



Pathway to a Competitive European
Fuel Cell micro-CHP Market

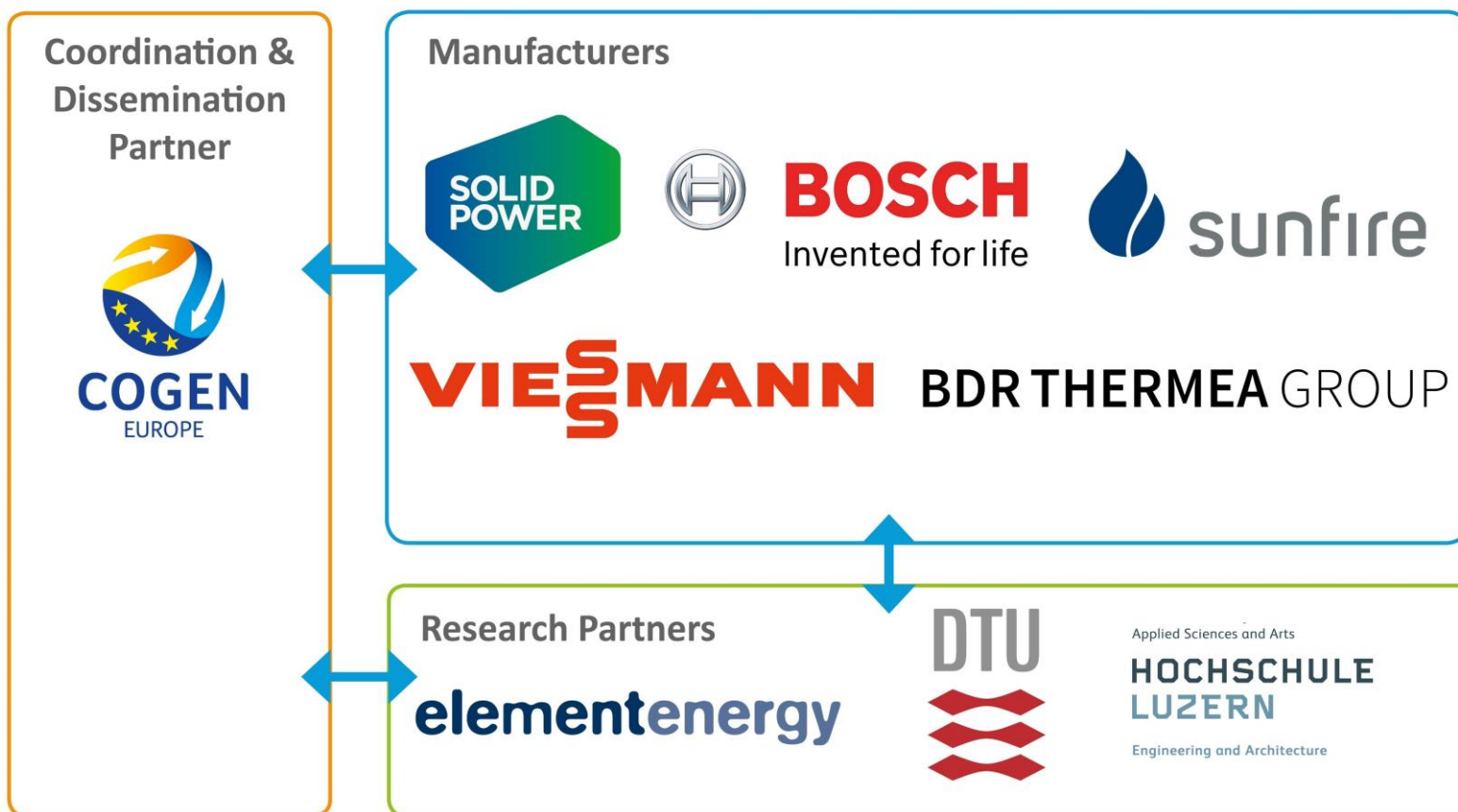
Fuel Cell Combined Heat and Power for Specialised Trade – Training Documents

Module 2: Planning, Dimensioning and Formal Requirements



PACE project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 700339.

This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and Hydrogen Research.



