ene.field project

ene.field

Technical procedure on data handling

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

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New Energy World JU

fuel cells & hydrogen for sustainability

CONTENT

1 PREAMBLE

This document is the agreed and working basis for data handling in the ene.field project between the following partners sorted by their access level to field data (see 6 Clean Room Process). The data handling agreement has the status of technical procedure and does therefore not require official signatures from the partners to go into effect.

Table 1: partners directly affected by this document

Manufacturers	Monitoring	Analysis partners
BAXI INNOTECH GMBH / SENERTEC KRAFT-WÄRME-ENERGIESYSTEME GMBH (short: BAXI)	DBI - GASTECHNOLOGISCHES INSTITUT GGMBH FREIBERG (short: DBI)	DENMARKS TEKNISKE UNIVERSITET (short: DTU)
BOSCH THERMOTECHNIK GMBH (short: BOSCH)	GAS- UND WÄRME-INSTITUT ESSEN E.V. (short: GWI)	EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF-KIT EWIV (short: EIFER)
DANTHERM POWER A/S (short: DANTHERM)	DANMARKS TEKNISKE UNIVERSITET (short: DTU)	ELEMENT ENERGY LIMITED (short: ELEMENT)
ELCORE GMBH (short: ELCORE)		IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE (short: IMPERIAL)
HEXIS GMBH (short: HEXIS)		THE ENERGY SAVING TRUST LTD BY GUARANTEE (short: EST)
RIESAER BRENNSTOFFZELLENTECHNIK GMBH (short: RBZ)		DBI - GASTECHNOLOGISCHES INSTITUT GGMBH FREIBERG (short: DBI)
SOLIDPOWER S.P.A. (short: SOLIDPOWER)		GAS- UND WÄRME-INSTITUT ESSEN E.V. (short: GWI)
VAILLANT GMBH (short: VAILLANT)		
VIESSMANN DEUTSCHLAND GMBH (short: VIESSMANN)		

This document will be circulated among the following partners:

Table 2: circulation list for data handling agreement

Partner no.	Partner	Name	Email	Document approval
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3	BOSCH THERMOTECHNIK GMBH	Wolfram Faas	wolfram.faas@de.bosch.com	
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8	RIESAER BRENNSTOFFZELLENTECHNIK GMBH	Katrin Grosser	grosser@rbz-fc.de	X
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12	BRITISH GAS TRADING LIMITED	Will Keown	will.keown@britishgas.co.uk	
13	ELEMENT ENERGY LIMITED	Ian Walker	ian.walker@element-energy.co.uk	
13	ELEMENT ENERGY LIMITED	Lisa Ruf	lisa.ruf@element-energy.co.uk	X
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14	GDF-SUEZ	David Dupuis	david.dupuis@gdfsuez.com	
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21	DBI GASTECHNOLOGISCHES INSTITUT GGMBH FREIBERG	Inbox ene.field	enefield@dbi-gti.de	
22	THE ENERGY SAVING TRUST LTD BY GUARANTEE	Andrew King	Andrew.King@est.org.uk	X
23	GAS- UND WÄRME-INSTITUT ESSEN E.V.	Michael Schmidt	schmidt@gwi-essen.de	
23	GAS- UND WÄRME-INSTITUT ESSEN E.V.	Frank Burmeister	burmeister@gwi-essen.de	
23	GAS- UND WÄRME-INSTITUT ESSEN E.V.	Rolf Albus	albus@gwi-essen.de	
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24	DANMARKS TEKNISKE UNIVERSITET	Carsten Brorson Prag	cbrpr@dtu.dk	
25	EUROPEAN INSTITUTE FOR ENERGY RESEARCH	Till Bachmann	till.bachmann@eifer.uni-karlsruhe.de	X
25	EUROPEAN INSTITUTE FOR ENERGY RESEARCH	Philipp Preiss	Philipp.Preiss@eifer.uni-karlsruhe.de	
26	DONG ENERGY POWER AS	Aksel Hauge Pedersen	akhpe@dongenergy.dk	
??	VIESSMANN DEUTSCHLAND GMBH	Jan Hendrik Dujesiefken	DujJ@viessmann.com	X

The update frequency for this document is limited to twice a year (after each half-year meeting). The current version can always be downloaded from the internal section of the project homepage (www.enefield.eu). New versions will be uploaded to homepage and circulated by email to all partners as listed in Table 2. Partners with "document approval" – status in Table 2 may give their founded objection by email to **enefield@dbi-gti.de and schmidt@gwi-essen.de** within a four week period, otherwise the document is considered as excepted. DBI will send out a reminder three weeks after circulation of the updated data handling agreement.

All changes to the previous document will be listed in a release list in Chapter 7 (Annex) for faster approval. Any changes with regard to the previous version are furthermore highlighted within the unreleased document.

2 QUESTIONNAIRE

| *Leading institute: DTU* (part: installer questionnaire: GWI)

The installer and end-user questionnaires will be carried out using the online tool Questback. The end-user questionnaire will gather domestic information (e.g. type of house, size, and number of people), expectations and historic energy demand and costs. The use of such a tool makes data handling and communication much safer and reduces the amount of work required during the field trials as data is handled, collected and stored automatically. The ease of filling out an online survey, as compared to mail a sheet of paper or e-mail an excel sheet, is anticipated to reduce the work load and risk of information loss, but also increase the overall response rate. Eight identical surveys will be created- one for each manufacturer. Each of the manufacturers will have exclusive access to the surveys from end-users having their fuel cell system installed at their household. DTU and GWI will have access to all surveys as they are responsible for data collection and for anonymising the data before further analysis is performed. A second follow-up end-user questionnaire will be submitted 1 year after installation in order to monitor satisfaction and issues encountered seen from the end-user perspective. A flowchart describing development and handling of the three questionnaires is presented in Figure 1.

The installer survey will follow similar procedure as the end-user survey. There is no follow-up questionnaire for the installers.

The manufacturer should further ensure that this requirement is included in their contracts with any field partners. The field partners are responsible for the completion of the questionnaire by the installer. The manufacturers are responsible to verify if all end-users and installer have replied on their respective questionnaires, and if necessary send out a reminder to those who haven't replied on time (specified response time within each e-mail).

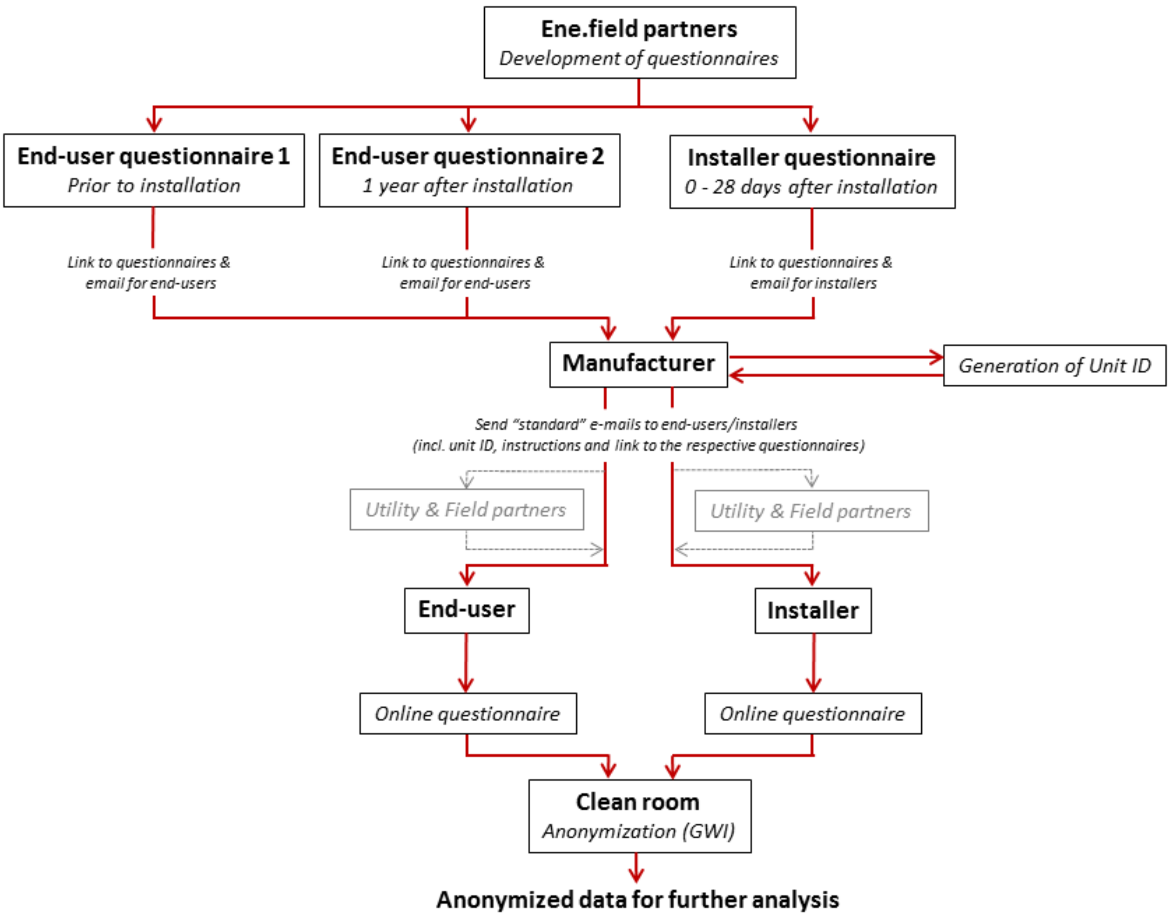

Figure 1: Flowchart describing the development and handling of the three questionnaires.

2.1 Language and Translation

The language of the questionnaire will be English. As mentioned in DoW task 3.2 the questionnaires will be translated by the consortium partners on demand to minimise costs. A list of the needed languages is shown in Table 3 with the related responsibilities regarding the translation.

Table 3: list of needed languages and responsible ene.field participants for translation

Language	responsible participant
English	standard language
German	Frank Erler (DBI-GTI)
Dutch	Employee at ELEMENT ENERGY
Italian	Alessandro Graizzaro (ENVIPARK)
French	Stephane Hody (GDF SUEZ)
Spanish	Maria Gomez-Reino (COGEN)
Slovenian	Tadej Auer (DCHT)
Danish	Eva Ravn Nielsen (DTU)

2.2 DATA COMMUNICATION

The questionnaire will be completed by the end-users during the contractual phase (e.g. answered before installation), in order to ensure that necessary information on historic energy demand and other important data is collected. The installers will complete the technical questionnaire just after installation of each unit (within 4 weeks). DTU will prepare a template e-mail text into which only the unit-ID needs to be copied. This email will include:

- Their unit IDs
- A web link to the questionnaire (individual for each manufacturer)
- A list of information / documents that they will need to have at hand to be able to answer the questions.

