Deliverable D4.1

Report on preparation of test-bed related activities

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1 Document Information

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3 Introduction

3.1 Scope and objectives of the deliverable

The deliverable focuses on the RE – COGNITION Test bed, a useful tool for researchers to validate and verify their work prior the system integration on pilot sites. Test bed will be installed in IDE premises, in fully equipped laboratory, providing the conditions of proper and safe operation. Within the following pages all the preliminary actions for the test-bed preparations related activities will be presented, including:

- the test-bed architecture design, the main components and their functionality
- the selection of RE – COGNITION Devices to be emulated and their operational/functional characteristics
- the determination of the required specification and the selection of the required Off-the-shelf components (inverters, batteries etc.) and auxiliary equipment
- listing of equipment availability

3.2 Structure of the deliverable

The current deliverable is structured as follows:

Chapter 4 provides a general description of the test-bed architecture. A list of the main components is made, highlighting their operational characteristics and the functionality they are going to have during test procedure.

Chapter 5 provides a deeper look in the analysis on which systems will be emulated on test-bed, their operational characteristics and supported protocols. Analysis outcome determined the specifications selected components must cover such as power size, input/output specifications, supported protocols and special functionality features.

Chapter 6 presents a brief description of Off-the-shelf components and peripheral equipment that have to be purchased or are available in lab premises.

Finally a preliminary list of the required components to build test-bed is presented in Annex.

3.3 Relation to other tasks and Deliverables

This deliverable is promptly related to T1.4 “Evolution of Technical Specifications and System Architecture”, concerning the technical specifications set up. Deliverable D4.1 is expected to act as an introduction for deliverables D4.2 and D4.3.

3.4 Abbreviations

Table 3-1: Abbreviations

AC	Alternative Current
ACEME	Automated Cognitive Energy Management Engine
Ah	Ampere - hours

BEMS	Building Energy Management System
BESS	Battery Energy Storage System
BIPV	Building Integrated Photovoltaics
BMS	Battery Management System
DC	Direct Current
ESS	Energy Storage System
EV	Electric Vehicle
kWh	kilo Watt hours
kWth	kilo Watt thermal
LHTS	Latent Heat Thermal Energy Storage
MCB	Miniature Circuit Breaker
micro-CHP	Micro-Combined Heat and Power
MPPT	Maximum Power Point Tracking
PC	Personal Computer
PV	Photovoltaic
PVG	Passive Variable Geometry
RE	Renewable Energy
RET	Renewable Energy Technologies
SCH	Hybrid Solar Cooling system
UI	User Interface
V	Volt
VAWT	Vertical Axis Wind Turbine
W	Watt
WCS	Worst Case Scenario

4 Test-bed concept

4.1 Aim of test-bed and required features

Test-bed shall be a laboratory prototype that will allow researchers, involved with RE – COGNITION framework development, to iteratively validate and experimentally verify implemented methods, algorithms, control and communication operation before the integration to pilot sites.

Test-bed shall act as a small-scale RE – COGNITION framework, embodying or emulating all the innovative developed RE Assets that shall be used in RE – COGNITION platforms in several building types (multi-family residential, medium-size tertiary and industrial buildings).

The test-bed design shall be characterized by:

- simplicity to use
- facilitation of debugging and repairing
- adaptation and flexibility on the emulated system configuration, supported protocols and under test control methods
- accurate measurements and logs, in a form to help proper operation validation and debugging
- no compromises to user and system safety

4.2 Test-bed architecture and general function description

Test-bed will be a network of six (6) main components (Figure 4-1), interconnected with an AC power path and/or several communication lines:

- Local server
- iGateway
- Battery Energy Storage System (BESS)
- Controlled AC source
- Controlled load
- Test-Bed controller

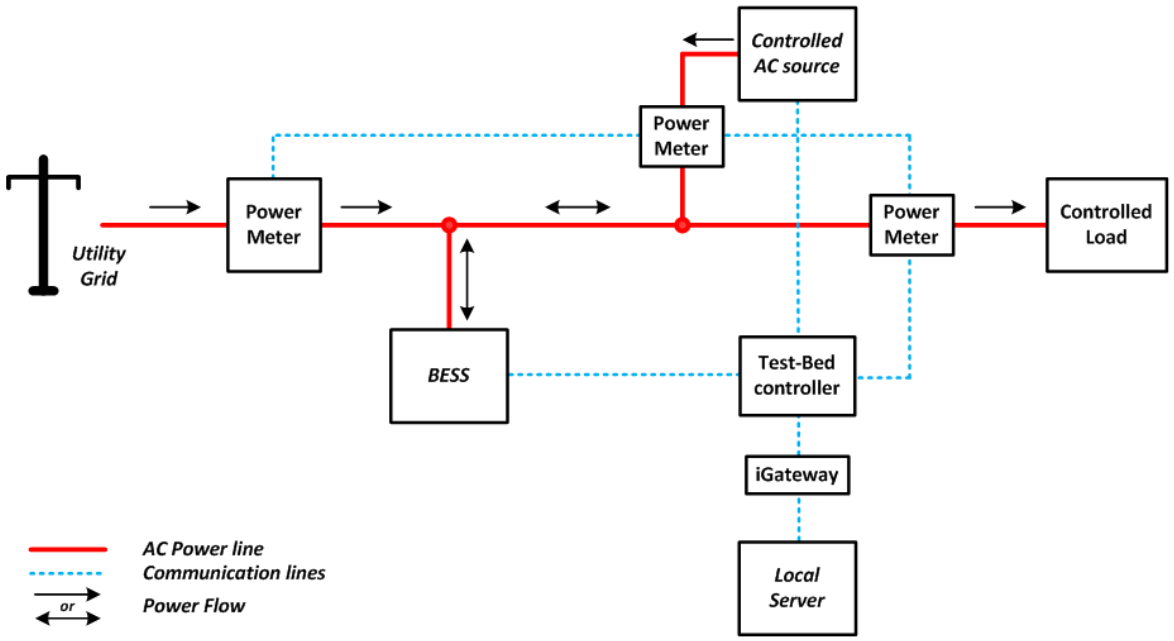

Figure 4-1: Test-bed architecture general diagram

With the current configuration researchers will be able to check:

- the power flow between the emulated RE Assets
- the communication performance and compatibility
- several control algorithms regarding field devices operation, system performance and safety

Tests on test-bed prototype will be able to emulate a RE – COGNITION framework 24h operation within 4h, which corresponds to a ratio of 10' test-bed operation for 1h of RE – COGNITION framework operation. The 4h tests will provide sufficient time in a working day for system preparation, one at least test round and documentation.

4.2.1 Local Server

Local Server will be a dedicated Personal Computer (PC), close to the test-bed platform. Server's main role will be to host ACEME and RE – COGNITION Repository software versions that need to be tested and validated.

This ACEME software version shall have an additional feature, compared to the released version, which is critical for test-bed operation. ACEME will generate synchronization signals to inform major test-bed components that have to change their state or proceed to an action according to the predefined test plans. In other words ACEME will act additionally as a test-bed "ticking clock", ticking every 10' if test pause or error don't occur. As a result the test plan time resolution will be limited to 1h per step.

In addition Local Server will be able to host any software that will emulate operation of specific Field devices with embedded control algorithms requiring interaction with iGateway and the rest of RE –

COGNITION framework devices. Through the test process software developers will be able to check and debug the control algorithms and interaction process before the RE – COGNITION framework installation in pilot sites.

Last but not least Server may also host Test User Interface (UI) software, developed by IDE. It will be a user-friendly software that will:

- help test-bed users to run test plan phases safely
- run critical routines for test-bed such as battery banks charging, start up, pause and shutdown processes
- upload initial lookup tables to Test-bed controller
- Keep and update logs and initial test reports

4.2.2 iGateway

iGateway will be an innovative component developed by Energy@Work Società Cooperativa a R.L. [1]. It will be specialized to aggregate and standardize protocols (wired and wireless) used by the different RETs and sensors, which usually represent a very fragmented operating environment. More specifically in test-bed platform, iGateway will act as a communication interface between test-bed field devices and Local server.

4.2.3 Battery Energy Storage System (BESS)

BESS will emulate the operation of third-party energy storage systems that may be installed on pilot sites. BESS will consist of one or more inverter-chargers, a battery bank and a dedicated controller, having a key role in the test-bed operation. In cases of electric energy excess, inverter-chargers shall charge the BESS bank. On the other hand, in case of lack of power inverter-chargers shall take advantage of the battery bank stored energy to contribute to loads so as to minimize the dependency of the Utility grid. BESS operation will be either automatic or manual, under the control and / or surveillance of Test-bed controller.

4.2.4 Controlled AC source

Controlled AC source shall be a subsystem of one or more grid-tied inverters and a dedicated battery bank, controlled by the Test-bed controller. AC source will be able to provide electric power on demand, equal to the sum of the generated power of all emulated power generating units, according to the active test plan.

4.2.5 Controlled load

Controlled load will be used to emulate the total electric consumption of all emulated power consuming units. The load value will be determined by the synchronization signal and the active test plan.

4.2.6 Test-bed controller

Test-bed controller will be a special control/communication unit, responsible for the proper operation of test-bed platform. Test-bed controller will have direct communication access to AC source, BESS, iGateway and measuring devices. The applied communication protocols will be dictated by the selected units.

Taking advantage of these communication channels Test-bed Controller will be able to:

- control AC Source and BEMS and collect information about their performance. Depending on the selected type (Electronic or Manual) Controllable Load may be controlled and monitored or just monitored by test-bed controller
- harness the current measurements from measuring devices
- receive ACEME synchronization signal and control commands
- receive updated test plans or action commands (control or messaging) from the special software for Field devices embedded control algorithms
- broadcast measurements and send/receive messages on behalf of the emulated devices, using the corresponding protocols and device ID's

In other words Test-bed controller will generate all control and communication actions ACEME software would need in order to emulate a RE – COGNITION framework operation in pilot sites.

Control and communication actions, determined in test plans, will be in a form of lookup tables. The tables will correspond specific control and communication actions with synchronization signals. The lookup tables will be stored in Test-bed controller at the start of each test round and every time plans need to be updated due to Local Server special software results.

5 Analysis of emulated subsystems and test-bed components specifications

The aforementioned test-bed major components will form a single-phase (1ph) 230 V / 50 Hz network that will be connected to the utility grid. Each component, within test-bed, will emulate the performance of a larger group of devices that shall cover some of RE – COGNITION framework options regarding device types, applied communication protocols and power specifications.