- The purpose of these training modules is to provide a general overview of the potential of Fuel Cell micro-Combined Heat and Power (FC mCHP) units as part of the future of European domestic energy.
- Each module in turn will focus upon a different aspect of FC mCHP units, with the aim to provide a working knowledge of the considerations that installers working with this technology will need to make.
- Specific material for each FC mCHP product can be obtained from each unit manufacturer, who also offer specific training on their units.
- These materials have been based upon material developed during the Callux project (2008-2016). Consequently, thanks go to NOW GmbH for permitting the use of this material:

- CHP – Combined Heat and Power (also known as Cogeneration)
- mCHP – Micro Combined Heat and Power Unit
- FC – Fuel cell
- FCH JU – Fuel Cells and Hydrogen Joint Undertaking
- GDL – Gas Diffusion Layers
- kW – Kilowatt

List of Abbreviations

Module 2: Planning, Dimensioning and Formal Requirements

- kWh – Kilowatt Hour
- MSD – Mains Monitoring Units with Allocated All-pole Switching Devices (MSD)
- MW – Megawatt
- PEMFC – Proton-Exchange Membrane Fuel Cell
- SOFC – Solid Oxide Fuel Cell
- VPP – Virtual Power Plant

I. Requirements for the Use of a FC CHP

1. Heat and Electricity Demand
2. User Behaviour
3. Preconditions for Installation
4. Installation of the FC CHP

II. General Planning Requirements

1. Checklist
2. Hydraulics
3. Storage
4. Supply and Exhaust System
5. Electric installation
6. Data Transfer

III. Formal Requirements

1. During the Planning
2. Before Operation
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Heat-lead appliances

- Similar or higher electrical vs thermal output (e.g. 0.7kW each for Bosch SOFC; 0.8kW electrical vs 1.5kW thermal output for Sunfire SOFC)
- Similar or higher thermal efficiency vs electrical efficiency
- Suit households with high heat demand but lower electrical demand (e.g. older buildings in cold climates without electrified heating appliances)
- Note that an additional peak load boiler is often required regardless

I. Requirements for use of a FC CHP

I 1. Heat and Electricity Demand

Electricity-lead appliances

- Higher electrical vs. thermal output (typically ~1.5kW electrical output and 0.6kW thermal output)
- Higher electrical efficiency than thermal efficiency
- Suit households with electrified heating appliances or notably large electricity consumption (e.g. regular electric vehicle charging)