The replies will be stored automatically in Questback databases. A similar email template including a reminder to both installers and end-users will also be prepared by DTU. The email templates will (just as the questionnaires) be translated by consortium partners to languages mentioned in Table 3.

GWI will extract the data from the surveys and anonymise the data before they are passed on to partners responsible for specific analyses. GWI/DBI will make sure that the data can be coupled with relevant data from the monitoring of field demonstration units.

3 MONITORING

| Leading institute: DBI + GWI

Objective of the monitoring work package is the creation of two databases, a detailed database of actual energy demand profiles of domestic buildings across Europe and a database of mCHP performance data gathered from the field test installations.

3.1 UNIT-ID

A central tool in the communication process will be the unit-ID. The unit-ID will be created by the manufacturer for the purpose of communication[1] inside the project before each installation. In the following cases the unit-ID will be needed:

- Communication between manufacturer and utility
- Communication between manufacturer and DBI/GWI
- For reference in the installation questionnaire -> for this purpose the unit-ID must be visible for the end user (maybe tagged on the unit)

Please make sure the unit-ID will follow this pattern:

First three letters of company name followed by random four digit number *e.g.RBZ0554, VAI0884, BOS0215, DAN2013*

This way only the manufacturer can be read out but not the order of installation.

3.2 DEFINITION OF DATA POINTS

| Leading institute: DBI

For a complete energy balance of the fuel cells, the heating systems and buildings several data points are needed as shown in Table 4. The meter numbers correspond to the numbers in the monitoring flow diagram (Figure 2).

<u>Used abbreviations:</u>

- BZE (fuel cell unit; consists of stack, reformer, inverter, balance of plant, controller)
- ZHG (peak load boiler; either integrated in fuel cell or external boiler)
- BZH (fuel cell heating device; if peak load boiler is integrated into fuel cell enclosure: BZH=BZE+ZHG; for external peak load boiler: BZH=BZE)

[1] Most manufacturers create something like IDs for their field installations anyways to communicate with the utilities. WP2 kindly asks to standardize this ID among all manufacturers to use it in an extended way. Note that the unit-ID will only be used before the clean room process. The clean room process will remove the unit-ID before data is passed on.

Table 4: list of data points

meter number	type	measured variable	code	physical quantity	measurement unit	description	Primary address (ACOS700)
1	gas	consumption peak load boiler	ZHG_Gas	V	m³	measured volume natural gas for peak load boiler (ZHG)	31
2	gas	consumption fc	BZE_Gas	V	m³	measured volume natural gas for fc (BZE)	30
3	electricity	power consumption fc	BZE_Wbezg	W	kWh	power consumption (active energy) fuel cell heating device from grid	20
		power production fc	BZE_Wabg	W	kWh	power export (active energy) fc into grid	21
4	electricity	power consumption house	HA_Nbezg	W	kWh	power consumption house from grid (if power export fc is smaller than power demand house)	23
		power grid export house	HA_Neinsp	W	kWh	power export house into grid (if power demand house is smaller than power export fc)	24
5	heat	heat output fc	BZE_WM	Q	kWh	usable heat delivered from fc, measured nearby	40
		outgoing temperature	BZE_TV	T	°C	outgoing temperature fc; measured nearby outlet	
		return temperature	BZE_TR	T	°C	return temperature fc; measured nearby inlet	
		flow rate	BZE_V	V	m³	flow rate fc; measured nearby inlet	
6	heat	heat output peak load boiler	ZHG_WM	Q	kWh	usable heat delivered from peak load boiler, measured nearby	41
		outgoing temperature	ZHG_TV	T	°C	outgoing temperature peak load boiler; measured nearby outlet	
		return temperature	ZHG_TR	T	°C	return temperature peak load boiler; measured nearby inlet	
		flow rate	ZHG_V	V	m³	flow rate peak load boiler; measured nearby inlet	
7	heat	heat output hot water	WW_WM	Q	kWh	heat output from storage vessel to domestic hot water supply; measured nearby storage vessel	45
		hot water temperature	WW_TA	T	°C	temperature domestic hot water; measured nearby outlet	
		cold water temperature	WW_TE	T	°C	temperature of cold supply water; measured nearby inlet	
		flow rate	WW_V	V	m³	flow rate of cold supply water to storage vessel	
8	heat	heat output space heat	HK_WM	Q	kWh	heat output from fc, peak load boiler, storage vessel to heating circuit; measured nearby storage vessel	42
		outgoing temperature	HK_TV	T	°C	temperature of heating circuit, measured nearby outlet	
		return temperature	HK_TR	T	°C	temperature of heating circuit; measured nearby inlet	
		flow rate	HK_V	V	m³	flow rate inside heating circuit; measured nearby inlet	
9	temperature	temperature outside	TA	T	°C	temperature outside, measured preferably at the north side of the building (no impact from other heat sources)	5
		relative air humidity	Fi_A	φ	%	optionally, if outdoor sensor CMa20 will be used	6
10	temperature	inside living area	TI	T	°C	temperature inside living area (preferred family room)	7
		relative air humidity	Fi_I	φ	%	optionally, if outdoor sensor CMa20 will be used	8

3.3 DETAILED MONITORING

| Leading institute: DBI

According to DoW “at least 10%” of fuel cell installations shall be equipped with detailed monitoring equipment. That means that in addition to fuel cell data, data from the building shall be collected in short time steps (every 15 minutes). For a complete balance of energy all needed sensors (numbers 1 to 10) are plotted into the following flow diagrams (Figure 2) below. Alternative installation schemes are shown in Figure 3, Figure 4 where the boiler is part of the fuel cell heating device. In this case it needs to be differentiated whether or not separate gas inlets for fc and boiler are foreseen by the manufacturer. If this is not the case the gas consumption of the combined inlet will be measured and respectively dealt with in the analysis section. Figure 5 shows another alternative installation scheme for fuel cell micro-CHP with external peak load boiler installed after the buffer storage.

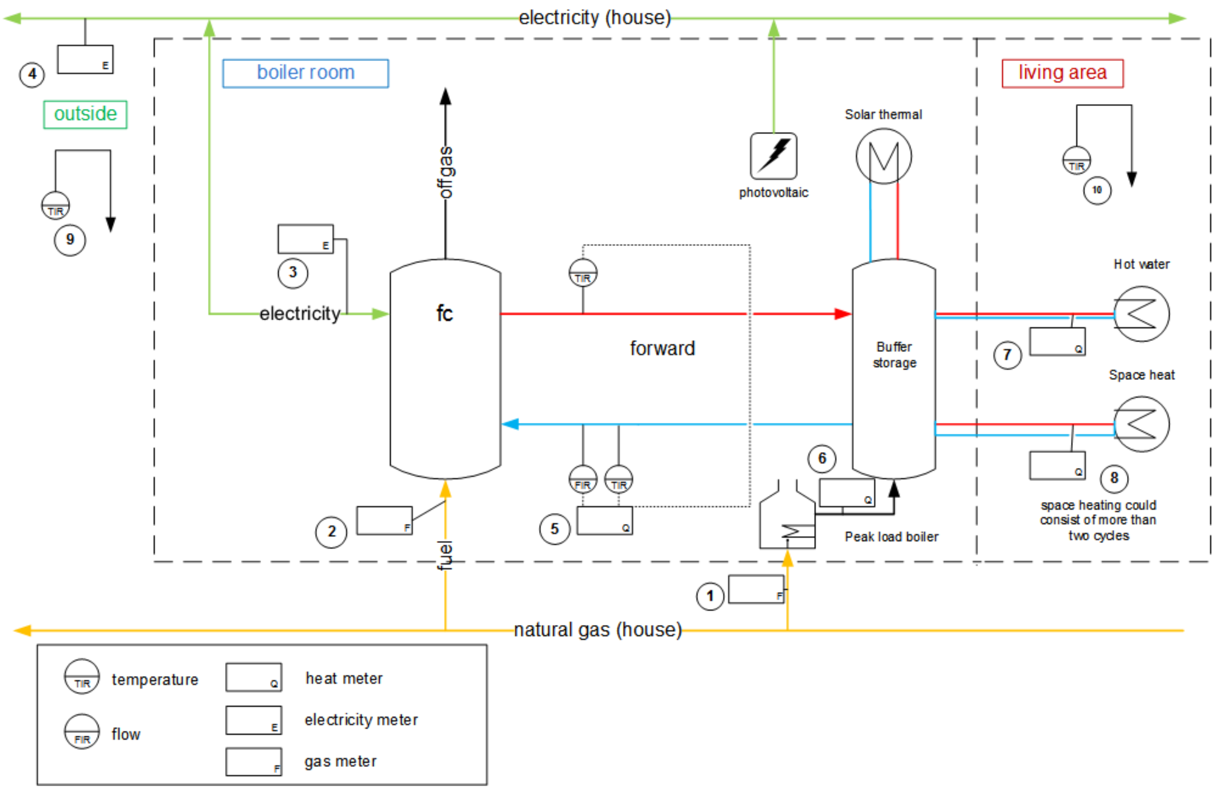

Figure 2: connection diagram detailed monitoring (scheme 1)