In the following subchapters an analysis is held about the field devices that will be considered to the test-bed platform, the emulated power levels and the supported protocols. This analysis will point out the rated power test-bed components shall have and the protocols that may use. This information will determine the test-bed component selection criteria regarding performance and functionality. It is important to mention that applied test plans will be able to include different energy profiles than the ones of the analysis, with the condition though that no violation of components rated power will occur.

Figure 5-1 depicts a diagram of test-bed network, emulated device, power flow and applied communication protocols.

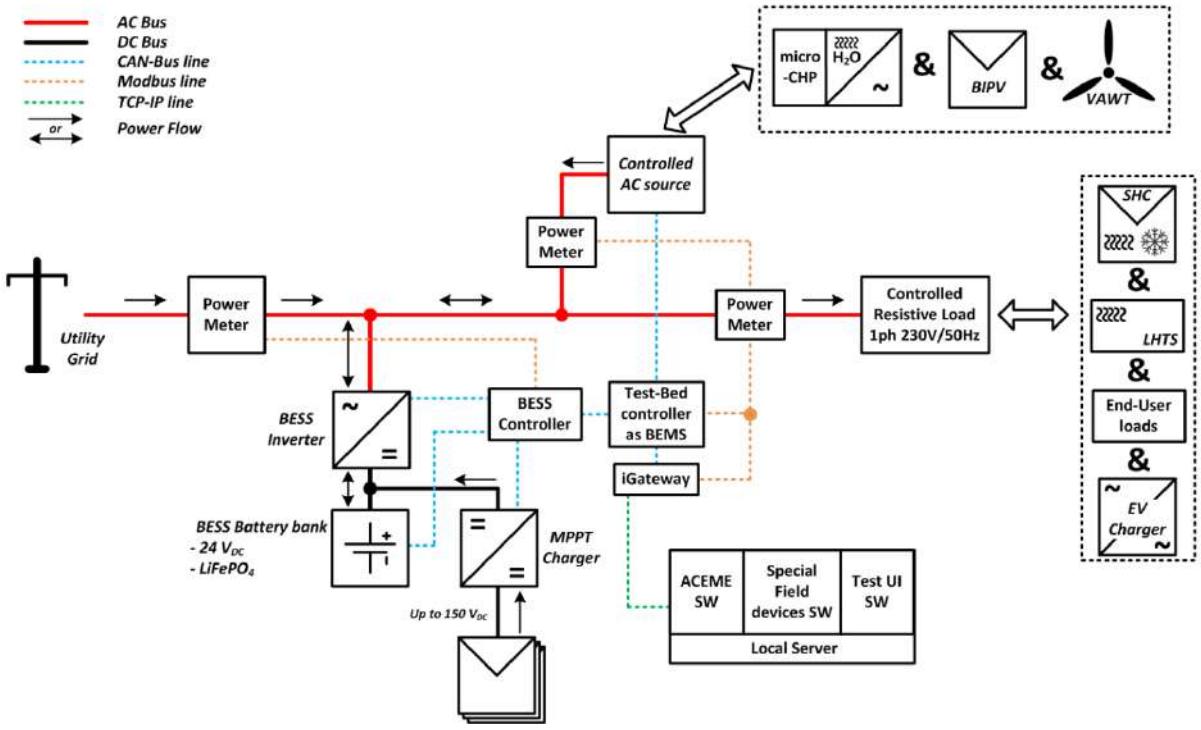

Figure 5-1: Test-bed diagram with the emulated devices

5.1 Emulated subsystems

5.1.1 Electric power consuming units

Test-bed shall be able to emulate all possible electric power consuming Field devices may applied to RE – COGNITION framework, namely:

- End-user loads
- Latent Heat Thermal Energy Storage system (LHTS)
- Hybrid Solar Cooling system (SCH)
- EV-Charger

5.1.1.1 End-user loads

End-user loads correspond to the power consumption due to users' presence in pilot sites. The power levels will change in every synchronization signal, according to the corresponding values of specific test-bed lookup table. Test-bed current design considers that lookup table values will correspond to single phase resistive loads with a rated power up to 10 kW, typical value for domestic loads. Figure 5-2 depicts an example of End-User power consumption profile that is used at test-bed power analysis

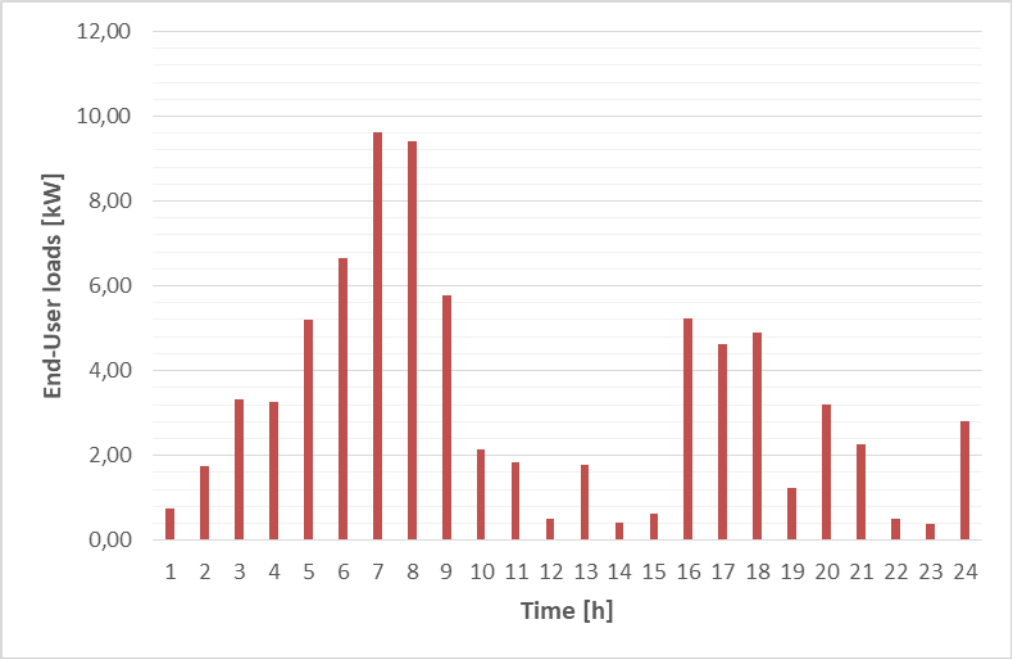

Figure 5-2: Typical End-user load profile

5.1.1.2 Latent Heat Thermal Energy Storage system (LHTS)

Latent Heat Thermal Energy Storage system will be an important unit for RE – COGNITION framework regarding thermal operation, with a limited electric power consumption. When the unit will be active, the only power consuming parts will be the embedded pumps. In this case the total power consumption may not overcome 1 kW.

For test-bed analysis is considered that LHTS will have a single charge/discharge cycle per day with both phases duration to be equal to the minimum test step of 1h. Figure 5-3 depicts a LHTS load profile that is applied to the analysis. Discharging phase is considered to start around 06:00 when users wake up and need heat. On the other hand charging phase shall start probably around 18:00, the time users return home, after work, and activate heating.

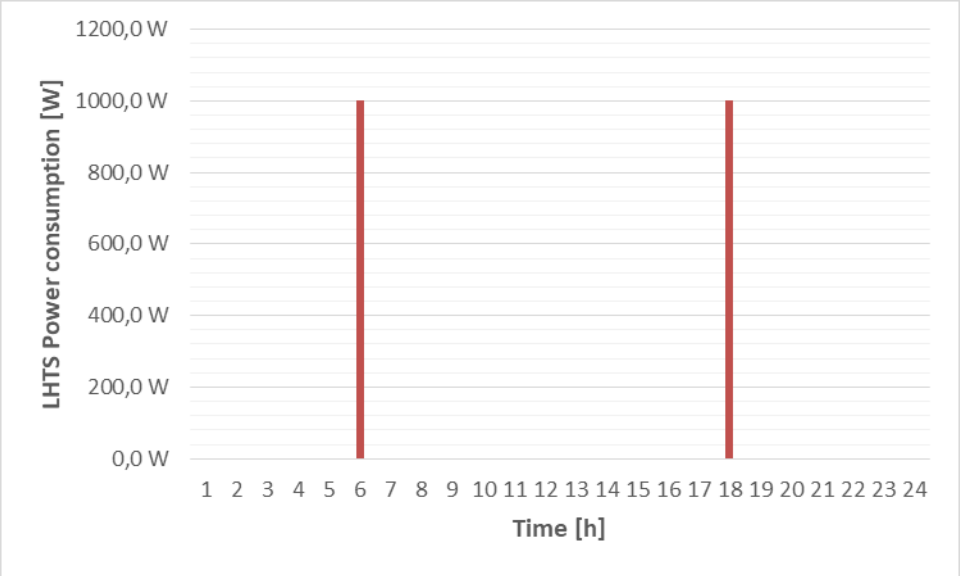

Figure 5-3: Typical LHTS electric load profile with 1h step

Modbus is considered so far the most likely communication protocol to be supported by LHTS prototype and therefore this will be the first option for emulated LHTS too.

5.1.1.3 Hybrid Solar Cooling system (SHC)

Hybrid Solar Cooling system (SHC) is another unit with contribution to RE – COGNITION framework thermal operation and low power consumption. The SHC system can have mainly four (4) operational statuses namely OFF, ON – Cooling Services, ON –Standby and ON – Switching. The appropriate operational status is determined each time by embedded control algorithms, taking into the account inputs from ACEME and other thermal devices on pilot sites. The electrical power consumptions have that a small difference among the statuses that the assumption each status power loss is equal to the highest one (175 W) simplifies tests procedure with no impact to analysis. Test-bed design considers a single SHC unit with a typical load profile as the one in Figure 5-4.