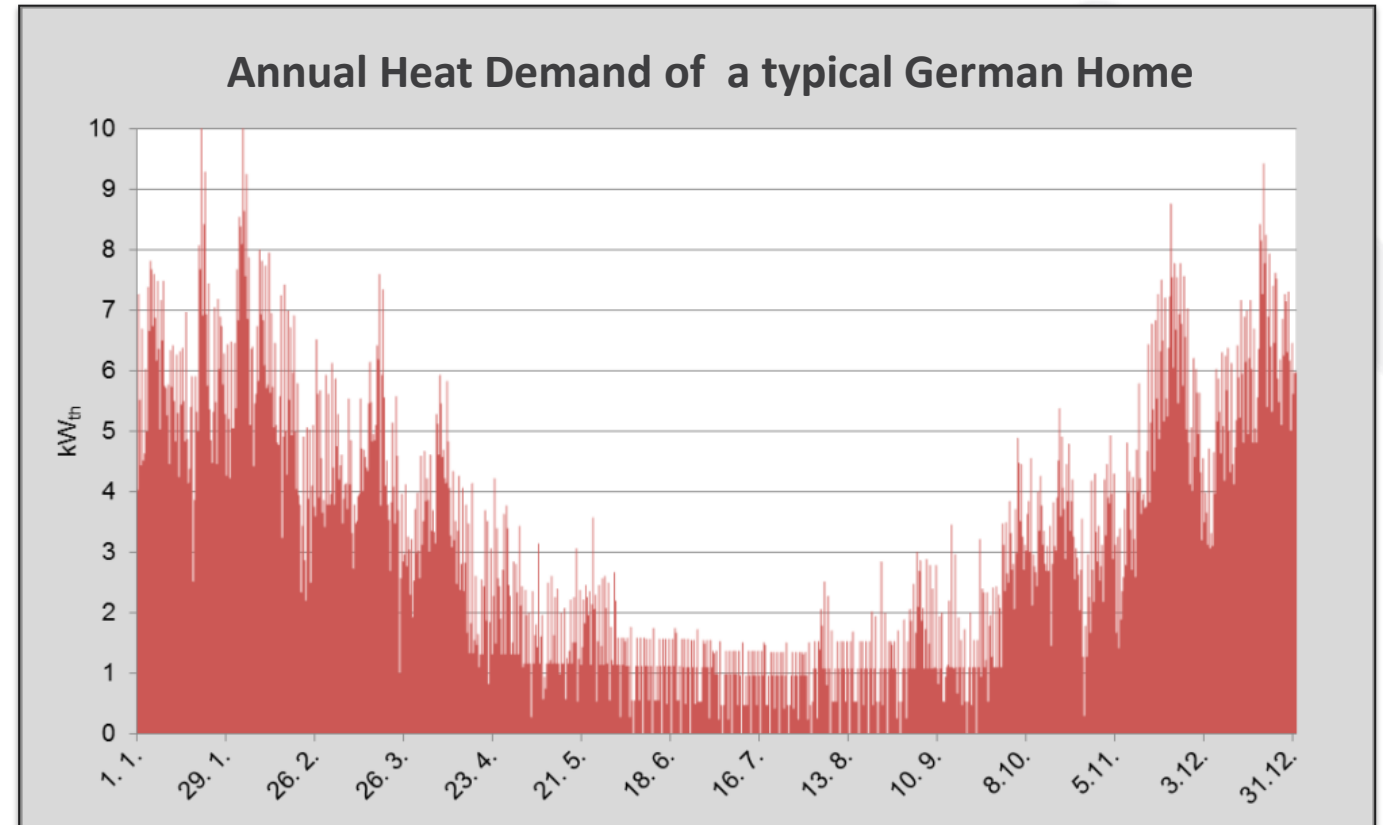
I. Requirements for use of a FC CHP

I 1. Heat and Electricity Demand

Heat Demand

Given that the heat requirements of a building are seasonally-determined (see graph) and FC mCHP units ideally run constantly, it is recommended to have a separate hot water storage paired with a FC mCHP that is capable of modulating its thermal output to match the peak load boiler.

The thermal output of the FC CHP should cover a maximum of about 20% of the peak load. It is therefore important to determine what the peak load of the building might be.



Source: Callux; Gertec GmbH

I. Requirements for use of a FC CHP

I 1. Heat and Electricity Demand

Electricity Demand

At 8,760 operating hours per year (constant operation), a FC CHP with 1 kW_{el} output at full load would produce 8,760 kWh of electricity per year.

The FC mCHP covers the base load. Higher requirements are drawn from the grid and excess electricity is fed into the grid.

Country	Annual Electricity Demand for 4-person Family (kWh)	Source
Germany	3,500	Callux
UK	3,700	Enerdata
Italy	2,500	Selectra
Netherlands	3,605	City Centre Estates



Source: Hager.de

I. Requirements for use of a FC CHP

I 2. User Behaviour

User Behaviour

Like all modern systems, FC CHP work automatically and with high efficiency.

Nevertheless, users can influence the function, economy, and efficiency of a system through their behaviour.

They should therefore be familiar with the system characteristics/control system and energy-relevant processes in the building.

Also, in order to avoid possible user errors leading to a loss of comfort, a detailed introduction to the system upon installation is important.

I. Requirements for use of a FC CHP

I 3. Preconditions for Installation

Installation Considerations

- Natural gas connection (including additional requirements such as condensing boiler)
- Available power supply (requirements: 230 Volt/50 Hz)
- Exhaust gas discharge: what is the required minimum length of the flue line? Is an open or direct flue possible? Is fresh air intake possible?
- Condensation removal (taking into account its calorific value)
- Are FC CHPs authorised and legal?
- Is a data (internet) connection possible?
- Space requirement: what is the minimum height, width and depth of the installation room?
- Is it possible to provide decalcified water?

I. Requirements for use of a FC CHP

I 4. Installation of the FC CHP

Requirements arise from

- Building regulations and fire protection laws
- Heating regulations
- Technical rules for gas installation
- Sound insulation
- Room size: Installation area, room height, work area for maintenance, connection options for water and gas, supply and return air, waste water
- Options for multiple use
- Access points