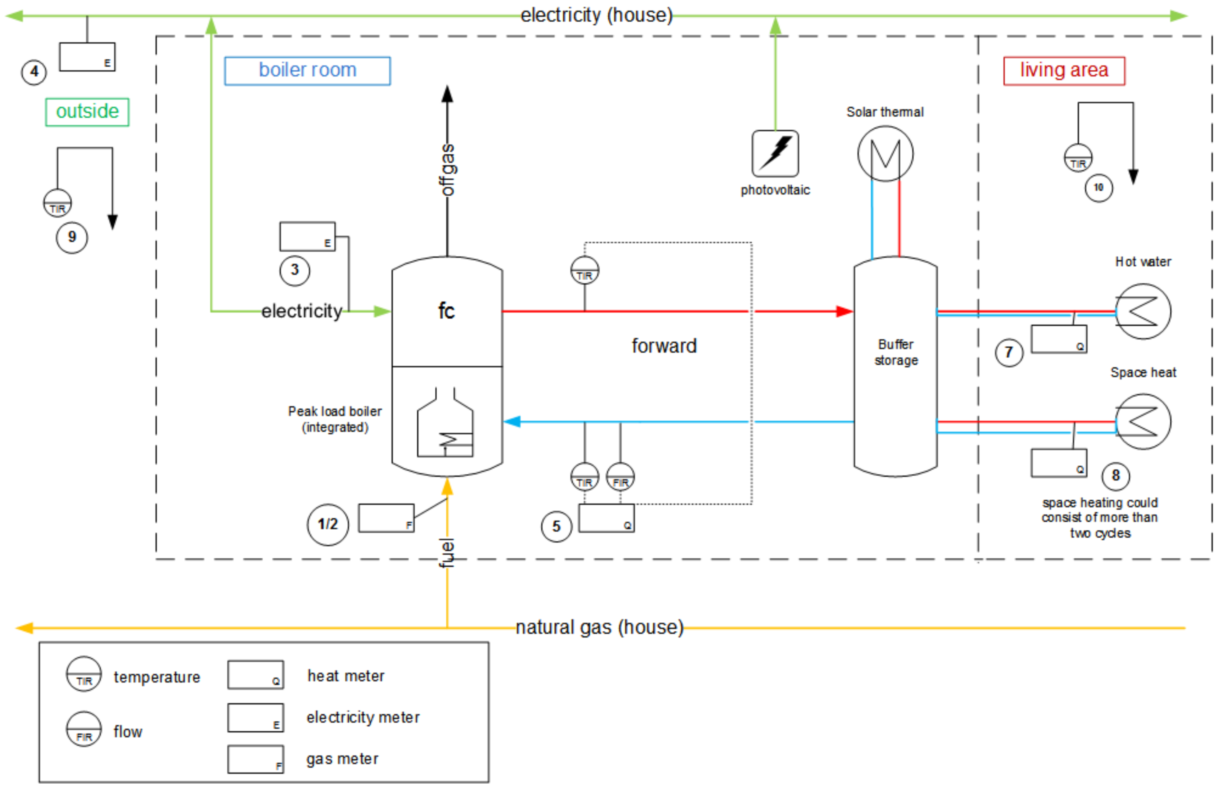

Figure 3: connection diagram detailed monitoring (scheme 2)

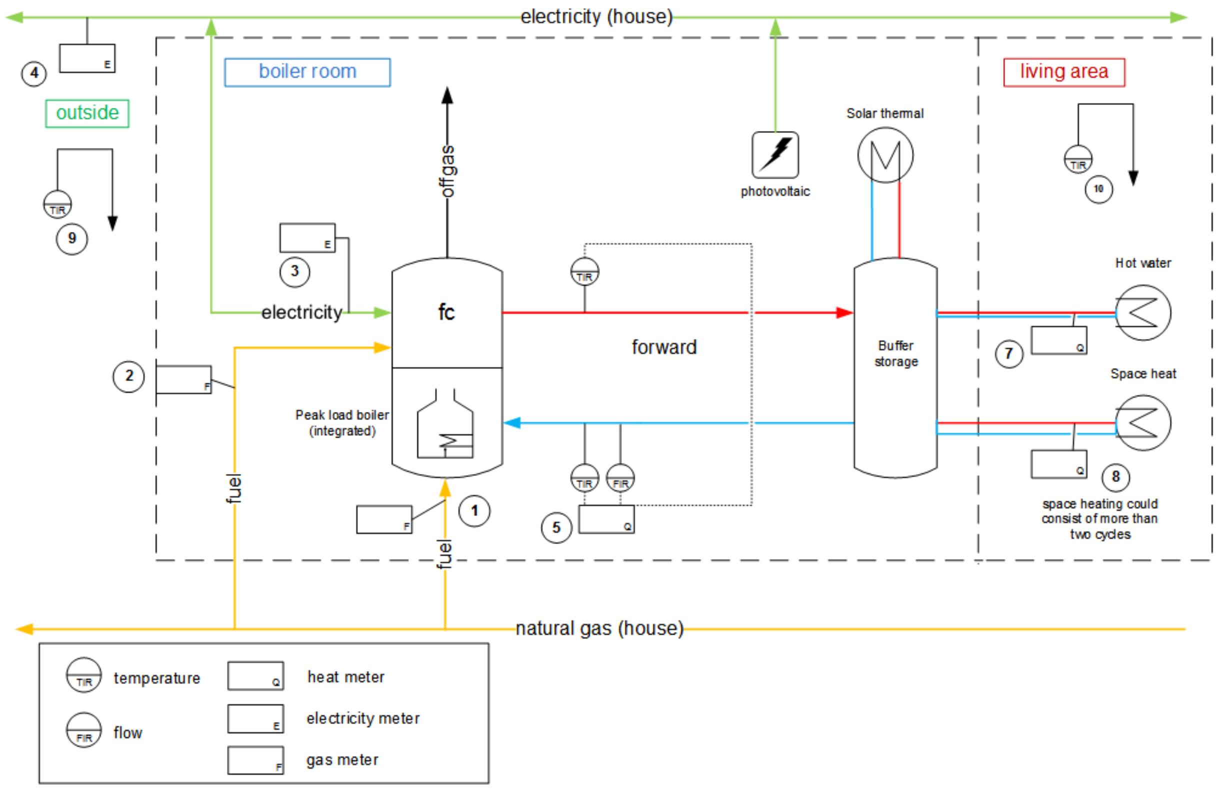

Figure 4: connection diagram detailed monitoring (scheme 3)

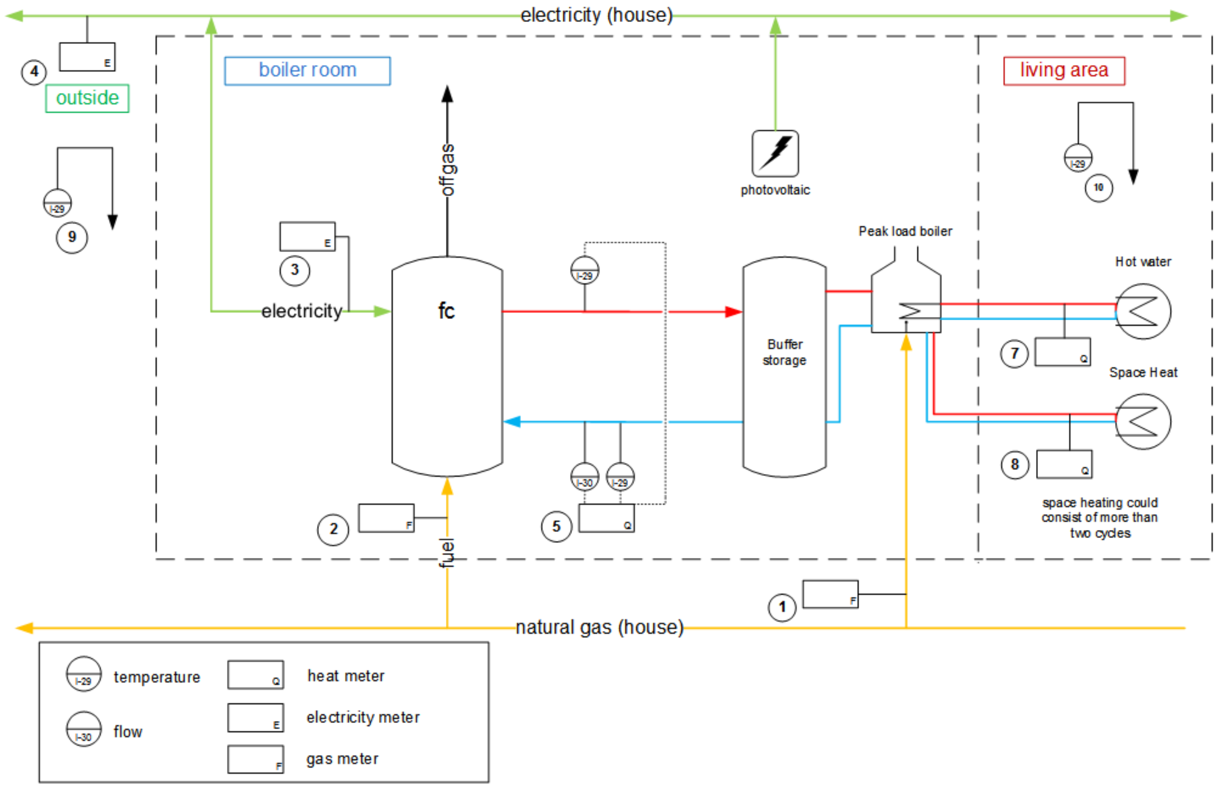

Figure 5: connection diagram detailed monitoring (scheme 4)

Each manufacturer decides which of his units are to be equipped for detailed monitoring. The equipment is bought by each manufacturer individually according to Table 6. Through the installation questionnaire procedure ELEMENT will learn about new installations and whether or not it was qualified for detailed monitoring. ELEMENT will keep track of all installations and will contact manufacturers with proposals if the 10%-mark is not reached or if distribution of detailed monitoring across Europe is unsatisfactory.

3.3.1 EQUIPMENT LIST

To ensure comparability of all field data, it is necessary that only sensors and meters listed in Table 6 are used for detailed monitoring. The installation of these sensors must occur according to the installation instructions of DBI.

Prices were given to DBI either exclusively or on a project discount. However each manufacturer has to ask for an individual quotation (see Table 5 for contacts). The companies may also have local distribution centres that can be found on the companies' webpages.

Table 5: contact list companies

company	**contact**
IDS GmbH	Mr Conrad +49 (0) 7243 218-0 IDS GmbH Nobelstrasse 18 Postfach 100506 76275 Ettlingen / Germany
DIEHL Gas Metering GmbH	Mr Lacher +49 (0) 981 1806-300 Diehl Gas Metering GmbH Industriestrasse 13 D-91522 Ansbach / Germany
Elster Kromschröder	+49 541 1214-0 Elster GmbH P.O. BOX 2809 49018 Osnabrück / Germany Strotheweg 1 49504 Lotte (Büren) / Germany
EMH	+49 (0) 0981 1806-0 EMH Metering GmbH & Co. KG Neu-Galliner Weg 1 19258 Gallin / Germany
DIEHL Metering Hydrometer GmbH	Mrs. Karmann +49 (0) 0981 1806-0 DIEHL Metering Hydrometer GmbH Industriestrasse 13 91505 Ansbach / Germany
International Control Metering – Technologies GmbH (Elvaco)	Ms. Inoubli, Mr. Fehling +49 (0) 40 608 761 99-0 International Control Metering - Technologies GmbH Willhoop 7 22453 Hamburg / Germany
pikkerton GmbH	Mr Knauf +49 (0) 30 3300724-0 Pikkerton GmbH Kienhorststrasse 70 13403 Berlin / Germany
Nordwestdeutsche Zählerrevision Ing. Aug. Knemeyer GmbH & Co. KG	info@nzr.de +49 (0) 5424 2928-290 NORDWESTDEUTSCHE ZÄHLERREVISION Ing. Aug. Knemeyer GmbH & Co. KG Heideweg 33 49196 Bad Laer or NZR Messtechnik GmbH Hagenower Chaussee 19249 Lübtheen

