 (2002) + Amd 2 (2005):</b> Domestic Gas Installations (Second Edition).	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.

#### A.7.2. Interconnection to the electrical grid

Standard	Explanation
<b>DTIS-230206-BRL (2009):</b> Conditions that govern the connection and operation of micro-generation.	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.
<b>ESBN NC6:</b> Micro-generation installation notification form.	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.
<b>ET 101 (2008):</b> National Rules for Electrical Installations.	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 1000VAC or 1500V DC.

<b>ET 210 (2003):</b> Code of Practice for the Installation of Low Voltage Generators.	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.
<b>ET 213 (2007):</b> Guide to the Basic Principles of Electrical Safety.	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.

[...]

## A.8. 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 fuel cell microCHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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>.

### A.8.1. 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 ( <b>Ministerial Decree 16/04/2008: Technical rule 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</b> ). <a href="http://www.cti2000.it">http://www.cti2000.it</a>	This technical rule has the aim of guaranteeing the safety, the possibility of interconnection and the interoperability of the systems.
<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> ).	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.
<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> ).	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.
<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> ).	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.
<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> ).	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.

<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> ).	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.
<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> ).	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.
<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> ).	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.

[...]

#### A.8.2. 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
<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> ). <a href="http://webstore.ceiweb.it">http://webstore.ceiweb.it</a>	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.
<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> ).	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

<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>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 microcogenerazione 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>

[...]

## A.9. 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 fuel cell micro CHP appliance installation, organized according to the five main areas mentioned Section A.1.1.

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>.

### A.9.1. Interconnection to natural gas and water networks

Standard	Explanation
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<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 A.2 "Pipe Materials"). The standard is applicable to the design, construction and operation, maintenance and refurbishment of connection cables and any associated tasks.
<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> ).	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.

[...]

#### A.9.2. Interconnection to the electrical grid

Standard	Explanation
<b>NEN 1010 (2007) + C1 (2008)/A1 (2011) + C1 (2011):</b> Veiligheidsbepalingen voor laagspanningsinstallaties ( <i>Safety requirements for low-voltage installations</i> ).	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.

<b>NPR 5310 (2007) +A5 (2013):</b> Nederlandse Praktijkrichtlijn bij NEN 1010 ( <i>Practices in Dutch NEN 1010</i> ).	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.
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[...]

## A.10. 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 contest, "**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>

## A.11. 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 fuel cell micro CHP appliance installation, organized according to the five main areas mentioned in Section A.1.1. 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).

#### A.11.1. 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
<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> ).	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.
<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> ).	The 4 <sup>th</sup> part of UNE 60670 defines the design and installation guidelines for the abovementioned gas reception systems.

<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> ).	This standard regulates the characteristic of the appliance premises, the ventilation requirements and the exhaust outlets for appliances <70kW. It is cited as a reference standard in RITE.
<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> ).	This standard deals with the requirements for the interconnection between gas appliances and the gas reception system.
<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> ).	UNE 60670-9 specifies the tests that should be carried out during the pre-supply testing and commissioning of a gas reception system.

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).

[...]

#### A.11.2. 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
<b>Ley 54/1997</b> , de 27 de noviembre, del Sector Eléctrico ( <i>Electrical Sector</i> ).	This law sets out the electrical energy activities in Spain
<b>Ley 48/1998</b> de 30 de diciembre sobre procedimientos de contratación en los sectores del agua, la energía, los transportes y las	This law sets the contracting procedures for the water, energy, transport and telecommunication sectors. It incorporates

telecomunicaciones, por la que se incorporan al ordenamiento jurídico español las directivas 93/38 CEE y 92/13 CEE ( <b>Law 48/1998 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</b> ).	Directives 93/38/EEC and 92/13/EEC in Spanish legislation.
<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 which establishes the Transportation, Distribution, Marketing, Supply and Authorization Procedures for Electric Power Installations</b> ).	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.
<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 ( <b>Royal Decree 1454/2005 which partially amends Royal Decree 1955/2000</b> ).	Amendment of Real Decreto 1955/2000.
<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 ( <b>Low Voltage Electrotechnical Regulation approved by Royal Decree 842/2002 and published in the Official Gazette No. 224, 18/09/2012</b> ).	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.
<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 ( <b>Royal Decree 661/2007 on the activity of electricity production under a special regime</b> ).	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 micro CHP 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.
<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 ( <b>Royal Decree 1699/2011 on the regulation of the networking of small power facilities that produce electricity</b> ).	This law defines the administrative, contractual, economic and basic technological conditions for small generators (< 100kW) connected to the electrical grid.
<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	This ordinance regulates energy metering activities in the electrical system. It covers different aspects, ranging from the physical

eléctrico ( <i><b>Royal Decree 1110/2007</b> on the approval of the unified regulations that deal with electrical system measurement points</i> ).	situation of the measurement activities to the characteristics of the energy meters.
<b>Código Técnico de la Edificación</b> (CTE) ( <i>Technical Building Code</i> ).	CTE regulates certain electrical interface topics through RITE.

[...]

## A.12. 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 fuel cell microCHP appliance installation, organized according to the five main areas mentioned in Section A.1.1.

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/>.