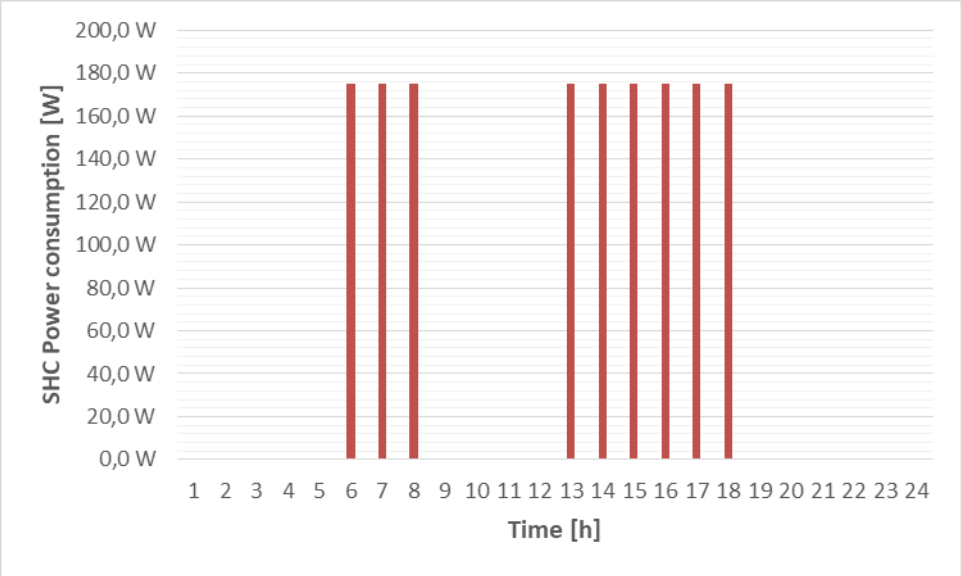

Figure 5-4: Typical electric load profile of a SHC unit

Modbus is considered so far the most likely communication protocol to be supported by SHC prototype and therefore this will be the first option for emulated SHC too.

5.1.1.4 EV-Charger

The primary role of EV charger is to assure a safe and reliable charging of electric vehicles' (EV) batteries. As regards the RE – COGNITION project, the EV charger will be upgraded with advanced functionalities to enable integration of EV charging with consumption/production optimization platform at a building level (BEMS).

To enable optimum planning and load optimization of EV charging, charger will dynamically interact with ACEME, EV and EV users and use data on sophisticated algorithms. Some of the required information will be:

- Planned departure time of EV User
- Historical data about past charging sessions
- EV user ID (optional)
- Maximum power of EV charger
- Maximum external power available for charging
- Rated power of cable that connects EV with EV charger: measured by EV charger.

Based on acquired inputs the EV charger will calculate:

- Time available for charging
- Energy required by EV user
- charging of the user to evaluate user's behavior and its needs related to energy to be delivered
- Maximum charging power
- Minimum charging power

The calculated variables will help EV-Charger algorithms to generate charging plans which can be adapted dynamically in case of parameter changes.
Test-bed analysis is based on a Worst Case Scenario (WCS) that uses:

- as references the followings:
  - ETREL INCH HOME single-phase 230V /50 Hz, 7.4 kW EV – Charger [2]
  - 2013 Nissan Leaf charging profile [3]
- the assumptions/simplification that charging has a 4h pulsing form with constant peak power equal to charger's output rated power plus overestimated losses due to a low efficiency of 93%

Figure 5-5 presents a typical WCS load profile of a single EV – Charger.

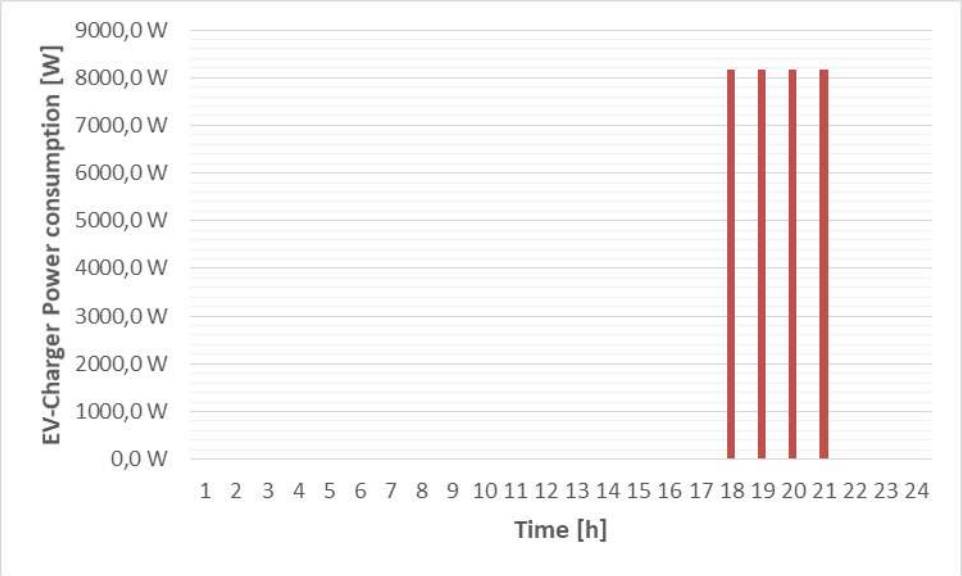

Figure 5-5: WCS electric load profile of a single EV - Charger

The corresponding reference charger supports both TCP/IP and Modbus communication protocols, protocols that will be both supported by test-bed.

5.1.2 Electric power generating units

Test-bed shall be able to emulate all possible electric power generating Field devices may applied to RE – COGNITION framework, namely:

- Building Integrated Photovoltaics (BIPV)
- Vertical Axis Wind Turbine (VAWT)
- Micro-Combined Heat and Power biogas-fueled system (micro-CHP)

5.1.2.1 Building Integrated Photovoltaics (BIPV)

BIPV are specialized PV panels that not only focus to power generation but also to be a part of building envelopes, covering specific architectural, thermal and structural specifications. In RE – COGNITION framework BIPV may be installed on existing buildings, mainly on available areas on roofs, skylights, or

facades. The available area is considered to be limited, not exceeding 10 m^2, which corresponds to a total rated electric power of 1 kW.

Typical BIPV average hourly power generation profiles (Figure 5-6) can be used for the analysis and test planning by scaling down available online PV power generation profiles, like the one of Fig.3 in [4].

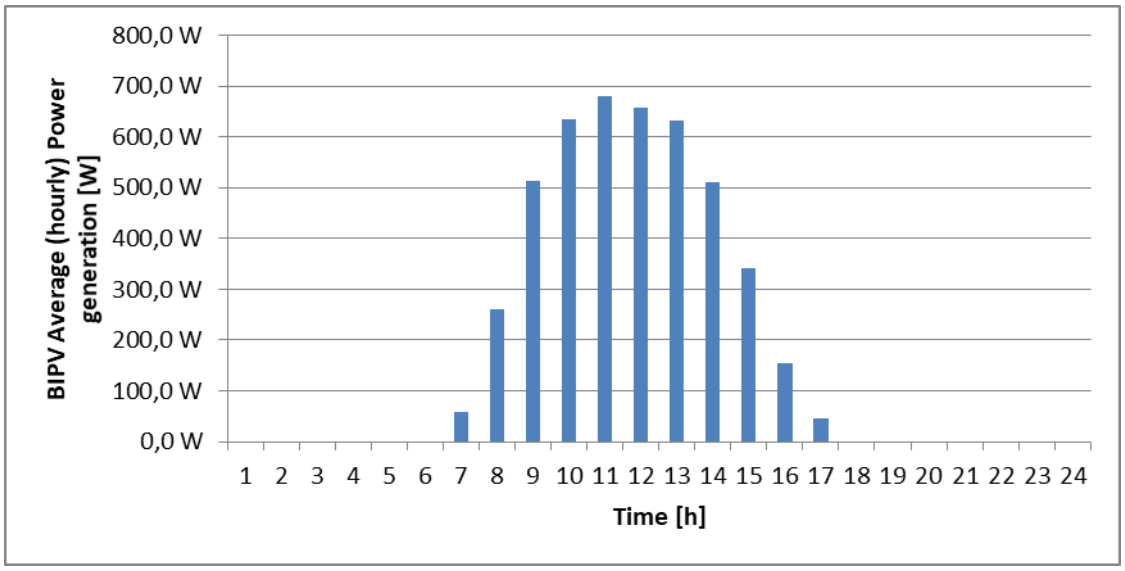

Figure 5-6: Typical average (hourly) power generation profile of a 10m^2 BIPV

BIPV operation will require the application of dedicated inverters and/or a network of sensors (radiation, thermal etc.) and weather station. The additional devices may provide useful information regarding BIPV performance and operational conditions, using several communications protocols such as Modbus According to the current test-bed design the aforementioned information will be either broadcasted by BEMS or the emulated devices.

5.1.2.2 Vertical Axis Wind Turbine (VAWT)

VAWT will be a "Passive Variable Geometry" (PVG) turbine, patented and produced by Windcity Srl [5], which will be installed on several pilot sites. The rated mechanical power of each VAWT may reach 2 kW, while more than one units will be able to be connected in parallel. Depending on the applied power electronics interface VAWT will provide electric power to the Utility grid or battery banks.

Test-bed will emulate a single VAWT, acting as a grid-tied power generator. VAWT power generation profiles can be easily generated by:

- using a diagram of the generated aerodynamic mechanical power versus wind speed, provided by the manufacturer
- estimating a WCS efficiency of 90% turning mechanical power to electrical
- using online average hourly wind speed records

Figure 5-7 depicts the average (hourly) power generation profile of a VWAT, based on the wind records in Peania, Greece on 16/01/2020 [6].

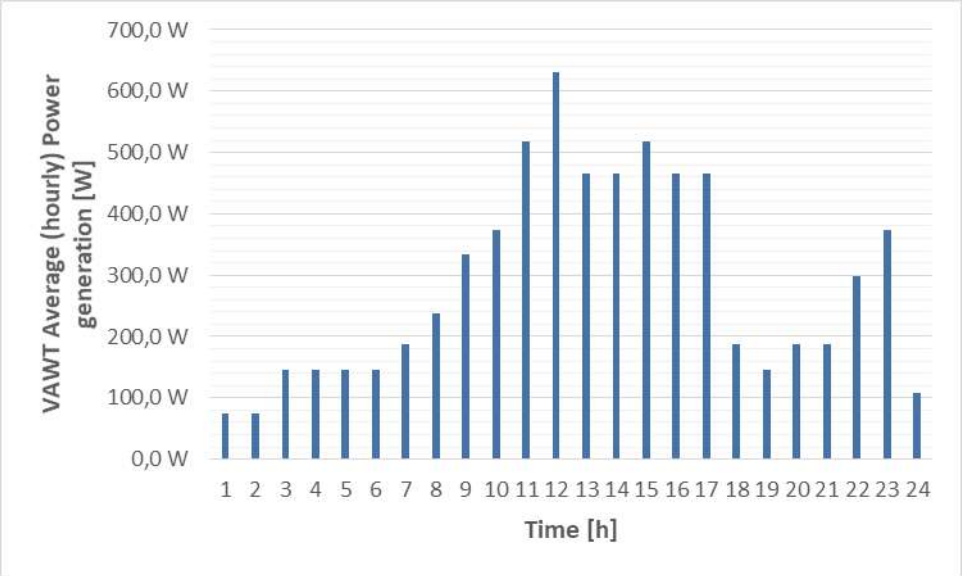

Figure 5-7: Typical average (hourly) power generation profile of a VWAT

Emulated VAWT will use Modbus as the communication protocol since this is the one the actual turbine will support.