Table 6: equipment list detailed monitoring

no.	type	company	details	price (1 pc) EUR	price (10 pcs) EUR	type code	comment	M-BUS standard loads[2]
controller								
0	ACOS 700	IDS GmbH	ACOS 700 MBus 230/Callux; wireless M-Bus; GPRS-antenna for SMA-port		≈ 500,00 (25-49 pcs)			10 resources
gas								
1,2	AERIUS	DIEHL Gas Metering	0,04 - 6 m³/h; self-calibrating; M-Bus and wireless	200,00	140,00	AERIUS (has wireless M-Bus and wired M-Bus always included	not suitable for natural gas type L	1 load
1,2	BK-G 2,5T with Absolute Encoder AE	Elster Kromschröder	0,025 - 4 m³/h; temperature compensated (operable range: -10 - +40 °C); M-Bus	320,00		BK-G2,5; default temperature compensation; AE2; ACM M-Bus Wire	for natural gas types H and L	2 loads
electricity								
3	MIZ Premium	EMH	1x 230V; 0,25 – 5 (32) A; M-Bus; one way	198,00	175,00	MIZ-W1TG-LMM-10-E50/K	Only for one direction	1 load
3	DHZ Professional	NZR	1 x 230 V; 5(63) A, M-Bus	Price from wholesaler approx. 105 EUR		08030122		1 load
3,4	DHL	NZR	3 x 230 V / 400 V; 5(65) A; M-Bus, both ways also for 1 x 230 V usable	Price from wholesaler approx. 315 EUR		47030416	Can also be used for one phase measurement	1 load
heat								
5	Sharky 775	DIEHL Metering Hydrometer GmbH	0,6 m³/h; DN: 20 mm; PN: 16 BAR; length 130 mm; certification EN 1434 /without declaration of conformity; 0,1 kWh steps; M-Bus	165,30	3 % project discount (more than 30 pcs)	SHARKY US-WZR-1 0.6 2.1 20 130 130 16	heating circuit fc; qmin = 4 l/h (starting value)	1 load
5,6, 8	Sharky 775	DIEHL Metering Hydrometer GmbH	1,50 m³/h; DN: 20 mm; PN: 16 BAR; length 130 mm; certification EN 1434 /without declaration of conformity; 0,1 kWh steps; M-Bus	165,30	3 % project discount (more than 30 pieces)	SHARKY US-WZR-1 1.5 2.1 20 130 130 16	heating circuits	1 load

[2] ACOS700 offers resources for 10 M-BUS standard loads. When choosing equipment from the list of meters, please sum up all loads and check that the sum is lesser than or equal to 10.

no.	type	company	details	price (1 pc) EUR	price (10 pcs) EUR	type code	comment	M-BUS standard loads[2]
7	Sharky 775	DIEHL Metering Hydrometer GmbH	2,50 m³/h; DN: 20 mm; PN: 16 BAR; length 130 mm; certification EN 1434 /without declaration of conformity; 0,1 kWh steps; M-Bus	165,30	3 % project discount (more than 30 pieces)	SHARKY US-WZR-1 2.5 2.1 20 130 130 16	hot water (no official certification)	1 load
temperature								
9	CMa20	International Control Metering - Technologies GmbH (Elvaco)	outdoor (IP65); M-Bus, with humidity	132,00	125,40	85E-001-MBUS-CMa20		1 load
9, 10	MBS-120	pikkerton GmbH	outdoor; wireless M-Bus	88,75	85,33	75MBS120R0V100		0 loads

For specific Field Trials it is possible to select other M-BUS sensors. The use of the sensors must be approved by DBI.

3.3.2 COMMUNICATION PROCESS

The ACOS700 is a simple data collection device with low power hardware. To collect the meter readings the database server has to establish a connection to the box. The following passage explains the collection process for the ene.field project with an ACOS700 box. Figure 6 shows the connection scheme for the standard set-up. More details to set-up, installation and communication process will be given in the *Installation Manual* DBI has published.

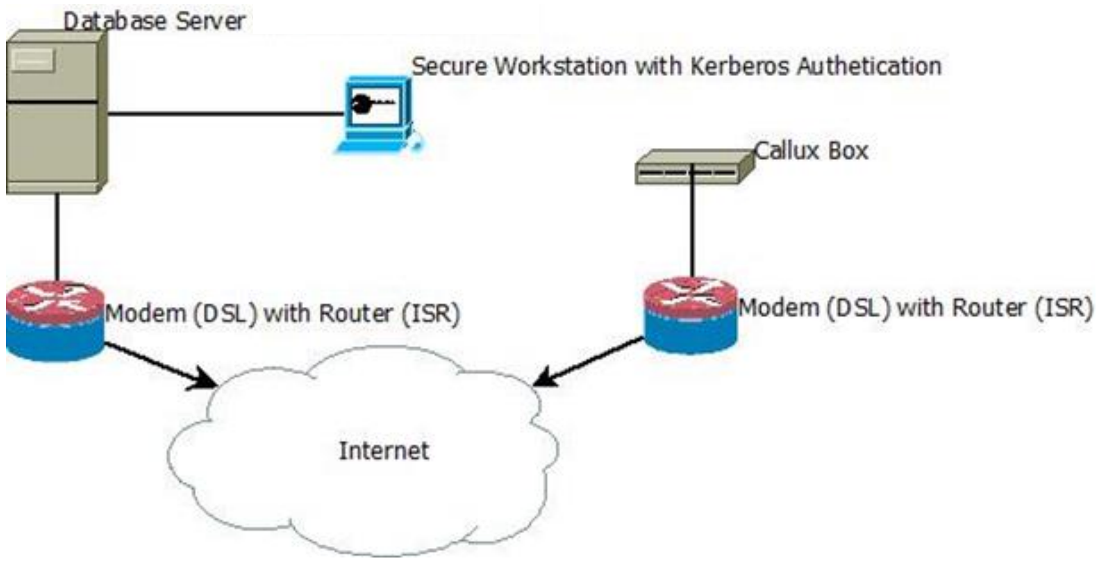

Figure 6: Connection scheme

1. **Preparations for installing ACOS700:**

- ⇨ Get ID, passphrase and server IP-address from DBI and configure box
- ⇨ connect the configured box to the internet
- ⇨ Check connectivity together with DBI

2. **Communication flow:**

- ⇨ The box establishes a secure IPSec VPN tunnel to the Database Server, which also runs a VPN Server to terminate the tunnel
- ⇨ The control centre now continuously checks whether the tunnel is established
- ⇨ At 15 minutes time intervals the control centre pulls the recorded datasets from the boxes and stores it into the database
- ⇨ missing data will be downloaded from ACOS700 internal archive storage preferably once every night
- ⇨ The record will be checked against logical errors before it is stored permanently
- ⇨ After storing the created dataset cannot be manipulated

3. **Monitoring the connections:**

- ⇨ Every connection will be checked permanently by the control centre
- ⇨ Connect, disconnect and any errors will be logged in the event management system
- ⇨ If a box reconnects itself after a long offline period, control centre fetches all records from the boxes archives (if they are valid and present!, records will be reconstructed by the control centre)

4. Security:

- ⇨ All connections are secure IPSec Tunnels
- ⇨ Every access to the control centre at DBI will be logged
- ⇨ The access is role based, no one without permission could see any records or connections
- ⇨ Daily backups of all servers

5. Installation:

- ⇨ After completion of each field installation a communication test between ACOS700 box and control centre at DBI is absolutely essential. DBI will also test, if all sensors data are available and plausible.
- ⇨ DBI needs the date and time of communication test approximately one week before for service personnel to be available.

6. Information flow before each installation

DBI will prepare a standard form to be filled out before each installation is ready for communication check and to be sent to DBI. The *Installation Manual* for detailed monitoring contains this standard forms, the setup parameters for the ACOS700 and a number of technical details that are needed to successfully check all connections and install the detailed monitoring systems. Details that are asked in the standard form are:

- unit-ID (see page 10)
- contact for communication in case of errors
- contact for communication at installation check
- used installation setup scheme
- actual meters and sensors used
- serial numbers of meters (for M-BUS protocol in ACOS700)
- location of meters in the houses and around the fuel cell

7. **Data flow from data base to manufacturer / utility**

Data gathered from the field trials for the purpose of high detailed monitoring is stored in a database on a special DBI server. Manufacturers can have access to data from their own products. Likewise utilities can have access to data from their own units. On demand DBI will send out a set of CSV – files containing all raw data from respective trial units once a month.

3.3.3 Actions at communication errors

In case of no communication to an ACOS700 in the field a hint is made by the control centre at DBI. DBI will communicate with the contact person of the fuel cell manufacturer within one day on weekdays. It is the manufacturer’s responsibility from this point to forward the error message.

In case of sensor errors, the automatic plausibility check of the control centre will report this. DBI will also contact the manufacturer within one day at weekdays.

3.4 STANDARD MONITORING

| Leading institute: GWI

With regards to DoW task 2.1 and 2.4, information on the energy demands and technical performance have to be collected for the remaining, not in detail monitored units. The locations of the meters inside the installation are similar to those in the detailed monitoring approach (see chapter 3.3), but the numbering differs from that approach. Additional meters, which are not part of the detailed monitoring, are indicated with an asterisk.

With regards to the DoW the standard data has to contain:

- Meters at the installation side:
  - HA_Gas_* [m³/month] | *term in DoW: gas meter in the house*
  - BZE_Gas_ [m³/month] | *term in DoW: gas meter around the unit (FC)*
  - BZE_Wabg_ [kWh/month] | *term in DoW: electricity meter around the unit (FC)*
  - BZE_WM_ [kWh/month] | *term in DoW: heat meter around the unit (FC)*
  - HA_Nbzg_ [kWh/month] | *term in DoW: electricity meter in the house*
  - HA_Nein [kWh/month] | *term in DoW: electricity meter in the house*
- Further information:
  - BZE_OnCy_* [1/month] | *term in DoW: on-off cycles*
  - BZE_OH_* [h/month] | *term in DoW: overall operational hours*

With regards to the discussions in development of the standard monitoring approach the measuring options for the manufacturers have been optimised to economical, technical and contractual feasibility. There are certain possibilities for the manufacturers to achieve these data points:

A. use available internal meter *[accuracy: high]*
B. calculate data points (with disclosed calculation method) *[accuracy: mid]*
C. manually read out meter monthly by end-user *[accuracy: low]* [3]
D. connect external meter to fuel cell system controller *[accuracy: high]*
E. installation of communication box (e.g. Callux-Box) *[accuracy: high]*

The different assignments of method to meter have already been fixed with most of the manufacturers. These assignments have been agreed in bilateral calls and are kept confidential.

[3] Manually monthly meter reading is the most inaccurate method, because it depends on the engagement of the end-user. This method shall therefore only be used in cases where the other possibilities are not feasible or are expensive.