#### A.12.1. Interconnection to natural gas ~~and water~~ networks

Standard	Explanation
<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	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.
<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.	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.
<b>GS(M)R 1996 :</b> Gas Safety (Management) Regulations.	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: - 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; - Arrangements for dealing with supply emergencies; - Arrangements for dealing with reported gas escapes and gas incidents; - Gas composition.

[...]

#### A.12.2. Interconnection to the electrical grid

Standard	Explanation
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<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 AC.</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.</p> <p>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).</p> <p>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>

[...]

## APPENDIX B

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### B.1. Glossary of Acronyms

#### A

A	Ampere
ACS	Accredited Certification Scheme
AC	Alternating Current

#### C

CCPI	Individual main circuit breaker
CE- marking	Conformité Européenne (European conformity marking)
CEI	Comitato Elettrotecnico Italiano (Italian Electrotechnical Committee)
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CHP	Combined Heat and Power
CTE	Código Técnico de la Edificación (Technical Building Code)
CV	Calorific Value

#### D

DB	Documento Básico (basic document)
DC	Direct Current
DDI	Interface Device
DECC	Department of Energy and Climate Change
DFP	Department of Finance and Personnel
DG	Distributed Generation
DSO	Distribution System Operator
DVGW	Mindestanforderungen bezüglich Interoperabilität und Anschluss an Gasversorgungsnetze (The minimum requirements for interoperability and connection to gas supply networks)
DVGW	

#### E

EEG	Erneuerbare-Energien-Gesetz (German Renewable Energy Act)
EMC-D	Electromagnetic Compatibility Directive
EN	European Standard
EnEV	Energieeinsparverordnung (Energy Conversion Ordinance)
ESB	Electricity Supply Board
EU	European Union

#### F

FC	Fuel Cell
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FiT	Feed in Tariff
FCH-JTI	Fuel Cells and Hydrogen Joint technology Initiative

## **G**

GAD	Gas Appliances Directive
GD	General user Device
GDL	General user Device
GSMR	Gas Safety (Management) Regulations

## **H**

HPFI	High Pulsating Failure-Current Indicator
HSE	Health and Safety Executive
HT	High Temperature

## **I**

IED	Industrial Emission Directive
IT	Intermediate Temperature
ITC	Instrucciones Técnicas Complementarias (Complementary Technical Instructions)

## **K**

kW	Kilo Watt
kWh	Kilo Watt hour
KWK-G	Kraft-Wärme-Kopplungsgesetz (Combined Heat and Power Act)
kWp	Kilo Watt peak

## **L**

LHV	Lower heating value
LPG	Liquified Petroleum Gas
LT	Low temperature
LV	Low voltage

## **M**

mA	Milli Ampere
MAWP	Maximum Allowable Working Pressure
MCC	Modalità e condizioni tecniche contrattuali (terms and conditions for technical contracts)
MCS	Micro-generation Certification Scheme
micro-CHP	Micro Combined Heat and Power
MOP	Maximum Operating Pressure
MPa	Mega Pascal

## N

NF Normes Françaises (French standards)

## P

PdC Point of Connection  
PEM Polymer Electrolyte Membrane  
PV Photovoltaic

## R

RCCB Residual Current Circuit Breaker  
RCD Residual Current Device  
RCS Regulations, codes and standards  
RITE Reglamento de Instalaciones Térmicas en los Edificios (Regulation for Heating Systems in Buildings)

## S

SOFC Solid Oxide Fuel Cell  
SSEGs Small Scale Embedded Generators

## T

TICA Testo Integrato delle Conessioni Attive (Integrated text on active connections)  
TSO Transmission System Operator

## U

UNI Ente Nazionale Italiano di Unificazione (Italian organization for standardization)

## V

VDE Verband der Elektrotechnik, Elektronik und Informationstechnik (Association for Electrical, Electronic and Information Technologies)  
VDEW Verband der Elektrizitätswirtschaft Messkonzepte (Association of Electricity Economic Management Measurement Concepts)

## W

Wh Watt hour

## **B.2. List of Tables**

Table 1 Technical characteristics of systems deployed within ene.field. \* based on the lower heating value, \*\* PEM = Polymer Electrolyte Membrane Fuel Cells, SOFC = Solid Oxide

Fuel Cells, LT = low temperature, HT = high temperature and IT = intermediate temperature.

### B.3. List of Figures

- Figure 1 Working principle of an SOFC including electrode reactions, using hydrogen as the anode fuel.
- Figure 2 Sketch showing a micro-CHP installed in a residential house.
- Figure 3 Installation procedure for single power producing plants of less than 11 kW in Denmark.
- Figure 4 Illustration of a Danish connection between a private area and the public area (the grid).
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- Figure 6 Illustrates different grid connections. Top: All of the produced electricity will be exported to the grid. Middle: Surplus electricity will be exported to the grid. Bottom: All electricity will be self-consumed.
- Figure 7 Illustration of the installation modes that is available in Germany. A: All of the produced electricity will be exported to the grid. B and C: Surplus electricity will be exported to the grid, with one difference, installation C includes a second electricity meter ( $Z_2$ ) which allows monitoring of all produced electricity and not only the exported electricity which is measured with  $Z_1$ .
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- Figure 12 Illustrates the power grid connection in UK.
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