I. Requirements for use of a FC CHP

I 4. Installation of the FC CHP

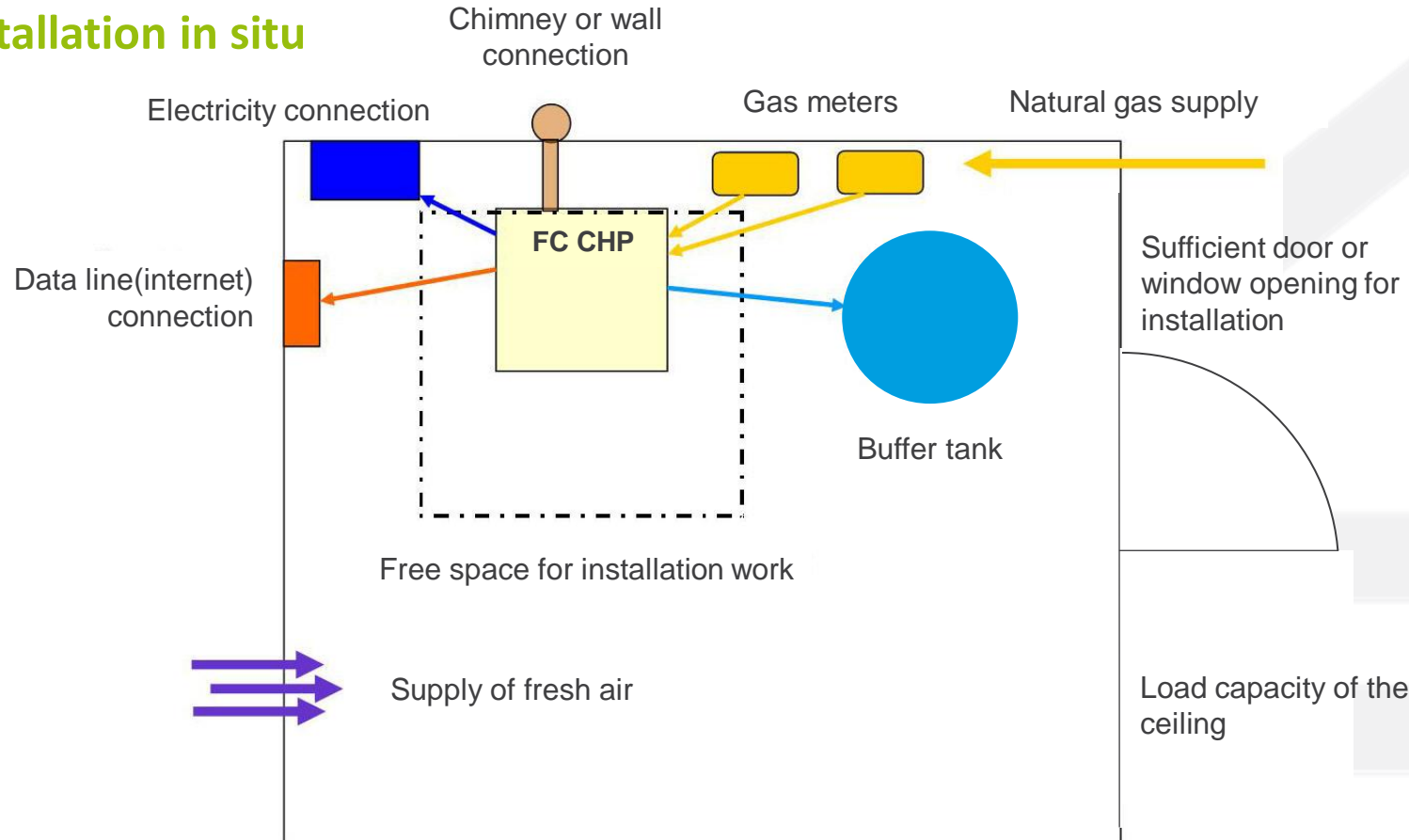
Installation of the FC CHP

- For delivery and installation, the following must be considered:
 - Size of door openings or stairs
 - Possibly necessary construction measures (e.g. breakthrough)
 - Angle of inclination when transporting the FC CHP
 - Suitable transport equipment (the largest individual component is usually the buffer storage tank)
- The installation room requires the following:
 - Sufficient space for the FC CHP and connection to the heating system (see manufacturer's documentation)
 - Accessibility for maintenance and repair work (approx. 0.5 - 1.0 m in front of and next to FC CHP)
 - To be able to withstand static load
 - To be dry, frost-free and ventilated

I. Requirements for use of a FC CHP

I 4. Installation of the FC CHP

An example of installation in situ



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1. Checklist
2. Hydraulics
3. Storage
4. Supply and Exhaust System
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6. Data Transmission

III. Formal Requirements

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Working with Checklists

Ensure the correct
technical checklist
for the unit being
installed is obtained
before installation
begins

Source: Bosch

II. General Planning Requirements

II 1. Checklist

Location:
Name:

Province:

Postcode: City:

Street:

Telephone:

User data:
Inhabitants: adults: children:

Employed: school:

Building:
☐ Single family house ☐ stand-alone ☐ mid-terrace house
☐ End-terrace house

With basement ☐ yes ☐ No

Floors:

Living space, heated [m²]:

Year of construction:

Reconstruction measures:
When have the measures been realized?

Which measures have been realized?

Is a gas connection installed already?
☐ Yes ☐ No ☐ planned
Distance of gas connection to µCHP-System [mtr]:

When is it planned to install the gas connection?
 Jan

Which gas quality is provided by your utility company?
☐ H-gas ☐ L-gas ☐ different
Description of delivered gas, upper heating value [kWh/m³]:

If possible, please enclose your latest gas accounting!

The µCHP-system shall be installed at which location in the building?
☐ Roof ☐ Cellar ☐ residential area ☐ garage
☐ Different place
Description of installation space (width x height x depth), please enclose picture or drawing.

Passing of exhaust-gas line
☐ Vertical ☐ horizontal
Vertical length [mtr]:

Horizontal length [mtr]:

Please enclose picture or drawing with chimney position.

Current heat generator
☐ Gas ☐ oil ☐ solid ☐ heating rod ☐ heat pump
☐ Different
Description of heat generator when „different“ is chosen:

Performance [kW]: age [years]:

How was the energy consumption during the last 3 years [kWh/a]?
2009
2010
2011

Please enclose a picture of the current installation.

How often is domestic water tapped in your household (shower, bathing number/week)
☐ 1-5 ☐ 5-10 ☐ 10-15 ☐ 15-20

Is a circulation line installed?
☐ Yes ☐ No
Are renewable energies used?
☐ Yes ☐ no
Which renewable energies?