*5.1.2.3 Micro-Combined Heat and Power **biogas-fueled system** (micro-CHP)*

micro-CHP is a combined Heat and Power biogas-fueled system, produced by MTT B.V. [7] under the product name EnerTwin. Being a Combined, Heat and Power system the EnerTwin is primarily a heat demand driven system while at the same time electricity is being generated. The EnerTwin will in principle run when there is a heat demand, or when there is an electrical power demand and thermal power can be buffered. The produced heat may range from 8 to 16kWth while the generated power will be within the range of 1 – 3 kW. Produced heat and electric power will change proportionally and electricity will be provided through a single-phase 230V / 50 Hz connection.

Figure 5-8 presents a typical power generation profile of micro-CHP, operating early in the morning and late in the afternoon, when end-users will be awake or back home and heating is required.

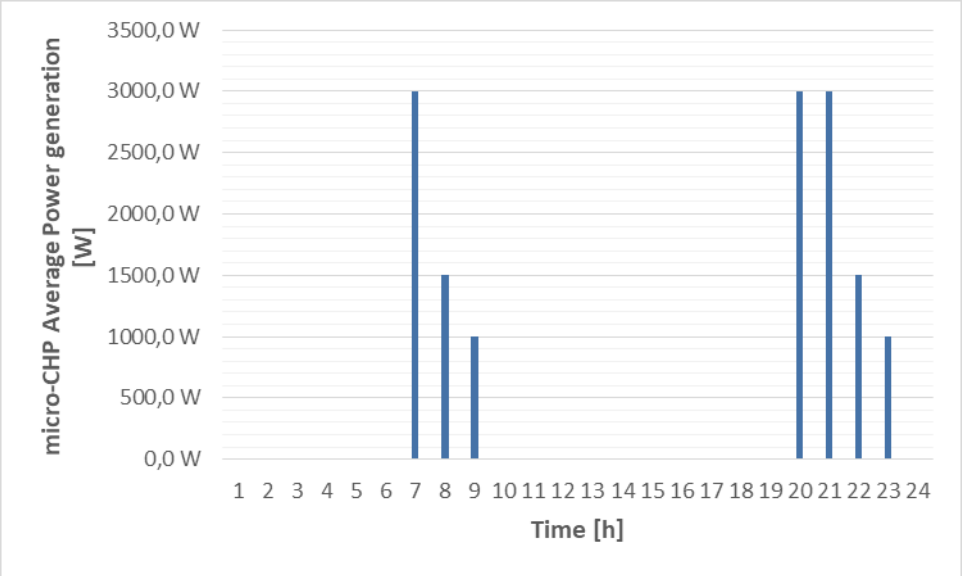

Figure 5-8: Typical average power profile of micro-CHP

Test-bed will use Modbus as the communication protocol for emulated micro-CHP since this is one of the protocols EnerTwin supports.

5.1.3 BESS

BESS subsystem won't be emulated in test-bed since an actual fully operational BESS, scaled to test-bed power levels, will act as an "energy buffer" during the test procedure.

5.1.4 Control units

RE – COGNITION framework will include two (2) major control units that shall be emulated from test-bed:

- Building Energy Management System (BEMS)
- ACEME and RE – COGNITION Repository host system

5.1.4.1 Building Energy Management System (BEMS)

BEMS may be a preinstalled unit in a pilot site which will interchange critical data with ACEME, for a proper operation of RE- COGNITION framework such as warning/fault/status messaging, measurements and control signals.

Test-bed controller will be the most appropriate device within the test-bed platform for the role of BEMS since this is the device that will control and/or monitor almost all major test-bed components (BESS, AC source, controlled load).

5.1.4.2 ACEME and RE – COGNITION Repository

In RE – COGNITION Framework ACEME and corresponding Repository may be either hosted in cloud or local servers. According to the current test-bed design ACEME and RE – COGNITION Repository will be stored in a Local server.

5.1.4.3 iGateway

iGateway will be the actual RE – COGNITION framework device which will act as a communication interface between test-bed field devices and Local server.

5.2 Test-bed major component specifications

Based on the aforementioned analysis, the specifications selected components must cover in order to be part of test-bed platform can be determined.

5.2.1 Controlled Load

Taking the maximum power consumption of each applied power profile in subchapter 5.1.1 leads to a total peak power consumption of 18.96 kW. Since test-bed must be a small-scale version of RE-COGNITION framework, the aforementioned peak power could be emulated with a single phase 230 V / 50 Hz controlled load of a lower rated power. A preferable value could be around 9 kW which is close to typical single phase domestic main power supplies.

It would also be preferable the available load values of the controllable load to provide an almost constant ratio of emulated and real power so as to minimize the deviation between required and actual load profile.

In addition one of the major goals of RE – COGNITION framework is to reduce electricity costs by limiting active power consumption from the Utility grid. Furthermore most of the potential pilot sites will be equipped with low power factor loads (residences, offices etc.). Based on that facts, a controllable resistive load could be a fair compromise between simplicity, cost and emulation approach.

Finally a communication port for remote control would be a must for the selected Load if manual control is not an option.

5.2.2 Controlled AC source

Summing the rated power of each emulated power generating unit in subchapter 5.1.2 leads to a total peak power generation of 5.6 kW. The peak power that will be provided to the test-bed network by the AC-source could be lower than 5.6 kW, keeping the same ratio of emulated and real peak total load though. In that case peak generated total power wouldn't exceed 2.65 kW.

The AC Source shall be a subsystem of one or more single phase 230V / 50 Hz inverter/chargers and a battery bank. The generated power will be provided by the discharge of the battery bank. Since the applied power generation profiles won't be the same in tests and operation duration of emulated devices is not known in advance, the battery bank efficient capacity can be estimated by considering that AC source will be able to provide peak power for the whole test round time, namely 4 h. If discharging efficiency is 95% the effective battery capacitance should be around 11.2 kWh.

By the end of tests inverter/chargers shall be able to restore battery bank's lost energy in a time of not more than 4 h.

Finally AC source power generation shall have the option of remote control and should report all critical information about operational status and performance.

5.2.3 BESS

BESS could be a preinstalled equipment in pilot sites, which will cooperate with RE – COGNITION framework but won't be part of it. BESS rated power is usually expressed as a percentage of the pilot sites total rated power. Based on this fact test bed could be equipped with a BESS of 70% of its peak total load of 9 kW, namely 6.3 kW.

BESS purpose is to act as an "energy buffer" to test-bed network and the interaction between BESS and RE – COGNITION platform is one of the things that should be examined during the test procedure. A BESS with a limited battery bank not only would save budget and space for test-bed but would also provide successive charging/discharging phases during the 4h test, covering all possible operational cases. A recommended effective capacitance would be around 4 kWh.

An additional feature BESS should have is the option for automatic or manual operation, giving ACEME software developers the option to decide when and if RE – COGNITION platform would need to take control of BESS.

5.2.4 Test-bed controller

Test-Bed controller shall be a programmable multipurpose control unit that will cover the following specifications:

- it shall be able to host software for controlling applied BESS, AC source and controlled load (if remote control is available)
- it shall support the appropriate communication protocols to establish a direct communication with the following devices:
    - iGateway (for emulating BEMS operation)
    - BESS
    - AC Source
    - Load (if remote control will be available)
    - Measuring devices
- It shall be programmable to work with the locally stored test plan lookup tables
- it should be able to emulate the communication of the selected field devices (SHC, LHTS, EV-Charger, micro-CHP, VAWT). The applied protocol on the connection with iGateway shall be Modbus and Test-bed Controller must use different ID per emulated device

5.2.5 Local Server

Local Server shall be a portable Personal Computer (PC) that will have the specifications and resources to:

- host the required software
- store the required information
- communicate directly with iGateway using at least TCP/IP protocol (wired or wireless connection)

Special effort shall be paid to software development in order to verify an easy setup and low size installation files. In this way the need of physical presence of software developers at test-bed premises will be minimized.

6 Test-bed equipment selection

In this chapter are presented the components that have been chosen to be used on test-bed according to the analysis and extracted specifications of subchapter 5.2. However the current test-bed configurations shall not be considered as final. Market research for some components is still in progress, while already selected units may fail during tests or new test requirements / needs may lead to hardware or configuration changes.

The presentation is organized in two (2) groups. One (1) about the aforementioned major components and one (1) about all the additional components, relevant to installation, safety, user interface and auxiliary units.

Additional information regarding the availability of the selected components at IDE premises or the need for their purchase will be presented.

6.1 Major components selection

6.1.1 Controlled load

IDE premises is already equipped with a 3ph 230 V / 50 Hz manual controlled resistive load, a phase of which can be used as a controlled load for test-bed. The phase total resistance is the result of a selectable combination of four (4) in series distinct resistors connection. The power consumption per phase may range from 1.55 to 10.5 kW.

IDE manual resistive load, due to the inherent quantized operation, will lead to a divergence between the emulated power levels and the real ones. The divergence must be calculated between emulated and actual power levels expressed as percentages of the corresponding peak values, namely the maximum possible emulated power (18.95 kW according to 5.1.1 and 5.2.1 analysis) and maximum load power (8.95 kW for IDE load in accordance to 5.2.1 specification).

Using analysis power profiles IDE manual load will have an average divergence of 0.7% with maximum and minimum values of 5.2% and -8.2% respectively. A research is in progress to answer if this kind of divergence will be acceptable for the required tests. In case of a negative outcome a single phase 230 V / 50 Hz , 9 kW electronic load must be purchased.

Figure 6-1 plots the total emulated power consumption profile used for the analysis and the corresponding actual power profile. Figure 6-2 plots the same data as percentages of the corresponding peak values (18.96 kW for emulations and 8.95 kW for real test).