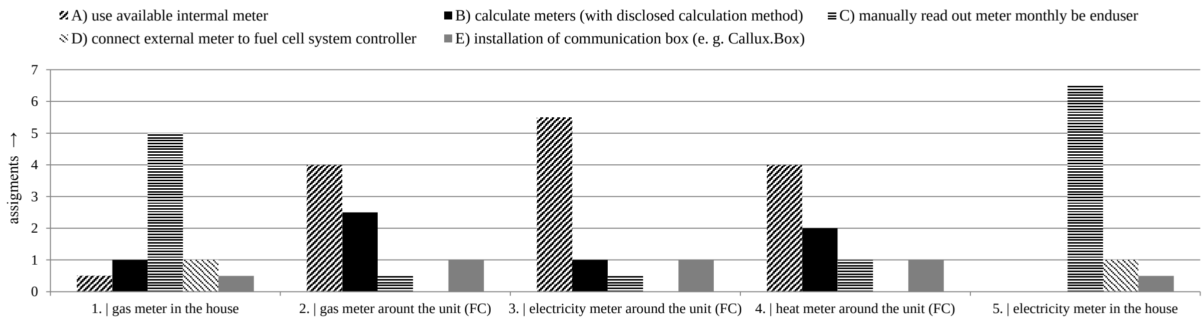

Figure 7: Standard monitoring: overview of assigned methods to required meters [4]

3.4.1 Definitions

- HA_Gas | term in DoW: gas meter in the house

  the gas meter in the house gives information on the gas demand of the house. This value can be calculated as the sum of gas demand of the the fuel cell (BZE_Gas) and of the peak load boiler (ZHG_Gas), if the house does not use gas for any other appliances like e.g. gas stoves.

- HA_Nbzg, HA_Nein | term in DoW: electricity meter in the house

  The output of the electricity meter in the house is seperated into two different meter values. The HA_Nbzg contains the amount of electric energy taken from the net, summed up for the last month. The HA_Nein contains the amount of electric energy injected into the net, summed up for the last month.

- BZE_OnCy | term in DoW: on-off cycles

  the on-off cycles are defined as the accumulated number of starts of the fuel cell CHP per month. For example if there is no heating demand the fuel cell CHP is off. If the fuel cell CHP is turned on to produce heat it would be counted as a first, then second and so on start.

- BZE_OH | term in DoW: overall operational hours

  the overall operational hours are defined as the accumulated working time of the fuel cell CHP on a monthly basis. The working time does not depend on the modulation-level of the unit.

- MMR_y / MMR_m / MMR_d

  with regard to the measuring option C. "manually read out meter monthly by end-user" the delivered information has to be reported with the related meter reading date, because end-user readings correlate with variations in accurateness.

[4] Some manufacturers have not finally assigned the measuring methods. Those manufacturers are still choosing between different methods or are planning to realize a certain method. If a manufacturer has assigned two different methods, both are counted with 0.5 in the diagram. With regard to the further process: All manufacturers are willing and able to deliver the requested information.

3.4.2 DATA COMMUNICATION

The data communication will be realised with a standardised data structure. The file format of the datasets is fixed to the common .csv format. The column separator is fixed to semicolon. The name of the file consists of the timeframe of the generated file and the name of the manufacturer. The format of the name of the file is fixed to: "M_YYYY_MM_MAN.csv". M is a fixed abbreviation and indicated the file "**m**onitoring", YYYY relates to the included year, MM relates to the included month and MAN relates to the name of the manufacturer. For example, if the monitoring begins in March 2013, the first delivery has to include the data since the start-up date to end of the month March. This would relate to the name "M_2013_03_GWI". The next file would be named: "M_2013_04_GWI.csv", the following would be named: "M_2013_05_GWI.csv" and so on. The generated file has to include the standard monitored information for all installed units (except the detailed monitored ones) from the manufacturer.

The file consists of information on the unit-ID, the year and the month, the five different meters with two decimal places, the number of on-off cycles, the overall operational hours of each unit and the information on the year, month and day of the manual meter reading. The format of the overall operational hours is fixed to hours (31.1842 hours is equivalent to 1 day 7 hours 11 minutes and 3 seconds) with four decimal places. The decimal separator is fixed to the decimal point and thousand cutting commas are not allowed to be used.

The standardised data structure is shown in Table 7 with the column names in the first, the unit in the second and the data format in the third row plus some examples in the following rows.

Table 7: standardised data structure and formats for the standard monitoring

unit ID	Year	Month	HA_Gas	BZE_Gas	BZE_Wabg	BZE_WM	HA_Nbzg	HA_Nein	BZE_OnCy	BZE_OH	MMR_y	MMR_m	MMR_d
			[m³/month]	[m³/month]	[kWh/month]	[kWh/month]	[kWh/month]	[kWh/month]	[1/month]	[h/month]			
MAN####	YYYY	MM	#,##	#,##	#,##	#,##	#,##	#,##	#	#,####	YYYY	MM	DD
GWI0001	*2013*	*03*	*291,70*	*97,23*	*388,93*	*486,17*	*12,48*	*51,20*	*4*	*630,1870*	*2013*	*04*	*02*
GWI0002	*2013*	*03*	*351,11*	*117,04*	*468,15*	*585,18*	*24,20*	*75,24*	*0*	*744,0000*	*2013*	*03*	*31*
GWI0003	*2013*	*03*	*284,19*	*94,73*	*378,91*	*473,64*	*107,50*	*2,10*	*2*	*678,1740*	*2013*	*04*	*01*

An example .csv file named "M_2013_03_GWI" is available in the intranet at submenu WP2.

The data communication between the manufactures and the GWI will be realised via a FTP-access to a sector on the manufacturers' data server or in exceptional cases via an HTTPS-access to an online folder to download the files on a monthly basis.

3.4.3 OBLIGATIONS OF PROJECT PARTNERS

The manufacturers are responsible for completeness and the in time delivery of the monitoring-file. Especially with regard to the monthly meter reading by the end-users, the manufacturers commit to do best efforts to gather the information. For calculated data the calculation method has to be disclosed in a traceable way.

The monitoring-file has to be made accessible for the GWI within the first 20 working days after the end of each month with the data for all units of the previous month.

The data files have to be available for at least 90 days.

4 Issues Encountered

| Leading institute: GWI

With regards to DoW task 2.5 issues encountered have to be collected during the installation process and during the operation of the field trials. The required information on issues encountered during the installation process will be gathered through the installer questionnaire *(see chapter 2)*. For the analysis on issues encountered during the operation of the trials, certain kinds of information are needed from the manufacturers.

The format of the issue information has to contain:

- unit-ID
- category of the issue
- duration of system non-availability

The upcoming issues during operation of the trials have to be logged and connected to one of the following categories by the manufacturers:

1. stack
2. reformer
3. *stack / reformer* [5]
4. inverter
5. balance of plant
6. service
7. back-up
8. periphery
9. other

[5] Some manufactures are willing but not able to distinguish issues in the stack and / or reformer into the stack or reformer category. To solve this problem a combined category "stack / reformer" has been added. This circumstance will be considered in the analysis and will be mentioned in the final report. <u>The "stack / reformer" category should only be used in exceptional cases</u>.

4.1 DEFINITIONS

- issue:
  an issue is defined as a status which is reducing the availability of the fuel cell. This contains faults causing a shut down (e.g. critical faults like "too high temperature") as well as the downtime caused due to service. A period during normal operation in which the trial is turned off is not counted as an issue. This could be the case if there is no thermal demand. A service activity during this regular off-time is also counted as an issue.

- back-up:
  this category contains all issues caused by the back-up system.

- stack: **This category is also part of CALLUX*
  this category contains all issues caused by the stack as a central part of the fuel cell system.

- reformer: **This category is also part of CALLUX*
  this category contains all issues caused by the reformer as a central part of the fuel cell system.

- stack / reformer:
  this category contains all the issues of the stack and / or reformer in case that an assignment of the issue in more detail into the category stack or reformer is not possible.

- inverter: **This category is also part of CALLUX*
  this category contains all issues caused by the inverter as a central part of the fuel cell system.

- balance of plant: **This category is also part of CALLUX*
  this category contains all issues caused by the balance of the plant. The balance of the plant includes all non central components of the fuel cell system. One example is an issue evoked due to problems with a gas valve inside the fuel cell system.

- service:
  this category contains the period of time by planned service on the fuel cell system. Delayed related issues e. g. due to wrong installation via the service technican are not part of this category. Those issues have to be assigned to the beloging category.

- periphery: **This category is also part of CALLUX*
  this category contains all issues caused by the system periphery components. One example is an issue evoked due to problems with a water pump in the heating circuit (if the water pump is not part of your system).

- other: **This category is also part of CALLUX*
  this category contains all other issues that are not mentioned above.

4.2 DATA COMMUNICATION

The data communication will be realised with a standardised data structure. The file format of the datasets is fixed to the common .csv format. The column separator is fixed to semicolon. The name of the file consists of the timeframe of the generated file and the name of the manufacturer. The format of the name of the file is fixed to: “I_YYYY_#_MAN.csv”. I is a fixed abbreviation and indicated the file “**i**ssues encountered, YYYY relates to the included year, # relates to the half year part (1: January - June, 2: July - December) and MAN relates to the name of the manufacturer. For example, if the monitoring begins in March 2013, the first delivery has to include the data until June 2013 (end of the first half year). This would relate to the name “I_2013_1_GWI”. The next file would be named: “I_2013_2_GWI.csv”, the following would be named: “I_2014_1_GWI.csv” and so on. The generated file has to include the issues for all installed units from the manufacturer.

The file consists of data-stamps with information on the unit-ID, the issue category and the duration of system non-availability. The format of the duration of system non-availability is fixed to hours (31.1842 hours is equivalent to 1 day 7 hours 11 minutes and 3 seconds) with four decimal places. The decimal separator is fixed to the decimal point and thousand cutting commas are not allowed to be used. Similar issues of a unit in a reporting period have to be listed separately, an aggregation of them is not allowed.

The standardised data structure is shown in Table 8 with the column names in the first, the unit in the second and the data format in the third row plus some examples in the following rows.

Table 8: standardised data structure and formats for issues encountered

unit ID	Year	Part	category	duration
				[h]
MAN####	YYYY	1 or 2	#	#,####
GWI0004	*2013*	*1*	*4*	*0.8124*
GWI0007	*2013*	*1*	*7*	*12.1000*
GWI0004	*2013*	*1*	*1*	*31.1842*

An example .csv file named “I_2013_1_GWI” is available in the intranet at submenu WP2.

The data communication between the manufactures and the GWI will be realised via a FTP-access to a sector on the manufacturers’ data server or in exceptional cases via an HTTPS-access to an online folder to download the files on a half-year basis.