Please answer only, if photovoltaic is installed.
☐ 100% feed-in of produced electricity to the grid
☐ Feed-in and own consumption

Electricity consumption:
How was the electricity consumption during the last 3 years [kWh/a]?

2009
2010
2011

Electronic installation
Is it possible to install additional meters in the electric meter cabinet?
☐ Yes ☐ No

Are heat generator and electric meter cabinet installed at the same floor?
☐ Yes ☐ No
If no: How many floors are in between?

Are heat generator and electric meter cabinet installed in the same room?
☐ Yes ☐ No
If no: How many walls are in between?

How far is the distance between electric meter cabinet and µCHP-location [mtr]?

Please enclose picture or drawing for each.

Network operator and utility company
Who is your current utility company?

Who is your network operator?

II. General Planning Requirements

II 2. Hydraulics

Requirements for Hydraulic Integration

1. Heat from the FC CHP must be dissipated reliably
2. Ability to meet heat demand
3. Ability to realise long running times for the FC CHP
4. Efficient use of fuel used

The hydraulic integration

- is based on the manufacturer's specifications,
- is comparable with other efficient technologies such as heat pumps, solar heating backup, etc.

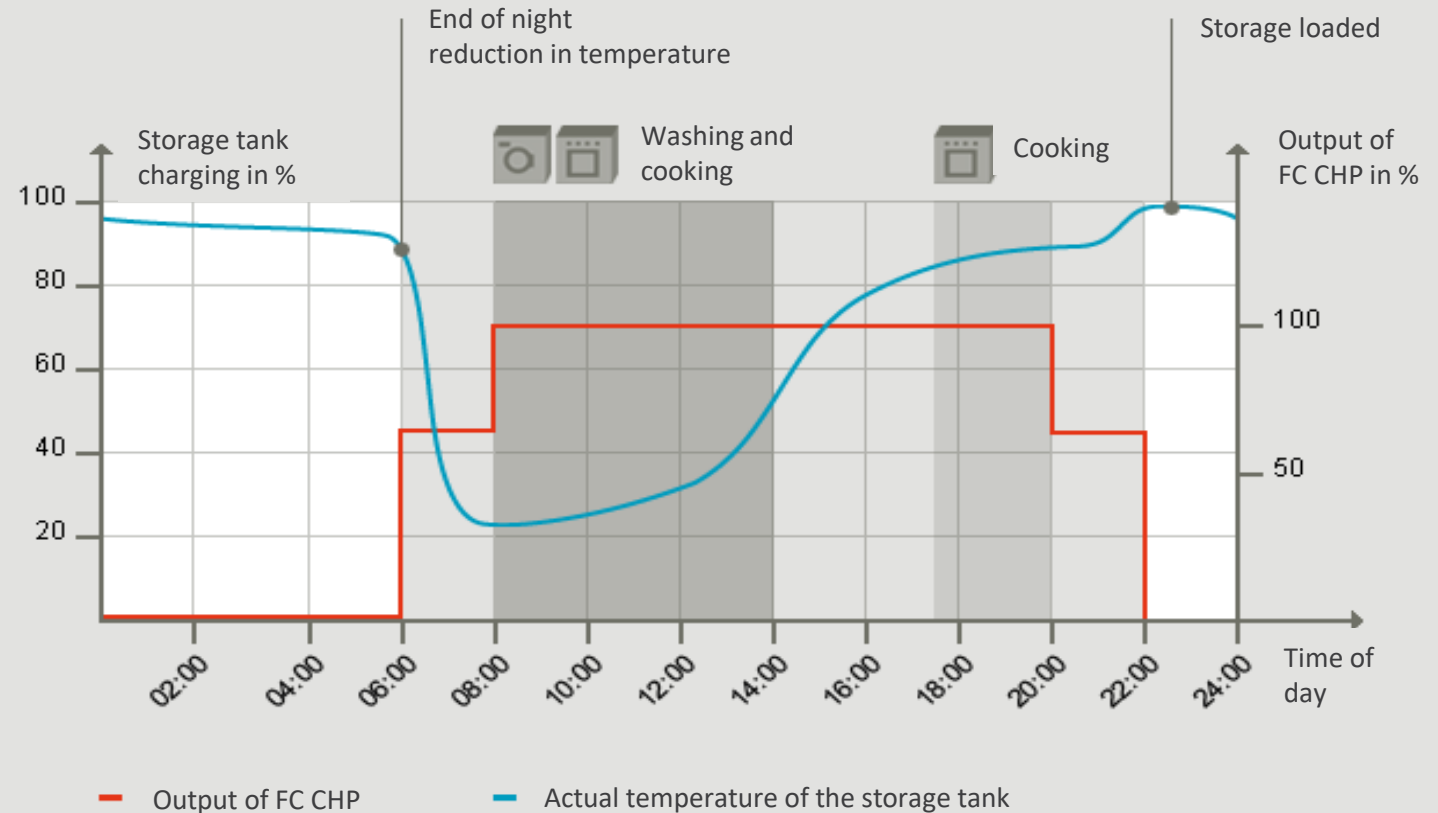
It is important to coordinate integration with the unit manufacturer's suggestions/requirements.