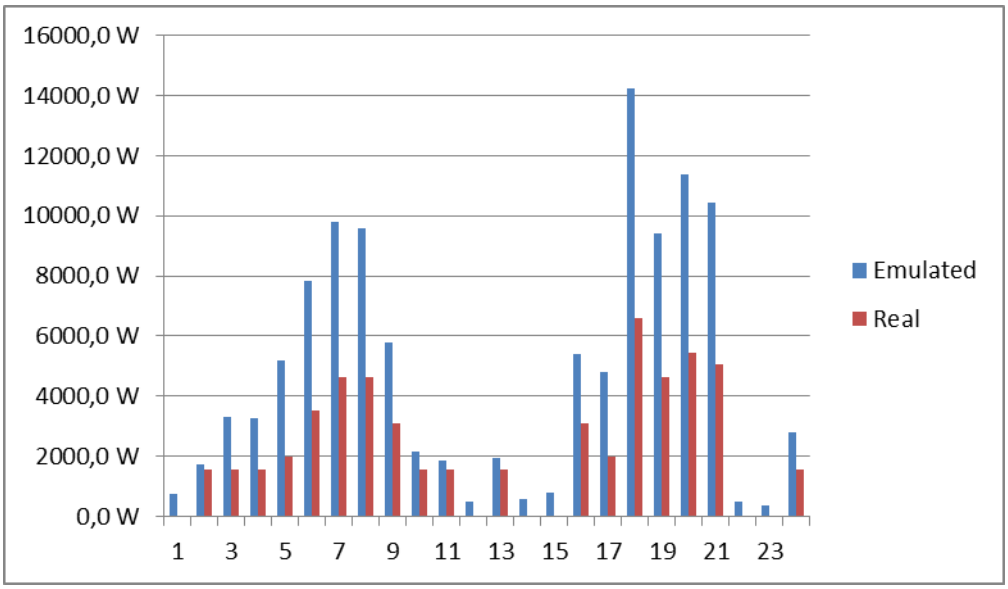

Figure 6-1: Emulated and actual total power consumption profiles using manual IDE resistive load

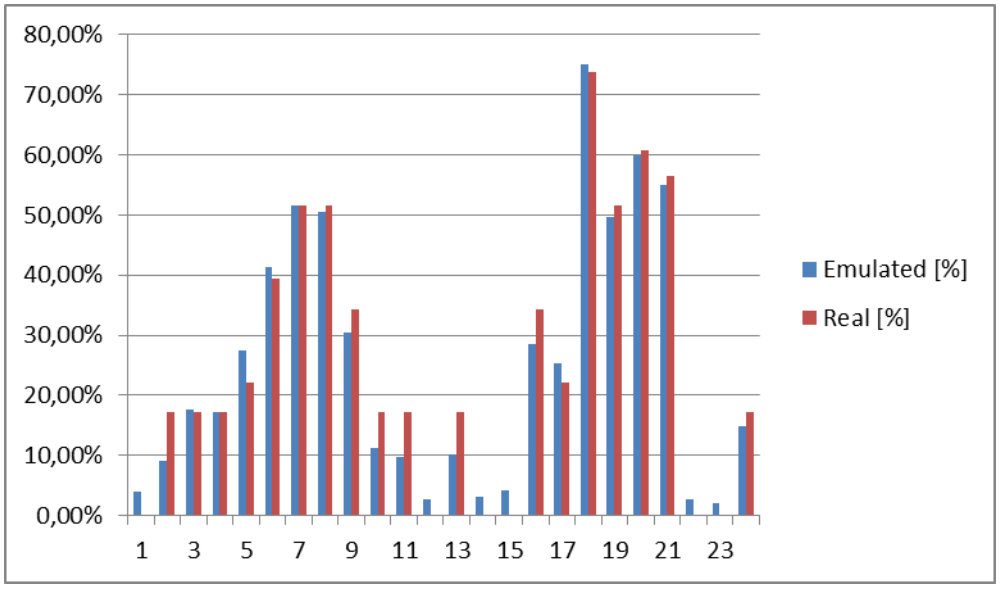

Figure 6-2: Total emulated and actual power consumption profiles as percentage of the peak values

6.1.2 Controlled AC source

The need of an AC source battery bank will be covered by existing laboratory equipment. More specifically four (4) battery modules with the following specifications are available:

Table 6-1: AC source battery bank module specifications

Chemistry	$LiFePO_4$
Nominal voltage	25.6 V

Nominal Ah	180 Ah
Nominal capacity	4.75 kWh
Maximum charge current	1 C
Maximum discharge current	1.5 C

Battery modules can support either a 24 V or 48 V dc bus and the total effective capacitance overcomes the required one of 11.2 kWh.

Provided battery modules are already accompanied with additional, available on lab, battery bank equipment, namely:

- Protected DC bus with embedded fuse holders for battery modules
- Protected DC bus with embedded fuse holders for AC source inverter/chargers
- Battery disconnection relay with embedded shunt resistance and CAN-Bus communication port (NMEA 2000)

Regarding AC source inverter/charger a market research is in progress, focusing to the purchase of a single unit, compatible to the specifications of subchapter 5.2.2, that will be able to operate with a 24 or 48 DC bus.

6.1.3 BESS

BESS will be a commercial solution based on Energy Storage System (ESS) provided by Victron Energy B.V. [8]. Victron ESS is a specific type of power system which stores energy when is available to use it when load needs tend to use power from the utility grid. ESS operation can be either manual or automatic. Selected ESS configuration will include:

- Main power meter
- Inverter / charger
- Battery bank and corresponding DC bus
- Solar charger system
- BESS Controller

6.1.3.1 BESS main power meter

ESS architecture requires the use of a main power meter, right after the test-bed connection to the Utility grid. Among the suggested devices Victron Energy ET340 [9] is chosen to purchase, a three phase (3ph) power meter with rated current of 63 A per phase. The selection of a 3ph meter instead of a 1ph one was made in order to keep a system upgrade option to a 3ph system without major changes to switchboards.

6.1.3.2 BESS inverter / charger

Test-bed BESS inverter / charger will be a single unit of Victron Energy Quattro 24/8000/200-100/100 [10]. Some of its most interesting characteristics are:

- Rated power of 6.5 kW (at 25 °C)
- Two (2) 1ph 230 V/50 Hz inputs, one of them dedicated for Grid connection
- Compatible with $LiFePO_4$ battery packs
- Operation with 24 V DC bus

Victron Energy Quattro 24/8000/200-100/100 is already available at IDE premises.

6.1.3.3 BESS battery bank system

Implementation of ESS in test-bed platform will require the acquisition of a compatible battery bank subsystem.

The most important component of this battery bank will be a single unit of Victron Energy Smart Battery 25,6V/200Ah [11] with the following specifications:

Table 6-2: BESS battery bank module specifications

Chemistry	$LiFePO_4$
Nominal voltage	25.6 V
Nominal Ah	200 Ah
Nominal capacity	5.12 kWh
Recommended discharge current	1 C
Maximum discharge current	2 C

Beside the battery module, a number of additional components must be purchased. Some of them are:

- Protected DC bus with embedded fuse holders for battery module and inverter / charger [12] (two pieces)
- Battery Management System (BMS) [13]
- Shunt resistance with CAN-Bus communication port (NMEA 2000) [14]

6.1.3.4 BESS Solar charger system

IDE premises is equipped with a string of three (3) panels [15], the use of which can provide more than one advantages to test-bed system:

- It will keep ESS operation close to “real life” application.
- It will provide additional “clean” power to BESS battery bank
- As an uncontrolled, unpredicted power source will contribute to RE – COGNITION algorithms testing
- It will emulate the operation of PV systems installed on pilot sites before RE – COGNITION framework

PV panel's main specifications are presented in the following table:

Table 6-3: IDE laboratory PV panel's specifications

Cell technology	mono crystalline silicon wafer surrounded by ultra-thin amorphous silicon layers
MPPT power	250 W
MPPT voltage	34.9 V
MPPT current	7.18 A
Module efficiency	18%
Short circuit current	7.74 A
Open circuit voltage	43.1 V

In order to connect PV string with BESS subsystem the following components must be purchased:

- A Solar MPPT charger with corresponding display and CAN-Bus port (NMEA 2000) (Victron Energy SmartSolar MPPT 150/70-Tr VE.Can [16])
- A compatible MPPT charger disconnection relay [17]

6.1.3.5 BESS controller

The automatic operation of Victron Energy ESS and the interconnection with third part systems will be arranged by a dedicated control unit, Victron Energy Color Control GX [18]. Color Control GX will establish more than one communication connections, using different protocols:

- Direct connection with BESS inverter / charger (VE.Bus)
- Direct connection with BESS power meter (Modbus through additional usb to modbus adapter)
- Direct connection to BESS CAN-bus network (NMEA 2000)

BESS controller is not available in IDE premises and shall be purchased.

6.1.4 Test-Bed controller

Test-bed controller will be implemented by a heavy duty, ruggedized multipurpose control device, designed, programmed and produced by IDE. As a part of several IDE products, Test-bed controller has been tested and verified for the performance, efficiency and reliability. It is equipped with multiple I/O's and internal storage, can drive several external relays and can support several communication protocols such as CAN-Bus (NMEA 2000) and Modbus. Regarding the on-board software, being built from scratch "in house", is fully adjustable and provides a full exploitation of hardware capabilities.

In test bed platform, test-bed controller will have direct access to:

- iGateway via a CAN-Bus network (NMEA 2000) for emulating BEMS operation
- BESS CAN-bus network in order to control and monitor BESS according to test plans
- AC source Battery bank CAN-Bus network for monitoring reasons
- AC source inverter / charger for control and monitoring reason. The communication protocol shall be determined by the inverter / charger selected unit
- Modbus communication network, where measuring devices and iGateway are connected too. Through the same network Test-bed Controller will communicate with iGateway on behalf of the emulated Field devices.

Additionally through purchased CAN-Bus to USB converter, test-bed controller will be able to connect to a PC that hosts the Test UI software.

6.2 Additional components

Beside major components test-bed will need a number of additional units that will certify proper, safe and efficient test procedures. The additional components can be categorized as follows:

- Measuring devices
- Electrical equipment and tools
- PCs and Test UI software
- Installation scaffold
- User and platform protection devices

6.2.1 Measuring devices

Measuring devices will be used to enrich the information provided by BESS and AC source or provide new ones about the system performance.

Test-bed current design suggests the purchase of additional three (3) auxiliary power meters, installed on the connection points of BESS, AC source and controlled load. The power meters will form a Modbus network that will supply BEMS (emulated by test-bed controller) and optionally iGateway with numerous current measurements and logs such as:

- Total imported Active power (kW)
- Total exported Active power (kW)
- Active power - per phase (kW)
- Total imported Reactive power (kVar)
- Total exported Reactive power (kVar)
- Reactive power - per phase (kVar)
- Apparent power - per phase (KVA)
- Current - per phase (A)
- Voltage - per phase (A)
- Power factor (%)

ABB B21 313 – 100 [19] is chosen to be the type for all three (3) auxiliary power meters. As in case of the main power meter, three phase version is selected in order to keep the option if a system upgrade into a three phase system occurs in the future.