4.3 OBLIGATIONS OF PROJECT PARTNERS

The link between the manufacturers' internal fault codes and the developed project categories as listed on page 25 has to be established by each manufacturer themself. The italic written category "stack / reformer" shall only be used in exceptional cases.

The manufacturers are responsible for completeness and the in time delivery of issues encountered file. To decrease the manufacturers' efforts, the delivery of the generated files contains a collection-period of 6 month as described in chapter 4.2.

The file on issues encountered has to be made accessible for the GWI within the first 20 working days after the end of a half-year with the data for all units of the previous half-year period. If there are still not assigned issues on that date (e. g. a complex issue on the 28th of June) it is allowed to include those issues into the following half-year data file.

The data files have to be available for at least 90 days.

5 LABORATORY TESTS

| Leading institutes: DBI + GWI

Between DBI + GWI and the manufactures a period for testing is agreed. Goal is to back-up field data, measurement of exclusive lab values and scenarios and definition of field measurement errors.

5.1 PROCEDURE

The units will be tested in the following laboratories:

DBI-GTI	GWI
BAXI	BOSCH
DANTHERM	HEXIS
ELCORE	VIESSMANN
RBZ	VAILLANT
SOLIDPOWER (BlueGEN)	SOLIDPOWER (EneGen)

Contents of test procedure:

- ⇨ 25%-step modulation range measuring of:[6]
  - ⇨ energy flow around fc
  - ⇨ emissions (exhaust gas from fc, acoustics)[7]
  - ⇨ calculation of thermal efficiency, electrical efficiency
  - ⇨ typical temperature spreads and forward temperatures will be agreed with each manufacturer before the lab-tests
- ⇨ start/stop performance
  - ⇨ from ‘switched-off state’ to ‘nominal load’
  - ⇨ from ‘nominal load’ to ‘switched-off state’
- ⇨ Reaction on shutdowns
  - ⇨ no gas connection
  - ⇨ no electricity connection
  - ⇨ no process water connection

[6] Five points per unit and return flow temperature if modulation is possible, one point per unit and return flow temperature if modulation is not possible. It might be applicable that not all points can be measured caused due to very specific requirements to the measurement. The cost-benefit ratio has to be in focus.

[7] This will be a positive argument for fc technology being compared to other CHP

Expected outcomes of the test procedure:

1. Comparable and anonymised overview (up to five measuring points per unit and return flow temperature)

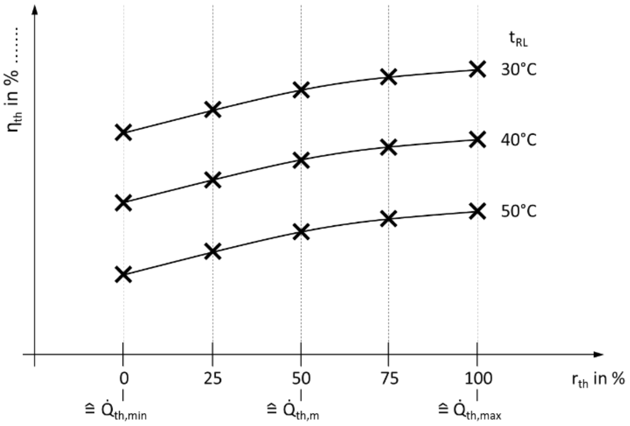

Figure 8: exemplary technical characteristic diagram

- information on the y-axis:
  - thermal efficiency in %
  - electric efficiency in %
  - gas demand in r_{gas} | $r_{gas} = dQ/dt_{gas} / dQ/dt_{th,nominal}$
  - heat flow temperature in °C and/or temperature spread in K
  - water mass flow in kg/h and/or water volume flow in l/h
  - relative electrical output compared to max. output in %

2. Additional at nominal level
   - off gas temperature
   - off gas parts CO, CO2
   - acoustics

3. Start / Stop performance and reaction on shutdowns
   - definition of endpoint ‘t2’: 95% nominal load

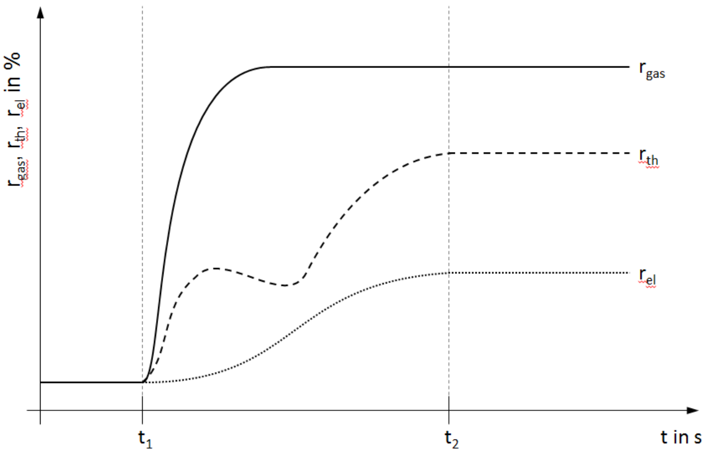

Figure 9: exemplary start/stop performance diagram

5.2 OBLIGATIONS OF PROJECT PARTNERS

The delivery of units has to be planned with the institutes. DBI and GWI put all reasonable effort to complete the tests within four weeks after deliverance of the unit of which two weeks are for testing itself. The following costs will arise for this task:

1. DBI/GWI's budget
   - Test laboratory
   - Test personnel
   - Analysis
   - gas and electricity used during test procedures
   - risk of damaging the unit while touching ground at DBI in Freiberg/Germany or GWI in Essen/Germany
     - loading and uploading actions are risk of the shipper
     - proof of loss is in responsibility of the manufacturer
2. manufacturers' budget
   - Shipment of units to and from institutes
   - Installation personnel (if necessary) inclusive travel costs
   - Unit itself for test time

A special agreement before each test will handle the conditions upon which the tests will be carried out if requested.

6 Clean Room Process

| Leading institutes: GWI + DBI

The basic idea of the clean room process (short: CRP) is to anonymise the collected sensitive data and to define which amount and kind of data may be passed to whom. The data flows are illustrated in the following figure.

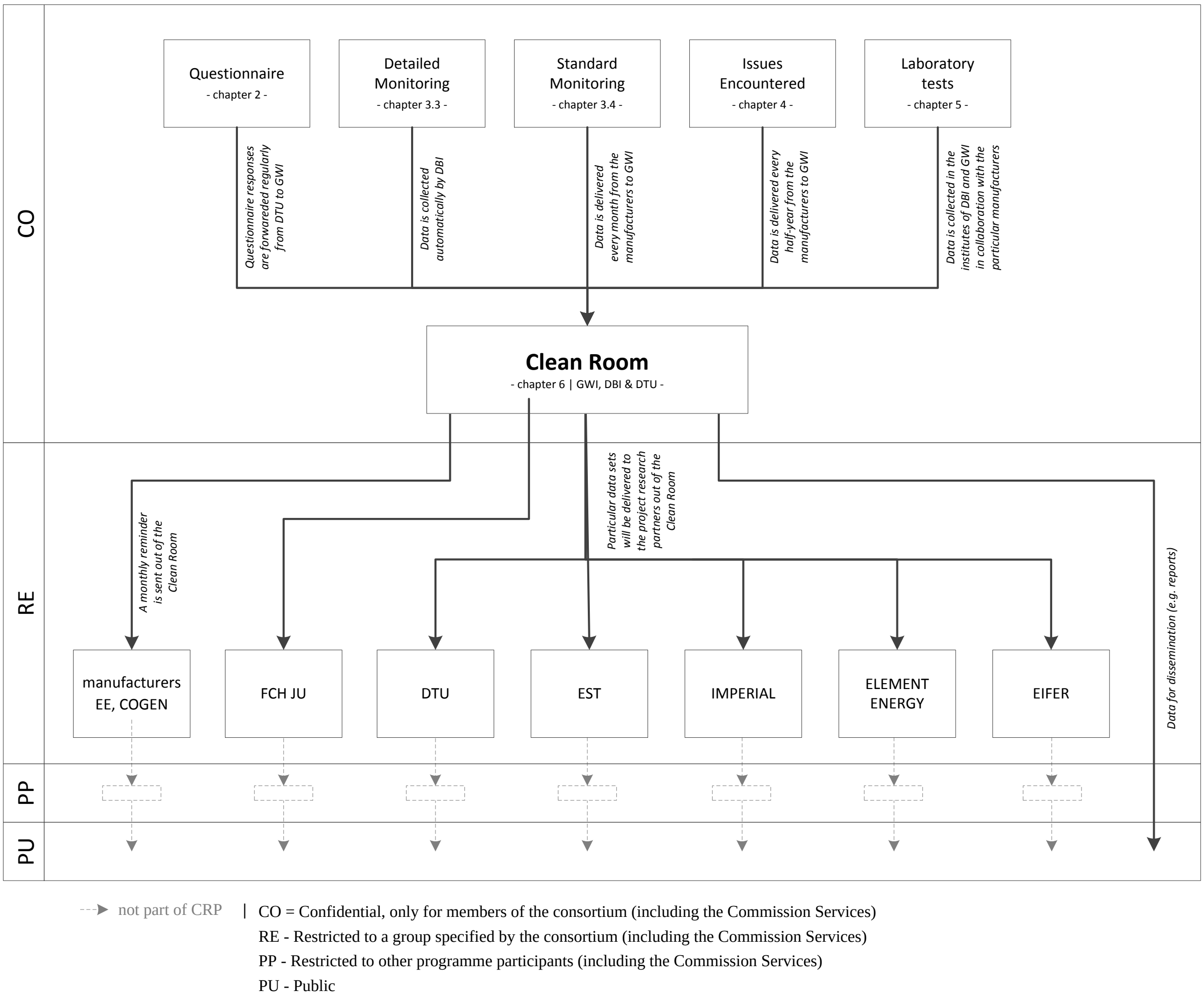

Figure 10: data flows into and out of the Clean Room (WP2: GWI, DBI, DTU)

The Clean Room works as an interconnector between the manufactures and their field test data on the one hand and the demanding research institutes on the other hand. The responsible partners are included with their task and role in the connector descriptions.

A coordination of dissemination activities or further data transfers from requesting research partners or other ene.field project partners is not captured in the Clean Room approach and will not be part of it in the future.