Storage and the FC CHP

II. General Planning Requirements

II 3. Storage

Demand adjustment through storage management



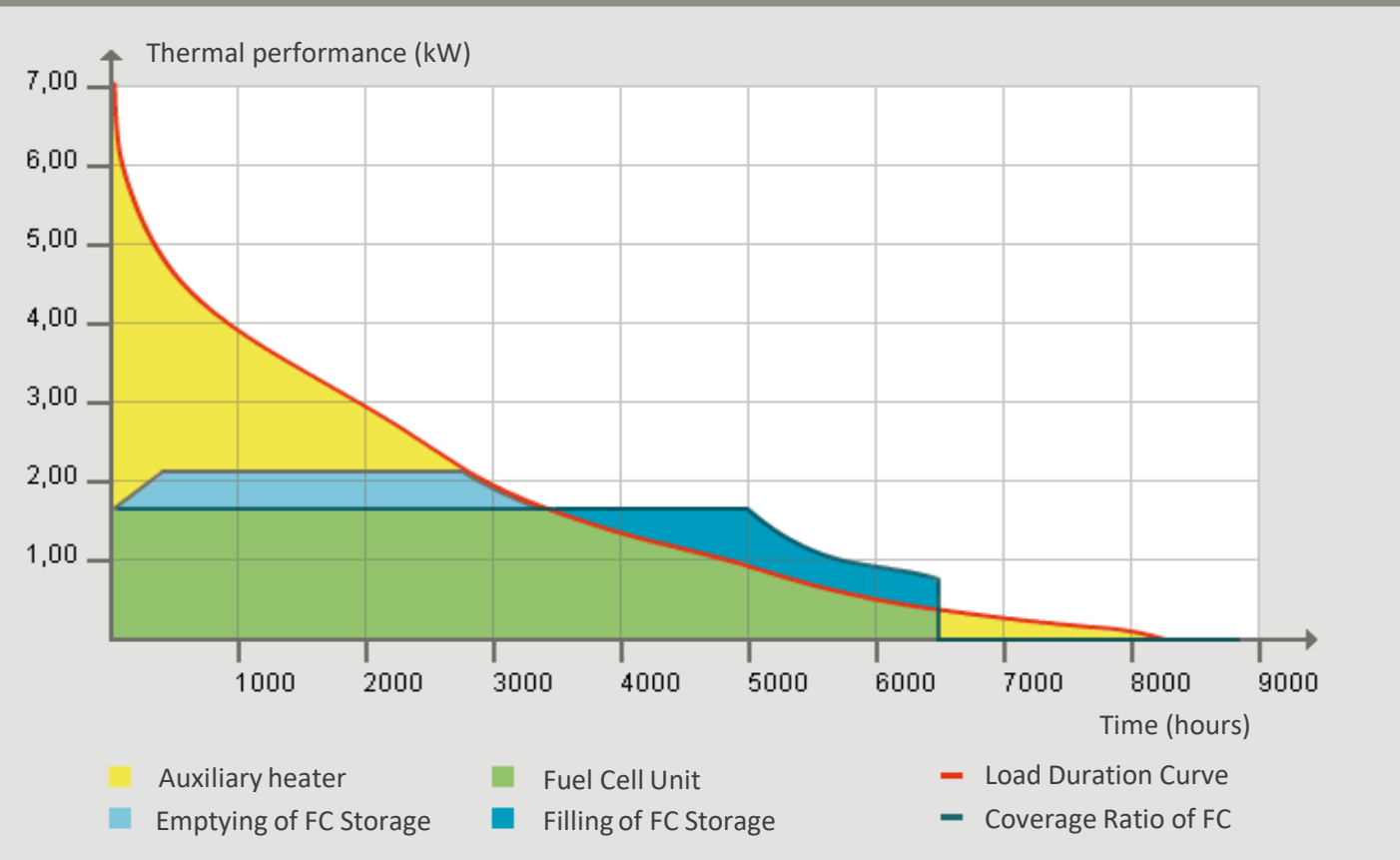
II. General Planning Requirements

II 3. Storage

Storage and the FC CHP (2)

NB. This curve is based upon a FC mCHP with a heat output of 1.5kW. The shape of the curve depends upon the size of the FC mCHP heat output

Load duration curve of warming demand and coverage by FC CHP (example)



II. General Planning Requirements

II 4. Supply and Exhaust System

Framework conditions for the supply and exhaust air system:

- Classification of FC CHP according to equipment class is crucial
- Similar requirements often apply to FC mCHPs as for gas condensing boilers
- Important to use moisture-resistant exhaust pipes due to low exhaust gas temperatures
- Ensure that condensation is extracted (see manufacturer's instructions)
- Length of exhaust system and number of deflections according to manufacturer's specifications
- Early consultation with chimney cleaning providers is useful – they need to agree with the installation

II. General Planning Requirements

II 4. Supply and Exhaust System

Regulations by country

Country	Regulation Name	Description	To-do for Installer
Denmark	Gasreglementet	Same requirements as a conventional boiler	Must be a certified plumber.
France	Arête du 2 aout 1977; Arrêté du 30 novembre 2005	Same requirements as a conventional boiler	Must be a certified plumber
Germany	DVGW G2000 (2011)	Same requirements as a conventional boiler	Unit requires registration with gas grid operator by both the qualified installer and the user. Fees vary as there are 730 different operators.
Italy	UNI 7129 (2008) / UNI 7140 (2013)	Same requirements as a conventional boiler	Must be a qualified installer compliant with CEI and UNI regulations.
UK	Gas Safety Regulations (1998)	Same requirements as a conventional boiler	Installer must have undertaken CCN1 Gas Safety Assessment and hence be on the Gas Safe Register.

II. General Planning Requirements

II 5. Electrical Installation

Electrical Installation

There is no common EU framework on the requirements for electrical installation.

Energy Efficiency Directive (2012/27) requires member states to adopt simplified grid connection ‘install and inform’ procedures. In theory means grid operators provide priority or guaranteed access to grid for highly energy efficient tech. This is rarely truly the case in reality.

The most important questions to answer in advance of installation are:

- Is it a new or old building?
- Is the meter cabinet large enough to accommodate a feed-in meter?
- Does the energy supplier allow the connection of electricity generating systems to the grid?
- Do electricians need special training/certifications to be able to carry out FC mCHP installations in your country?

Connection of a FC CHP:

- What are the electricity meter requirements in your country?
- What are the electrical safety requirements in your country (e.g. for a circuit breaker/mains power protector in case of surges?). This may vary depending on if unit-owner plans on only self-consuming electricity vs selling surplus to the grid.

Regulations by country

II. General Planning Requirements

II 5. Electrical Installation

Country	Regulation Name	Description	To-do for Installer
Denmark	<ul style="list-style-type: none"> Teknisk Forskrift 3.2.1 	<ul style="list-style-type: none"> For power producing plants with current below 11A /11kW. Based on EU nor, EN 50438. DSO responsible for registering of metering data and reporting of plant data to TSO. 	<ul style="list-style-type: none"> Use a bidirectional meter. Facilitate the signing of agreements between the producer (FC mCHP owner) and the DSO and TSO (this paperwork takes 1-2 weeks to clear). No special qualifications required for electrician.
France	<ul style="list-style-type: none"> Decree No. 2008-386 	<ul style="list-style-type: none"> Sets a clear list of requirements -> 	<ul style="list-style-type: none"> Requirement for a circuit breaker with public access (NF C 14-100); electronic meters; and an agreement between the DSO and the producer (usually takes 1 month to clear – requires signatures). Two meters required if selling surplus electricity. Qualified electricians required for commissioning.
Germany	<ul style="list-style-type: none"> KWK-G, Kraft-Wärme-Kopplungsgesetz VDE-AR-N 4105:2011-08 	<ul style="list-style-type: none"> Enshrines right for all CHP units to be connected to electricity grid. Outlines a number of forms that need to be filled in before commissioning and after commissioning. 	<ul style="list-style-type: none"> Fill in forms G1, G2, G3, F2 and a Scheme Plan before installation. Fill in form F1 after commissioning. Installers require special training on CHP units and grid connection.
Italy	<ul style="list-style-type: none"> CEI 0-21 CEI 64-8 	<ul style="list-style-type: none"> Specific requirements concerning protection devices and metering. DSO personnel required to complete metering. Defines design and installation criteria and how to complete compliance certificate for electrical installation. 	<ul style="list-style-type: none"> A security circuit breaker is required, along with a bidirectional smart meter. Facilitate agreement between DSO and producer (average 20 days for completion). Must be a qualified electrician to complete grid connection.
UK	<ul style="list-style-type: none"> EREC G83/2 	<ul style="list-style-type: none"> Operates on a ‘fit and inform’ basis in which mCHP unit is connected to the grid and then DSO is informed (G83 notification). Products must be certified under Microgeneration Certification Scheme (MCS). 	<ul style="list-style-type: none"> Only a generation meter is required, not an export meter. Installer must be certified under Microgeneration Certification Scheme (MCS).

II. General Planning Requirements

II 6. Data Transmission

Data (internet) Connection

FC CHPs are currently designed with remote monitoring. Data communication is often a necessary condition for receiving funding under EU-funded projects (such as PACE). The units can also run without data connection.