It is important to mention that the use of a power meter would be obligatory in the case of a manually controlled load.

6.2.2 Electrical equipment and tools

The budget for test-bed includes also costs for several necessary electrical equipment and parts such as:

- Power and control cables and wiring
- Cable connectors
- Switchboards and accessories for the AC power network and BESS control devices
- Miniature Circuit Breakers (MCB), terminal boxes, relays ,auxiliary contacts and indication lights
- Cable routing components
- DC switches and fuses

Additional costs about installation tools and instruments shall be considered only in case IDE laboratory equipment is not sufficient.

6.2.3 PCs

At least one portable PC must be purchased to operate as test-bed Local Server. The model selection shall be determined by the time software requirements are finalized.

6.2.4 Installation scaffold

IDE will adapt available wheeled laboratory metallic scaffolds (Figure 6-3), in order to host test-bed. The installation scaffold will be a ruggedized, compact construction that will:

- withstand test-bed weight
- be easily transferable
- provide full access for installation
- help maintainability and serviceability
- provide full access to users to switchboards, switches and monitors
- allow devices proper ventilation

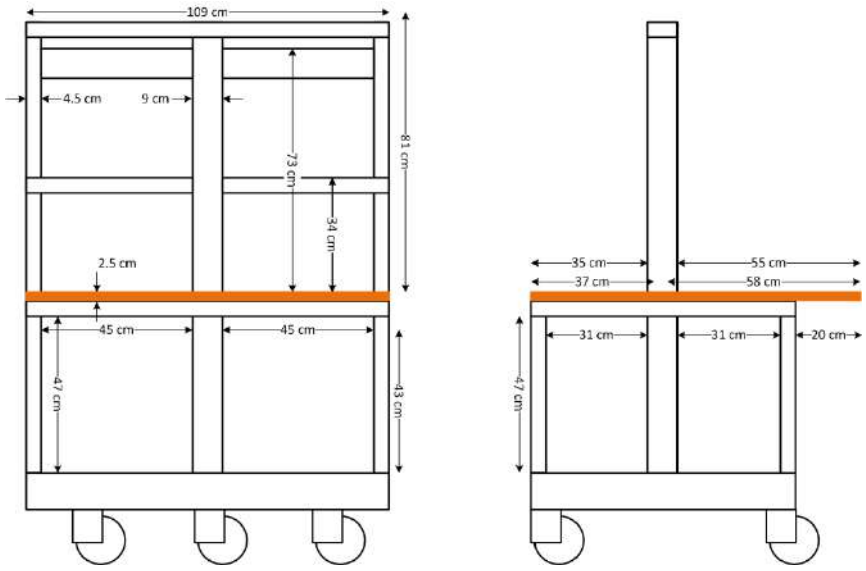

Figure 6-3: Typical diagram of wheeled metallic scaffolds to host test-bed

6.2.5 User and platform protection devices

Special provision has been made in order to ensure a safe operation for both users and equipment.

During tests the test-bed scaffold will be placed in a special test chamber, already available in IDE premises. The chamber is equipped with ventilation system and fire alarm / extinguishing system, specialized for electronic and electromechanical devices.

Grid and PV string power lines that end up in the chamber are already protected with dedicated switchboards.

Users will be able to run tests, protected outside the test chamber, by using Test UI software and manually controlled load. An eye contact to test-bed is feasible through the test chamber window.

In case of emergency users may stop test-bed operation with the dedicated emergency stop button.

7 Conclusions

Aim of this report is to highlight the activities have been made towards to test-bed preparation.

As an introduction, a short description is held about the role of test-bed in RE – GOGNITION project, the suggested test-bed architecture, the main components and the functionality they are going to have.

An analysis is made to point out which RE – COGNITION framework devices should be considered in test-bed emulations. Emphasize is given to the operational characteristics they should have and the supported communication protocols. The analysis outcome helps the determination of the required specification selected devices and equipment should cover in order to build an efficient, safe and adaptable test-bed.

The last part of this report is dedicated to the Off-the-shelf components and auxiliary equipment that have been or going to be selected and their availability on IDE premises.

As a conclusion it is important to point out once again that test-bed intends to be a useful tool for RE – COGNITION researchers in order to reveal and address operation malfunctions and incompatibility issues prior the pilot installation. This is the reason test-bed architecture needs to be adaptive regarding hardware, software and test routines. As a result the test-bed architecture should be considered as evolving than static, running in parallel with RE – COGNITION framework development.

8 References

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9 Annex

Table 9-1: Preliminary list of test-bed components

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
1	AC source	**Inverter-charger**	24 or 48VDC, >5.6kW, 230V, 50Hz	TBD	TBD	1
2		**Battery**	$LiFePO_4$ 24V/180Ah, BMS	Victron Energy	Lithium-ion 24V 180Ah 4.75kWh battery	4
3		**DC - BUS (for batteries)**	A modular DC bus bar, used to connect batteries to the Lynx DC distribution system.	Victron Energy	Lynx Power In	1
4		**DC - BUS (for sources)**	A modular DC bus bar, with locations for four DC fuses. It will monitor the status of each fuse, and indicate its condition with a LED on the front. Part of the modular Lynx distribution system.	Victron Energy	Lynx Power In	1
5		**DC-Bus Inverter fuse**	250A, 58V	Victron Energy	MEGA-fuse 250A/58V (1 pc)	1
6		**DC-Bus Battery fuse**	250A, 58V	Victron Energy	MEGA-fuse 250A/58V (1 pc)	2
7		**DC - BUS Relay**	It contains the 600A safety contactor, and controls the cell-balancing, charging and discharging of the system. The Lynx Ion will protect the battery pack from both overcharging and depletion	Victron Energy	Lynx Ion + Shunt 600	1
8		**CAN-Bus cables**	CAT5, ethernet cable, 2m			5
9		**AC source bus cables**	CAT5, ethernet cable, 2m			3
10		**CAN-Bus terminal resistor**	VE.Can RJ45 terminator (bag of 2)	Victron Energy	ASS030700000	2

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
11		**CAN-Bus cable connector Female (to IDE Controller)**	CONN,METR,CIRC,SACC-FR-5CON-PG9-MSCO,R/Aknurl, cable screw connection Pg9	Phoenix Contact	1543414	1
12		**AC source bus cable connector Female (to IDE Controller)**	CONN,METR,CIRC,SACC-FR-5CON-PG9-MSCO,R/Aknurl, cable screw connection Pg9	Phoenix Contact	1543414	1
13	**BESS**	**Inverter-charger**	$28V_{DC}$, 8KVA, 230V, 50Hz	Victron Energy	Quattro 24/8000/200-100/100	1
14		**BESS controller**	ESS control unit	Victron Energy	Color Control GX	1
15		**BESS Battery expansion cables to BMS**	Cables with M8 circular connector, Male to Female 3 pole 3 m (bag of 2)	Victron Energy	ASS030560300	1
16		**BESS controller fuseholder**	Fuse Holder INLINE 2AG 5X20MM 16 Awg Red wir	Littelfuse	01500274Z	1
17		**BESS controller fuse**	5x20mm, 1A, Cartridge	Littelfuse	0213001.MXP	1
18		**Battery**	$LiFePO_4$ 25,6V/200Ah, 5,12 kWh, BMS, smart	Victron Energy	$LiFePO_4$ Battery 25,6V/200Ah - Smart	1
19		**Battery BMS**	BMS for Victron batteries	Victron Energy	VE-BUS BMS	1
20		**Battery BMS fuseholder**	Fuse Holder INLINE 2AG 5X20MM 16 Awg Red wir	Littelfuse	01500274Z	1
21		**Battery BMS fuse**	5x20mm, 500mA, Cartridge	Littelfuse	0617.500MXP	1
22		**DC - BUS (for batteries)**	A modular DC bus bar, with locations for four DC fuses. It will monitor the status of each fuse, and indicate its condition with a LED on the front. Part of the modular Lynx distribution system.	Victron Energy	Lynx Distributor	1

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
23		**DC - BUS (for sources)**	A modular DC bus bar, with locations for four DC fuses. It will monitor the status of each fuse, and indicate its condition with a LED on the front. Part of the modular Lynx distribution system.	Victron Energy	Lynx Distributor	1
24		**DC - BUS shunt**	It contains the 600A safety contactor, and controls the cell-balancing, charging and discharging of the system. The Lynx Ion will protect the battery pack from both overcharging and depletion	Victron Energy	Lynx Shunt VE.Can	1
25		**DC - BUS shunt fuse**	Very fast fuse, CNN, 700A/48V_{DC}, 2,5kA peak	Littelfuse	0CNN700.V	1
26		**DC Bus Battery fuse**	250A, 32V	Victron Energy	MEGA-fuse 250A/32V (5 pc)	1
27		**DC Bus MPPT fuse**	125A, 32V	Victron Energy	MEGA-fuse 125A/32V (5 pc)	1
28		**DC Bus battery charge relay**	Circuit Breaker: 24V_{DC}: 230A 48V_{DC}: 80A	Victron Energy	Cyrix-Li-Charge 24/48-230	1
29		**MPPT**	28V_{DC}, 2000W / 150V_{DC}, 70A @ 40°C	Victron Energy	SmartSolar MPPT 150/70-Tr VE.Can	1
30		**MPPT display**	Optional MPPT display	Victron Energy	SmartSolar Pluggable Display	1
31		**Control Box**	IP65, wall mounted	ABB	SB12774 (12469)	1
32		**Control Box backplate**	Metallic	ABB	BP12846 (12432)	1
33		**Control Box Cable input interface**	Flange for input cables	ABB	SF12601 (43736)	1
34		**Control Box holding kit**	Wall-mounting kit	ABB	WB12858 (12475)	1
35		**Control Box Rail**	Aluminum DIN-Rails 35x7.5x1.5 mm, 1m			1
36		**Control Box Rail screws**				2
37		**Control Box Rail nuts**				2