6.1 Definitions

- climate zone(s):
  the current differentiation with regard to the location of the unit differs between three climate zones. These are Northern, Central and South, containing the following countries:

Northern:	*Finland, Sweden*
Central:	*Austria, Germany, Denmark, The Netherlands, Poland, France, UK, Ireland, Switzerland*, Czech Republic*, Luxemburg*, Slovenia*, Belgium*, Andorra**
South:	*Greece, Italy, Portugal, Spain*

- technology:
  Contrary to the technology-classes mentioned in the DoW the monitored and collected data will be summed up to the two classes SOFC and PEMFC containing a system distributed by the manufacturer as follows:

SOFC:	*Bosch, Hexis, Solidpower (EneGen + BlueGEN), Vaillant*
PEM:	*Baxi, Dantherm, elcore, RBZ, Viessmann*

- monthly data:
  A delivery of monthly data out of the clean room contains only data from units, which have already been installed at least one month ago. This guarantees that data of uncompleted captured months from unique units are not falsifying the overall results.

6.2 Responsibility of WP2

WP2 is not defining which information are allowed to pass out of the Clean Room. It is a balance between manufacturers and demanding research institutes. WP2 is trying to moderate and arbitrate as good as possible between the partners. WP2 is integrated as a consulting project partner and is therefore not able to fix any problems by WP2 decisions.

It cannot be guaranteed that for every unit inside the Clean Room will be able to deliver all information that analysis partners asked for. This is true for standard and detailed monitoring, the issues encountered and for the different questionnaires as well. This is caused by different systems, objects and system integrations which are not always comparable to each other. Due to system integrations in non-residential building and multifamily houses certain information asked for might be insufficiently defined. WP2 is therefore not responsible for completeness and correctness of the delivered data, but we try to work everything up to the best data quality as possible.

* potentially additional countries extending the predefined countries in the DoW

6.3 DELIVERY RESTRICTION

The delivery of data for differentiation path (e.g. climate zone: central | technology: SOFC) is only allowed if both of the following criteria are fulfilled for the unique differentiation path:

- At least units from 3 different manufacturers are installed for each technology
- The percentage of installed units of one manufacturer is less than 50 % (if the amount of one manufacturer is more than 50 %, excessive units will be randomly reduced)

The delivery restrictions are applicable for standard and detailed monitoring separately for demanded data points which are based on just one database (standard or detailed).

This approach might lead – in the worst case – to a reporting of monthly data with blank information in some months, because the status of the fulfilment of the delivery restriction can change during the project due to new installations

6.4 DATA DELIVERY IN URGENT CASES

To increase the flexibility of the CRP in urgent and important cases (e. g. FCH JU request), data can be released in a two-step process:

1st step:

> An E-mail notice with the requested data point(s) will be sent out to the manufacturers for approval. The manufacturers are allowed to deny the data delivery if they give reasons for their decision within four weeks; otherwise the request is taken as accepted

2nd step:

> The final acceptance is fixed within the steering committee. The acceptance including the explicit data point(s) and the related requester(s) will be included into the official minutes of the steering committee. The official minutes of the steering committee has to be sent out via the coordinator to the whole consortium.

After the minutes have been circulated, the data delivery is officially and formally approved. The data point(s) will be included into the following data handling agreement update.

6.5 TABLE OF ACCEPTED DATA DELIVERY FOR RE (TABLE 9)

FCH JU	DTU	EST	IMP	ELE	EIF	sample rate	differentiation	anonymisation	description	unit	data source
	x	x	x			15 min	technology	average	el. power consumption house from grid	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	el. power consumption house from grid	kWh	standard + detailed
	x	x	x			15 min	technology	average	el. power export fuelcell	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	el. power export fuelcell	kWh	standard + detailed
	x	x	x			15 min	technology	average	el. power export house into grid	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	el. power export house into grid	kWh	standard + detailed
				x	x	monthly	technology	accumulated	gas consumption fuel cell	kWh	standard + detailed
					x	monthly	technology	accumulated	gas consumption house	kWh	standard + detailed
	x	x	x			15 min	technology	average	heat output from fuel cell	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	heat output from fuel cell	kWh	standard + detailed
				x	x	monthly	technology	accumulated	on-off cycles fuel cell **[s. Annex]**	1	standard + detailed
x	x	x		x	x	static	technology	accumulated	overall operational hours from project start until the end of the reporting period	h	standard + detailed
x	x	x		x	x	static	technology	accumulated	overall operational hours from beginning to the end of the reporting period	h	standard + detailed
x	x	x		x	x	monthly	technology	accumulated	overall operational hours as an average daily operation	h	standard + detailed
	x	x	x			15 min	technology	average	el. power consumption fuelcell	kWh	detailed
			x	x	x	monthly	technology	accumulated	el. power consumption fuelcell	kWh	detailed
				x	x	monthly	technology	accumulated	gas consumption back-up	kWh	detailed
	x	x	x			15 min	technology	average	heat demand for domestic water	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	heat demand for domestic water	kWh	detailed
	x	x	x			15 min	technology	average	heat demand for heating circuit	kWh	detailed
	x	x	x	x	x	monthly	technology	accumulated	heat demand for heating circuit	kWh	detailed
	x	x	x			15 min	technology	average	heat output from peak load boiler	kWh	detailed
			x			monthly	technology	accumulated	heat output from peak load boiler	kWh	detailed
			x			15 min	technology	average, min, max	outside humidity	%	detailed
			x			monthly	technology	average, min, max	outside humidity	%	detailed
				x	x	monthly	technology	average, min, max	inlet temperature of heating circuit - back-up	°C	detailed
				x	x	monthly	technology	average, min, max	inlet temperature of heating circuit - fuelcell	°C	detailed
	x	x	x			15 min	technology	average, min, max	inside temperature	°C	detailed
	x	x	x	x		monthly	technology	average, min, max	inside temperature	°C	detailed
				x	x	monthly	technology	average, min, max	return temperature of heating circuit - back-up	°C	detailed
				x	x	monthly	technology	average, min, max	return temperature of heating circuit - fuelcell	°C	detailed
	x	x	x			15 min	technology	average, min, max	outside temperature	°C	detailed
			x		x	monthly	technology	average, min, max	outside temperature	°C	detailed
x	x	x				1/2 year	technology	accumulated	relative duration of system non-availability (available h / total h per half year)	%	issues encountered
	x	x				1/2 year	technology	accumulated	count of malfunctions	1	issues encountered

TABLE OF ACCEPTED DATA DELIVERY FOR RE (TABLE 9)

FCH JU	DTU	EST	IMP	ELE	EIF	sample rate	differentiation	anonymisation	description	unit	data source
	x	x				static	climatic region	accumulated	ratio of malfunctions as a function of type of event (after completion of field test)	%	issues encountered
	x	x				static	climatic region	reduced	installer questionnaires (without ID , postal code and country)	table	installer quest.
			x	x		monthly	technology	average, min, max	capacity of the thermal storage [1)]	litres	installer quest. + detailed
			x	x		static	technology	average, min, max	capacity of the thermal storage	litres	installer quest.
	x	x		x		static	climatic region	reduced	pre-installation end-user questionnaires (without ID, postal-code and country)	table	pre-install. quest.
	x	x		x		static	climatic region	reduced	post-installation end-user questionnaires (without ID, postal-code and country)	table	post-install. quest.
x						yearly	trial	reduced	country and ZIP code	table	database
	x	x				static	technology	accumulated	total installed electrical capacity after completion of all installations	kW	database
	x	x				static	technology	accumulated	total number of units after completion of all installations	1	database
					x	static	manufacturer	-	integrated back-up heating system	yes / no	manufacturer
					x	static	manufacturer	-	internal pump for heating circuit	yes / no	manufacturer
				x	x	static	manufacturer	-	nominal electric efficency fuelcell (LHV)	%	manufacturer
				x		monthly	technology	accumulated	Number of units (where we have received any information that the unit exists) **[s. Annex]**	1	standard + detailed
	x	x	x			monthly	technology	average	nominal electric output fuelcell [1)]	kW	manufacturer + detailed
			x			static	manufacturer	-	nominal electric output fuelcell	kW	manufacturer
				x	x	static	manufacturer	-	nominal thermal efficency fuelcell (LHV)	%	manufacturer
	x	x	x			monthly	technology	average	nominal thermal output fuelcell [1)]	kW	manufacturer + detailed
			x			static	manufacturer	-	nominal thermal output fuelcell	kW	manufacturer
					x	static	manufacturer	-	approximate mass of fuelcell (for each manufacturer)	kg	manufacturer
			x	x	x	monthly	technology	average	off gas parts CO fuel cell [1)]	%	manufacturer + detailed
			x	x	x	static	technology	-	off gas parts CO fuel cell	%	manufacturer
			x	x	x	monthly	technology	average	off gas parts CO2 fuel cell [1)]	%	manufacturer + detailed
			x	x	x	static	technology	-	off gas parts CO2 fuel cell	%	manufacturer
x					x	static	technology	accumulated	number of units with can be operated with natural gas	1	manufacturer
x					x	static	technology	accumulated	number of units with can be operated with liquified gas	1	manufacturer
x					x	static	technology	accumulated	number of units with can be operated with biogas	1	manufacturer
x						static	technology	-	noise during lab test (not an offical certification test)	db @1m	laboratory tests
			x			static	technology	-	characteristic diagram (y-axis: electric efficiency)	table	laboratory tests
			x			static	technology	-	characteristic diagram (y-axis: relative electrical output)	table	laboratory tests
			x			static	technology	-	characteristic diagram (y-axis: thermal efficiency)	table	laboratory tests
x						static	technology	-	off gas parts CO2 fuel cell	mg/kWh	laboratory tests
			x	x		monthly	technology	average	start-performance indicator „t2“ [1)] **[s. Annex]**	s	laboratory tests + detailed
			x			static	technology	-	start-performance indicator „t2“ **[s. Annex]**	s	laboratory tests
x						static	manufacturer	-	nominal electric efficency fuelcell (LHV)	%	laboratory tests
x						static	manufacturer	-	nominal thermal efficency fuelcell (LHV)	%	laboratory tests
x						static	manufacturer	-	average total system efficiency	%	laboratory tests

[1)] Values will be calculated only for detailed monitored FC CHPs (the same ones for which 15 min data are supplied).