Before selecting the data (internet) connection, it is necessary to check which communication options are available at the installation site and what costs they cause.

Some units require an ethernet connection, and some can use WiFi/GSM.

In order to protect the connection against unauthorized access, encryption technology is required for data transmission.

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III. Formal Requirements

III 1. During the Planning

Gas network operator and natural gas supplier

Gas network operator:

- FC CHPs register as conventional gas appliance (by locally approved gas installation company)
- Manufacturer's documents must be enclosed (CE declaration of conformity, approval certificate for exhaust system)
- Specify the connected load
- Installation of a separate calibrated meter
- If there is no gas connection, agree on a natural gas network connection contract with gas meter and, if necessary, pipe connection

Natural gas supplier:

- Contact recommended

III. Formal Requirements

III 1. During the Planning

Chimney sweeps and building authorities

It is important(/mandatory in some countries) to contact (district) chimney sweeps prior to installation:

- A necessary process for gas supply by gas network operators.
- Include this in planning at an early stage
- Certifies the suitability and safe usability of the exhaust system
- If necessary, coordinate new exhaust system with the chimney sweep and submit technical documentation from the FC CHP manufacturer.
- Fireplace acceptance takes place after commissioning.
- Note approval requirements vary

III. Formal Requirements

III 2. In Operation

Electricity grid operator

As detailed before, sometimes DSOs and TSOs must approve use of a FC mCHP plant and the right to feed CHP electricity into the distribution grid. The process requires:

- Requesting application for grid connection and for operation of a generation plant (by approved electrical installation company),
- Submission of manufacturer's documents (declaration of conformity and safety certificate) and documentation on the installation site (site plan and system diagram).

A separate electricity meter is often required in this case – a generation meter with bidirectional measurement. This will need to be commissioned.

From a legal point of view, the FC CHP operator must conform to grid use rules. Details will have to be provided to the grid operator to organise remuneration.

There are associated small business regulations that may be relevant to the FC CHP operator (especially for VAT purposes).

III. Formal Requirements

III 3. After installation/commissioning

After installation considerations

There are specific requirements in each national jurisdiction for the specific requirement relating to how the unit must be verified to allow the start of grid-connected generation (relating to grid balancing etc).

The unit exhaust pipe system, data (internet) connection, auxiliary boiler function and overall unit function will also need to be verified during the commissioning process.

Re-inspection interval differs by country, but is usually every 2 years (and is generally dependent upon the service contract).

III. Formal Requirements

III 4. Paperwork/Explanations

Paperwork for tax office and electricity network operator

Specific paperwork submission requirements also apply to different national contexts.

Such paperwork that might be required include formal taxation certificates relating to the contribution of electricity to the grid/tax breaks for low-carbon technology.

Moreover, the electricity network operator will have requirements for the paperwork that must be submitted before grid connection can be initialised.

III. Formal Requirements

III 5. Subsidy Funding

General Funding Advice

Before placing the order to purchase or install the FC CHP, clarify the requirements for investment support and, if necessary, submit an application.

It is important, too, to examine whether multiple funding schemes are eligible together - some funding programmes are not jointly approved with other funding schemes.

Possible funding sources are included on the next slide.

As of Nov. 2019 (source: PACE, Challoch Energy)	Feed-in-tariff	Feed-in-premium	Quota obligation and certification scheme	CAPEX support	Tax incentives	Self-production incentives	Others
Poland	Yes	No	No	No	No	No	No
Italy	No	No	White certificates	No	Very general, rarely apply to cogeneration	Tax exemption on the gas used	No
The UK	Yes, starting 1st January 2020	No	No	No	No	No	No
France	No	No	No	No	No	No	No
Austria	No	No	No	Yes, if electrical output >100kW and supplies the public heating district	No	No	No
Belgium (Flanders region)	Yes, not specific to µCHP. Green electricity certificates are issued for systems >10kW if biogas is used.	No	No	No	No	No	Up to 30% of costs if installation <10kW, Jan 2018
The Netherlands	No	n/a	n/a	n/a	n/a	n/a	n/a
Germany	Yes	No	No	Yes, investment incentive program for mini-CHP from the Federal Environment Ministry	Yes, tax relief based on the Energy Tax Act	Yes	No
Switzerland	No	No	No	n/a	n/a	n/a	n/a
Luxembourg	Yes	No	n/a	n/a	Yes, mCHP plants between 1 and 6kW subsidised by the state	n/a	n/a

Additional Materials

Specific material on the FC mCHP is available in German on the Buderus webpage:

<https://www.buderus.de/de/technische-dokumentation?query=FC10&searchType=query>

Material on the specification of each PACE manufacturer's units will be found in PACE D1.7 'Summary report on specifications for 'Gen Y' systems for use in communication'. This has yet to be published, but once it has a link will be added to this slide.

In addition, each FC mCHP manufacturer has specific training materials for their unit, which is generally only issued during training events.



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