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
38		**Control Box Rail washer**				4
39		**USB extension cable for CCGX wall mount enclosure**		Victron Energy	ASS060000100	1
40		**MPPT cables terminal blocks**	TERMINAL BLOCK,1LEVEL,2CONNECTIONS,1kV, 125A, 10-35 mm^2, Grey	Phoenix Contact	3074130 (UK 35 N)	2
41		**MPPT cables terminal blocks End clamp**	Quick mounting end clamp for NS 35/7,5 DIN rail or NS 35/15 DIN rail, with marking option, width: 9.5 mm, color: gray	Phoenix Contact	3022218 (CLIPFIX 35)	2
42		**CCGX, Cyrix, BMS power supply terminal blocks**	TERMINAL,BLOCK,2LEVEL,4POSITION, 500V, 32A, 0.2-4 MM^2	Phoenix Contact	2791388 (UKK 5-PV)	2
43		**End cover for CCGX, Cyrix, BMS power supply terminal blocks**	End Cover, black	Phoenix Contact	2770228 (D-UKK 3/5 BK)	2
44		**Zack marker strip for CCGX, Cyrix, BMS power supply terminal blocks**	Zack marker strip: 1-10	Phoenix Contact	1053027-0001 (ZB10,QR:FORTL.ZAHLEN)	2
45		**Control box power supply cable fuseholder**	Fuse Holder INLINE 2AG 5X20MM 16 Awg Red wir	Littelfuse	01500274Z	1
46		**Control box power supply cable fuse**	5x20mm, 5A, Cartridge	Littelfuse	0218005.MXP	1
47		**DC Bus Battery manual switch**	Knob, ON-OFF, 48V_{DC}, 300A	Blue Sea Systems	6006	3
48		**DC Bus Battery manual switch box**	Wall-mounting junction box, IP55	ABB	JB0821	3
49		**DC Bus Battery manual switch box Rail**	Aluminum DIN-Rails 35x7.5x1.5 mm, 1m			2
50		**DC Bus Battery manual switch box Rail screw**				12
51		**DC Bus Battery manual switch box Rail washer**				24

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
52		**DC Bus Battery manual switch box Rail nuts**				12
53		**BESS inlet (from Grid)**	Plug, 5p, 400V/50Hz, 63A, IP67, 6h, male	MENNEKES	13212	1
54		**BESS outlet (to load)**	Connector, 5p, 400V/50Hz, 63A, IP67, 6h, female	MENNEKES	14212	1
55		**VE-Bus cables**	CAT5, ethernet cable, 2m			6
56		**CAN-Bus cable connector Male (to IDE Controller)**	CONN,METR,CIRC,SACC-MR-5CON-PG9-MSCO,R/Acable screw connection Pg9	Phoenix Contact	1543003	1
57	**Load**	**Load cable inlet**	Plug, 5p, 400V/50Hz, 63A, IP67, 6h, male	MENNEKES	13212	1
58		**Load power inlet mate**	Connector, 5p, 400V/50Hz, 63A, IP67, 6h, female	MENNEKES	14212	1
59	**User Interface**	**Local server laptop**	Laptop for Local server			1
60		**USB to CAN-Bus converter**	CAN-Bus: 5K ~ 1Mbps baud rate USB Type B 12M kbps No external Power supply 1.5 W consumption DIN-Rail	ICP DAS	I-7565-H2	1
61	**Battery switch**	**Battery Fuse Combiner Box**		Schneider Electric	ConextTM Battery Fuse Combiner Box 250	1
62	**AC switchboard**	**Box**	GEMINI 4x 24 components (17.5 mm), 400A max Size 4	ABB	GEMINI 24262	1
63		**Box door**	Transparent, Size 4	ABB	GEMINI 24274	1
64		**Box Base Plate**	Blank metal base plate, Size 4	ABB	GEMINI 24284	1
65		**Box Uprights**	Uprights, Size 3/4 (Set of 2)	ABB	GEMINI 23422	1

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
66		**DIN-Rails & Panels**	DIN-Rails 24 items (17.5mm), Size 4 with corresponding panels (H=150mm)	ABB	GEMINI 24314	4
67		**Box Blank panels**	Blank panel, H=150mm, Size 4	ABB	GEMINI 24326	1
68		**Box Blind cover**	Blind covers (Set of 12)	ABB	GEMINI 12863	2
69		**Box Wiring duct kit**	Wiring duct kit 40x60, Size 4 (Set of 4)	ABB	GEMINI 24345	4
70		**Box plastic wall fixing brackets**	Plastic wall fixing brackets (Set of 4)	ABB	GEMINI 23427	1
71		**Box standard locker**	Standard locker	ABB	GEMINI 80172	1
72		**Grid input LED light**	Indication light, 3 LED, 3ph, $230V_{AC}$, Red	ABB	E219-3C	1
73		**Grid input Circuit Breaker**	Miniature Circuit Breaker - S200 - 2P - B - 63 ampere	ABB	S202-B63	1
74		**Grid input Circuit Breaker Aux contact**	1p auxiliary contact	ABB	S2C-H6R	1
75		**Grid input Relay**	Coil: $24V_{DC}$ Main: 230V, 63 A, 3P+1, 4NO	ABB	ESB63-40N-01	1
76		**Grid input Relay Aux contact**	Aux.-contact NO+NC	ABB	EH04-11	1
77		**Grid input power meter**	3ph power meter for ESS. 65A/phase	Victron Energy	ET340	1
78		**Grid input power meter cable to CCGX**	RS485 to USB interface cable 5 m	Victron Energy	RS485 to USB interface cable 5 m	1
79		**Grid input RCD**	RCD, 3P+1, 30mA, 40A	ABB	F204AC-63/0.03	1
80		**Grid input RCD Aux contact**	1p auxiliary contact	ABB	S2C-H6R	1
81		**Input Phases and Neutral Distribution box, 125A**	1 x (10...35) mm^2 1 x (6…16) mm^2 6 x (2.5…16) mm^2	ABB	DBL125	4
82		**AC source LED light**	Indication light, 3 LED, 3ph, $230V_{AC}$, Red	ABB	E219-3C	1
83		**AC source Circuit Breaker**	CIRCUIT BREAKER, 4P, 63A	ABB	S204-B63	1

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
84		**AC source circuit breaker Aux contact**	1p auxiliary contact	ABB	S2C-H6R	1
85		**AC source Relay**	Coil: $24V_{DC}$ Main: 230V, 63 A, 3P+1, 4NO	ABB	ESB63-40N-01	1
86		**AC source Relay Aux contact**	Aux.-contact NO+NC	ABB	EH04-11	1
87		**AC source power meter**	Electricity meter, 3ph, 65A, Modbus	ABB	B23 212-100	1
88		**Load LED light**	Indication light, 3 LED, 3ph, $230V_{AC}$, Red	ABB	E219-3C	1
89		**Load Circuit Breaker**	CIRCUIT BREAKER, 4P, 63A	ABB	S204-B63	1
90		**Load circuit breaker Aux contact**	1p auxiliary contact	ABB	S2C-H6R	1
91		**Load Relay**	Coil: $24V_{DC}$ Main: 230V, 63 A, 3P+1, 4NO	ABB	ESB63-40N-01	1
92		**Load Relay Aux contact**	Aux.-contact NO+NC	ABB	EH04-11	1
93		**Load power meter**	Electricity meter, 1ph 65A, MODBUS	ABB	B21 313 - 100	1
94		**ESS input LED light**	Indication light, 3 LED, 3ph, $230V_{AC}$, Red	ABB	E219-3C	1
95		**ESS Circuit Breaker**	CIRCUIT BREAKER, 4P, 63A	ABB	S204-B63	1
96		**ESS circuit breaker Aux contact**	1p auxiliary contact	ABB	S2C-H6R	1
97		**ESS Relay**	Coil: $24V_{DC}$ Main: 230V, 63 A, 3P+1, 4NO	ABB	ESB63-40N-01	1
98		**ESS Relay Aux contact**	Aux.-contact NO+NC	ABB	EH04-11	1
99		**ESS power meter**	Electricity meter, 1ph 65A, MODBUS	ABB	B21 313 - 100	1
100		**Power Feed-through terminal block (Phases)**	TERMINAL BLOCK,1LEVEL,2CONNECTIONS,800V, 57A (76A with $16mm^2$ cable), 0.5-16 mm^2, Grey	Phoenix Contact	3005073 (UK 10 N)	9

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
101		**Power Feed-through terminal block (Neutral for loads)**	TERMINAL BLOCK,1LEVEL,2CONNECTIONS,800V, 57A (76A with 16mm2 cable), 0.5-16 mm^2, blue	Phoenix Contact	3005086 (UK 10 N BU)	1
102		**End cover for Power Feed-through terminal block**	END COVER, GRAY	Phoenix Contact	3003020 (D-UK 4/10)	3
103		**Zack marker strip for Power Feed-through terminal block**	Marker 1-10	Phoenix Contact	1053014 (ZB10,LGS:FORTL. ZAHLEN)	2
104		**Marker for terminal blocks**	Marker L1, L2, L3, N, PE (Set of 2)	Phoenix Contact	1053412 (ZB10,LGS:L1-N,PE)	2
105		**Output Ground and AC-Source / BESS Output Neutral Distribution boxes, 125A**	1 x (10...35) mm^2 1 x (6…16) mm^2 6 x (2.5…16) mm^2	ABB	DBL125	3
106		**Signal Double-level terminal block**	TERMINAL BLOCK,2LEVEL,4POS, 0.2-4 MM^2, 24A, Grey	Phoenix Contact	2770011 (UKK-3)	17
107		**End cover for Signal Double-level terminal block**	END COVER TB, L=56MM,W=2.2MM,H=52MM,GRAY	Phoenix Contact	2770024	2
108		**Spacer plate for Signal Double-level terminal block**	SPACER PLATE TB,L=56MM,W=2.5MM,H=66.5MM	Phoenix Contact	2770794	1
109		**Zack marker strip for Signal Double-level terminal block (1-10)**	MARKER FOR TB-ZB 5,LGS:FORTL.ZAHLEN,1-10	Phoenix Contact	1050017-0001	2
110		**Zack marker strip for Signal Double-level terminal block (11-20)**	MARKER FOR TB-ZB5,LGS:FORTL.ZAHLEN,11-20	Phoenix Contact	1050017-0011	2
111		**Zack marker strip for Signal Double-level terminal block (21-30)**	MARKER FOR TB-ZB5,LGS:FORTL.ZAHLEN,21-30	Phoenix Contact	1050017-0021	2
112		**Signal Ground Double-level terminal block**	TERMINAL,BLOCK,2LEVEL,4POSITION, 0.2-4 MM^2	Phoenix Contact	2791388 (UKK 5-PV)	2
113		**End cover for Signal Ground Double-level**	End Cover, black	Phoenix Contact	2770228 (D-UKK 3/5 BK)	3