TABLE OF ACCEPTED DATA DELIVERY FOR PU (TABLE 10)

PU	sample rate	differentiation	anonymisation	description	unit	data source
x	15 min	building typ	average	Electrical energy demand object	kWh	detailed
x	15 min	building typ	average	Heat demand for heating circuit	kWh	detailed
x	15 min	building typ	average	Heat demand for domestic water	kWh	detailed
x	15 min	building typ	average	Outside temperature	°C	detailed
x	15 min	building typ	average	Inside temperature	°C	detailed
x	monthly	technology	average	Electric **utilisation** FC **[s. Annex]**	%	standard + detailed
x	monthly	technology	average	Thermal **utilisation** FC **[s. Annex]**	%	standard + detailed
x	monthly	Technology	average	Availability **[s. Annex]**	%	standard + detailed
x	monthly	Technology	average	Relative On-off cycles fuel cell **[s. Annex]**	1/m	standard + detailed
x	monthly	technology	average	Relative overall operational hours	%	standard + detailed
x	monthly	technology	accumulated	Number of units (where we have received any information that the unit exists)	units	standard + detailed
x	monthly	technology	average	Relative Hours of full utilisation **[s. Annex]**	%	standard + detailed
x	monthly	technology	average	Electrical self-use ratio FC **[s. Annex]**	%	standard + detailed
x	monthly	technology	average	Electrical demand coverage degree **[s. Annex]**	%	standard + detailed
x	monthly	technology	average	Thermal demand coverage degree **[s. Annex]**	%	detailed
x	monthly	technology	accumulated	Installed electrical power FC	kW	standard + detailed
x	monthly	technology	accumulated	Installed thermal power FC	kW	standard + detailed
x	overall	-	average, min, max	Lower heating value gas **[s. Annex]**	kWh/m^3	standard + detailed
x	½ year	technology	average, min, max	Count of malfunctions per category (1-9)	1	issues encountered
x	½ year	technology	average, min, max	relative duration of system non-availability (available h/total h per half year)	%	issues encountered
x	Static	unit	-	Country + ZIP code		standard + detailed + issues
x	Static	technology	average, min, max	Overall duration of installation	d	install. quest.
x	Static	technology	average, min, max	Man hours needed for installation of entire system	h	install. quest.
x	Static	technology	average, min, max	Man hours needed for installation of fuel cell	h	install. quest.
x	Static	technology	average, min, max	Results of the subjective installer survey	-	install. quest.

7 ANNEX

7.1 DESCRIPTION OF INEXPLICIT DATA POINTS

GENERAL DIFFERENTIATION BETWEEN STATIC AND MONTHLY DATA

- STATIC data: These data points are specific for every type of unit and will not change over the duration of the project. Data sources are values delivered by the manufacturers, measured data from laboratory tests and statistical data from questioners and databases.
- MONTHLY data: These data points are calculated according the Clean Room Process (differentiation, anonymisation) from measured data of every unit.
  Monthly data are dynamic data which can also be calculated from originally static data by calculation according the differentiation and anonymisation with the current numbers of installed units.

DEFINITIONS, CALCULATIONS AND FORMULAS

Equation abbreviations relate to chapter 3.4 (Standard), chapter 3.2 and 3.3 (Detailed) and chapter 4 (issues encountered)

- <u>on-off cycles fuel cell</u>
  The on-off cycles BZE_OnCy_are deliverd within the standard monitroing by the manufacturers.
  Within the detailed monitoring the on-off cycles BZE_OnCy will be calculated from the measuring data on base of the power output of fuel cell. Changes of power output fuel cell from x to 0 and afterwards from 0 to x will be counted by an internal used counter with a hystereses of 1 ¼ hour.

- <u>Number of units (where we have received any information that the unit exists:</u>
  The number of units indicate the amount of units, where we have ever received any information from. In case, that we have not received monitoring data for a trial in a month, which has deliverd any data (e.g. via standard montoring or by questionnaire) previously to this mouth, the unit is countered within this accumulated list of installed units. This information can not be used to compare it to accumulated measured data, because the amount of units based on the monthly accumulation might differ from this number.

- <u>start-performance indicator “t2”</u>
  This indicator quantifies the start-up time to reach 95% of the nominal load for each fuel cell during the lab-test (compare to chapter 5.1 Figure 9)

- <u>Electric utilisation FC</u>
  DBI derives the data which is used within the standard monitroing from the measured field data and passes these on to GWI for the overall comparison.
  - ⇨ Unit specific: *eta_el = BZE_Wabg_ / BZE_Gas [kWh]*

The average is related to the amount of useable data points n_data and merges the results of the standard and the detailed monitoring

⇨ Overall average: *eta_el_avg = Σ eta_el / n_data*

- <u>Thermal utilisation FC</u>

  DBI derives the data which is used within the standard monitroing from the measured field data and passes these on to GWI for the overall comparison.

  ⇨ Unit specific: *eta_th = BZE_WM_ / BZE_Gas [kWh]*

  The average is related to the amount of useable data points n_data and merges the results of the standard and the detailed monitoring

  ⇨ Overall average: *eta_el_avg = Σ eta_th / n_data*

- <u>Availability</u>

  The system availability is based on the informtion regarding off time t_{off} of the issues encountered. At first the refernce time is calculated, taking into account, that not all units were installed during the ½ year reporting period (from m_0 to m_0+6) of the issues encountered report.

  ⇨ Manufacturer (man) specific reference time:

$$t_{ref}(man) = \sum_{m=m_0}^{m=m_0+6} t(m)\left[\frac{\text{h}}{\text{month}}\right] \cdot n_{units}(m, man)$$

  ⇨ Overall averagae:

$$availabilty = \sum_{man=1}^{10} \frac{t_{off}(man)}{t_{ref}(man)}$$

- <u>Relative On-off cycles fuel cell</u>

  The on-off cycles fuel cell were defined within in the first bullet point. The relative on-off cycles indicate the monthly average on-off cycles. It takes into account, that a duration of the month differs comapred to each other (e.g. January vs. February). The on-off cycles are therewith related to an average month with , discribed by:

  t_month = 8.760 [h/a] / 12 [month/a] = 730 [h/month]

  The calculations of the relative on-off cycles of the fuel cells are shown in the following equations:

  ⇨ *Unit specific: BZE_OnCy_corr = BZE_OnCy_ / t(m) * t_month*

  This correction progress is afterwards called “made relative”.

  The average is related to the amount of useable data points n_data and merges the results of the standard and the detailed monitoring

  ⇨ Overall average: *BZE_OnCy_corr_avg = Σ BZE_OnCy_corr / n_data*

- <u>Relative Hours of full utilisation</u>

  The caluclation is similar to the relative On-off cycles. In this case the BZE_OH are made relative to ensure the comparability.

- <u>Electrical self-use ration FC</u>
  DBI derives the data which is used within the standard monitroing from the measured field data and passes these on to GWI for the overall comparison.
  - ⇨ Unit specific: *r_el_self = (BZE_Wabg_ − HA_Nein_) / BZE_Wabg_*

  The average is related to the amount of useable data points n_data and merges the results of the standard and the detailed monitoring
  - ⇨ Overall average: *r_el_self_avg = Σ r_el_self / n_data*

- <u>Electrical demand coverage degree</u>
  DBI derives the data which is used within the standard monitroing from the measured field data and passes these on to GWI for the overall comparison.
  - ⇨ Unit specific: *r_el_cov = (BZE_Wabg_ − HA_Nein_) / (BZE_Wabg_ − HA_Nein_ + HA_Nbzg_)*

  The average is related to the amount of useable data points n_data and merges the results of the standard and the detailed monitoring
  - ⇨ Overall average: *r_el_cov_avg = Σ r_el_cov / n_data*

- <u>Thermal demand coverage degree</u>
  DBI derives the data which is used within the standard monitroing from the measured field data and passes these on to GWI for the overall comparison.
  - ⇨ Unit specific: *r_th_cov = BZE_WM / (HK1_WM + WW_WM)*

  Hint: heat losses of buffer storage and heat destribution are not considered
  The average is related to the amount of useable data points n_data and considers the results of the detailed monitoring.
  - ⇨ Overall average: *r_th_cov_avg = Σ r_th_cov / n_data*

- <u>Lower heating value gas (LHV)</u>
  The lower heating value (kWh/m³) will be used to convert the measured amonuts of gas (m³) into kWh. The values are slightly different across Europe.
  That's why the values are requested by the questionares or at start-up of every detailed monitoring unit by DBI at manufacturers or utilites.
  The following calculations will be done directly by the database system:
  - ⇨ BZE_Gas_kWh = BZE_Gas * LHV_Gas
  - ⇨ ZHG_Gas_kWh = ZHG_Gas * LHV_Gas

7.2 RELEASE CHANGES TO POST VERSIONS:

Table 11: release changes to V07: (23.09.2015 / 23.10.2015 / 20.11.2015)

Document section	Updated part
Preamble	Partner list updated (+ VIESSMANN, + SOLIDPOWER) Contact list updated
Detailed Monitoring	Allmess GmbH and Allmess meters deleted in table 5 and 6
Laboratory Tests	Update of unit allocation - SOLIDPOWER (BlueGEN) and VIESSMANN added
Clean Room Process	- Changes in 6.3 (DELIVERY RESTRICTION) - Changes in table 6.5 - Changes in table 9 - Table 10 added
Annex	Description of inexplicit data points added

Table 12: release changes to V06: (22.05.2015)

Document section	Updated part
Preamble	Contact list updated, period of objection inserted
Detailed Monitoring	Advice 3.3.1 to the Equipment list (under table 6)
Standard Monitoring	Changes regarding data delivery by manufacturers
Clean Room Process	- Changes in 6.3 (DELIVERY RESTRICTION) - Changes in table 6.5

Table 13: release changes to V05: (26.09.2014)

Document section	Updated part
Preamble	Contact list updated
Detailed Monitoring	Connection diagrams (meter 4 position corrected) Contact list companies updated (Hydrometer - company name changed) Equipment list (ED300 removed, Hydrometer - company name changed)
Laboratory Tests	Update of unit allocation - Hexis switched with elcore Insert of measurement limitation possibility
Clean Room Process	all

Table 14: release changes to V04: (05.07.2013)

Document section	Updated part
Preamble	Contact list updated
Questionnaire	all
Standard Monitoring	Update on 'house electricity meter' - net consumption - net injection
Detailed Monitoring	Data access for manufacturers/utilities
Laboratory Tests	Update on 'test procedure' - the procedure itself - expected outcomes Update of 'obligation of project partners'

Table 15: release changes to V03: (17.05.2013)

Document section	Updated part
Preamble	circulation list, GWI name DBI/GWI added to analysis partners DTU added to monitoring partners
Questionnaire	
Standard Monitoring	add chapter (has been circulated on 28th of June 2013) with the following adoptions: • “standard” instead of “overall” with regard to the term in the DoW • [kWh/month] instead of [kWh/m] • [kWh/month] for gas meters has been changed to [m³/month] • add: “to expensive” in footnote on manually meter readings
Detailed Monitoring	One additional electricity meter
Issues encountered	some small formal adoptions some added clarifications
Clean room process	
Lab testing	Risk of damage

Table 16: release changes to V02: (25.03.2013)

Document section	Updated part
Preamble	Contact list, document approval, time to comment after circulation of new version
Questionnaire	Complete section
Overall Monitoring	Left out of document
Detailed Monitoring	Updated flow schemes, additional flow scheme, additional heat meter,
Issues encountered	Updated section
Clean room process	Interim solution introduced
Lab testing	Distribution of manufacturers across labs, testing procedure