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
		terminal block				
114		**Fixed bridge for Signal Ground Double-level terminal block**	FIXED,BRIDGE,10POSITION,PITCH=6MM	Phoenix Contact	0203250 (FBI 10-6)	1
115		**Fixed bridge for Signal Ground Double-level terminal block**			0203425 (FBI 3- 6)	2
116		**BEMS power supply terminal blocks**	TERMINAL,BLOCK,2LEVEL,4POSITION, 500V, 32A, 0.2-4 MM^2	Phoenix Contact	2791388 (UKK 5-PV)	2
117		**End cover for BEMS power supply terminal blocks**	End Cover, black	Phoenix Contact	2770228 (D-UKK 3/5 BK)	2
118		**End clamps**	CLAMP,END,GRAY	Phoenix Contact	1201442 (E/UK)	6
119		**Input and Load Cable Glands**	IP68, plastic, appropriate for 18 - 25 mm	EATON	O-CA-453212	2
120		**AC-Source and BESS cable glands**	IP68, plastic, appropriate for 18 - 25 mm	EATON	O-CA-453212	6
121		**Signal cable gland**	IP68, plastic, appropriate for 4 - 8 mm	EATON	O-CA-450912	3
122		**Cable Gland for Emergency button cable**	IP68, plastic, appropriate for 5 - 10 mm	EATON	O-CA-451112	1
123		**AC input outlet**	Plug, 5p, 400V/50Hz, 63A, IP67, 6h, male	MENNEKES	13212	1
124	**Emergency Stop Box**	**Emergency button box**	Wall-mounting junction box, IP55	ABB	JB0821	1
125		**Emergency button Cable Gland**	IP68, plastic, appropriate for 5 - 10 mm	EATON	O-CA-451112	1
126		**Emergency button**	28MM, RED	IMO	B3P3RED-O	1
127		**Emergency button colar**	CLIP ON, FOR B3T CONT	IMO	B3S	1
128		**Emergency button contact**	1NC, 250VAC, 6A,	IMO	B3T01	3
129		**Emergency button label**	LABEL, 70MM,YELL, WITH MARKING	IMO	B3-7603-2	1
130	**Cables**	**DC cables low power cable Red**	Single pole NYAF H05V-K PVC 0,75mm², Red		1x 0,75mm^2 Red	1
131		**DC cables low power cable Black**	Single pole NYAF H05V-K PVC 0,75mm², Black		1x 0,75mm^2 Black	1

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
132		**DC cables low power Cable Ends**	Cable End 0,75mm² Blue (set of 100)	SAS	AK-AK-073	2
133		**BEMS power supply cable Red**	Single pole NYAF H05V-K PVC 1mm², Red		1x 1mm² Red	1
134		**BEMS power supply cable Black**	Single pole NYAF H05V-K PVC 1mm², Black		1x 1mm² Black	1
135		**DC cables low power Cable Ends**	Cable End 1mm² Red (set of 100)	SAS	AK-AK-074	2
136		**BESS & AC source battery/inverter cables Black**	Single pole NSLFF H01N2-D 50mm², Black D=16,5mm Imax= 274A Vmax=100V		1x 50mm² Black	1
137		**BESS & AC source battery/inverter cables Lugs**	LUG,00AWG(50mm²),UNINSUL,M8,TIN-PLTD			35
138		**MPPT charging cables Red**	Single pole NYAF H07V-K PVC 25mm², Red D=8,5mm Imax= 80A		1x 25mm² Red	1
139		**MPPT charging cables Black**	Single pole NYAF H07V-K PVC 25mm², Black D=8,5mm Imax= 80A		1x 25mm² Black	1
140		**MPPT charging cables Lugs**	LUG,RING,4AWG(25mm²),UNINSUL,M8,TIN-PLTD			8
141		**MPPT charging cables ends**	Cable End, 25mm2, insulated, black (pack of 50)	SAS	AK-AK-081	1
142		**Cable connection sleeve**	0.5-1.5mm², Red (pack of 100)	SAS	AK-AK-060	1
143		**Cable connection sleeve**	1.5-2.5mm², Blue (pack of 100)	SAS	AK-AK-061	1
144		**UTP cable extension interface**	2x RJ45, CAT5e, White	CENTRAL	01-60-491M	2
145		**MPPT PV cables connectors**	Solar connector pair MC4, 1x Male / 1x Female	Victron Energy	SCA520300000	2

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
146		**Grid supply power/Load cable (incl. BESS input output)**	0,6/1kV NYY J1VV-R 5X16mm² black D=22,4mm Imax=78A		5x 16mm^2	1
147		**Chamber inlet (from Grid)**	Plug, 5p, 400V/50Hz, 63A, IP67, 6h, male	MENNEKES	13212	1
148		**Chamber outlet (to BESS)**	Connector, 5p, 400V/50Hz, 63A, IP67, 6h, female	MENNEKES	14212	1
149		**AC-Source/BESS Inverter AC power cable**	0,6/1kV NYY J1VV-R 3X16mm² black D=19,3mm Imax=78A		3x 16mm^2	1
150		**Distribution Box AC cable Brown**	Single pole NYA H07V-K PVC 16mm² Brown D=7mm Imax=61A		1x 16mm^2	1
151		**Distribution Box AC cable Black**	Single pole NYA H07V-K PVC 16mm² Black D=7mm Imax=61A		1x 16mm^2	1
152		**Distribution Box AC cable Grey**	Single pole NYA H07V-R PVC 16mm² Grey D=7mm Imax=61A		1x 16mm^2	1
153		**Distribution Box AC cable Blue**	Single pole NYA H07V-R PVC 16mm² Blue D=7mm Imax=61A		1x 16mm^2	1
154		**Distribution Box AC cable Ground**	Single pole NYA H07V-R PVC 16mm² Yellow-Green D=7mm Imax=61A		1x 16mm^2	1
155		**AC Power cable Cable Ends**	Cable End, 16mm^2, insulated, White (pack of 100)	SAS	AK-AK-080	3

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
156		**Aux Power meters Modbus cables (incl. cables to IDE Controller and iGateway) & IDE Controller to Chamber interface and from interfce to CAN-Bus/USB**	F/FTP 2X23AWG 4Z CAT6	Panduit	PFC6004LG-KD	1
157		**IDE Controller to Chamber interface Female connector**	CONN,METR,CIRC,SACC-FR-5CON-PG9-MSCO,R/Aknurl, cable screw connection Pg9	Phoenix Contact	1543414	1
158		**IDE Controller to Chamber interface Male connector**	CONN,METR,CIRC,SACC-MR-5CON-PG9-MSCO,R/Acable screw connection Pg9	Phoenix Contact	1543003	1
159		**Chamber interfce to CAN-Bus/USB Female connector**	CONN,METR,CIRC,SACC-FR-5CON-PG9-MSCO,R/Aknurl, cable screw connection Pg9	Phoenix Contact	1543414	1
160		**Chamber interfce to CAN-Bus/USB Male connector**	CONN,METR,CIRC,SACC-MR-5CON-PG9-MSCO,R/Acable screw connection Pg9	Phoenix Contact	1543003	1
161		**CAN-Bus to USB cable**	male USB-A, male USB-B, 1.5m	HAMA		1
162		**Ethernet cables for iGateway, ACEME VM, switch & Combox to Schneider UI**	CAT5, ethernet cable, 2m	Plaisio	Turbo-X	6
163		**Spare ethernet cables**	CAT5, ethernet cable, 5m	Plaisio	Turbo-X	3
164		**Emergency Stop cable**	NYMHY H05VV-F PVC 4X 1.5mm², White		4x 1.5mm^2	1
165		**Emergency Stop cable Cable Ends**	Cable End, 1.5mm^2, insulated, Black (pack of 100)	SAS	AK-AK-075	1
166		**Powerstrips for PCs**	with switch, 4 positions, 3x 1.5mm^2, white, 3m	LEGRAND	694627	2

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
167	BEMS	**IDE Controller**	28V IDE Controller	IDE	DWG no: F07A0362 Red line: 25/10/2016	1
168		**IDE Controller power supply mate**	CONN,CIRC,FEMALE,STR.PLUG,CRIMP,SS#10SL	ITT Cannon Electric	CB6URSB110SL-3SC	1
169		**IDE Controller P2200 mate**	CONN,HOUSING,2x10CKT,4.2mm,RECP	Molex		1
170		**IDE Controller P2200 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
171		**IDE Controller P2201 mate**	CONN,HOUSING,2x10CKT,4.2mm,RECP	Molex		1
172		**IDE Controller P2201 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
173		**IDE Controller P2202 mate**	CONN,HOUSING,2x8CKT,4.2mm,RECP	Molex		1
174		**IDE Controller P2202 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
175		**IDE Controller P2203 mate**	CONN,HOUSING,2x7CKT,4.2mm,RECP	Molex		1
176		**IDE Controller P2203 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
177		**IDE Controller P204 mate**	CONN,HOUSING,2x5CKT,4.2mm,RECP	Molex		1
178		**IDE Controller P2204 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
179		**IDE Controller P2205 mate**	CONN,HOUSING,2x6CKT,4.2mm,RECP	Molex		1
180		**IDE Controller P2205 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
181		**IDE Controller P1002 mate**	CONN HOUSING,2x4CAV,+CLIP,UL94V-2	Molex	39-01-2080	1
182		**IDE Controller P1002 mate pins**	CONN,CONTACT,FEMALE,4.2mm,AWG 18-20	Molex	457501111	20
183		**BEMS power supply fuseholder**	Fuse Holder INLINE 2AG 5X20MM 16 Awg Red wir	Littelfuse	01500274Z	1
184		**BEMS fuse**	5x20mm, 10A, Cartridge	Littelfuse	0218005.MXP	1
185		**IDE Controller screw**				4
186		**IDE Controller**				4

S/N	System	ITEM	MAIN CHARACTERISTICS	VENDOR or MANUFACTURER	MODEL	QTY
		washer				
187		**IDE Controller nuts**				8
188		**CAN Bus T connectors terminals male**	CONN,METR,CIRC,SAC-5P-M12MS CAN TR	Phoenix Contact	1507816	2
189		**CAN Bus T Distributors**	CONN,METR,CIRC,SAC-M12T/2XM12 CAN	Phoenix Contact	1424712	2
190	**Additional Accessories**	**Insulation tape**	Insulation, PVC, 19x0.15 mm, 20 m, 90°C, white	TEMFLEX		4
191		**Tire up 2.5mm**	200mmX2.5mm, black (set of 100)	3M		1
192		**Tire up 3.6mm**	280mmX3.6mm, black (set of 100)	3M		1
193		**Tire up 4.8mm**	360mmX4.8mm, black (set of 100)	3M		1
194		**Tire up 7.6mm**	360mmX7.6mm, black (set of 100)	3M		1