D6.10 – Phase 1 Evaluation Report

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0.3	2018-01-26	ISMB	Contribution to section 2.3
0.4	2018-01-30	FIT	Contribution to section 2.4
0.5	2018-02-19	Eniig	Contribution to section 1, 4 and 7
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1.0	2018-05-02	ENIIG	Final version, ready for submission to the EC

Internal Review History

Review Date	Reviewer	Summary of Comments
2018-03-28(v1)	UBP	Approved: • General minor corrections
2017-03-26 (v0.9)	Veronika Krauß (FIT)	Not approved: • General minor corrections • Please update the references for figures and tables, as well as the enumeration of both • Chapter 2 requires more focus of the actual technical evaluation (what was evaluated, how was it measured, what were the main results, which methods were applied …) • Please do an additional grammar and spell-check • Please add missing information to the commented sections

2018-04-20(v0.92)	UBP	Approved: • General minor corrections
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2018-04-30 (v0.92)	Vasco Delgado-Gomes (UNINOVA)	Approved: • General minor corrections

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Executive Summary

This deliverable summarizes the **phase 1 evaluation** in all the three S4G test sites (Bucharest, Bolzano and Fur) resulting from the analysis activities performed by the Milestones (MS). Additionally, the evaluation follows up on year1 Key Performance Indicators (KPIs) with respect to Technical Objectives (TO) and Strategic Objectives (SO).

MS1; First reference scenarios, use cases and key requirements available.
Several use cases, designed as high level, and primary use cases have been described. Related to these use cases scenarios have been described and the technical partners have formulated requirements to obtain the use cases. The business partners have defined and developed business models related to use cases. More business models have been developed for each use case. Lessons Learned related to MS1 are that it is difficult to calculate the baseline for grid reinforcement, the need of different competencies in business modelling and that all partners need to take part of defining the initial requirements and learn how to use the dedicated tools, in the case of Storage4Grid it is Atlassian Jira.

MS4; Technical evaluation of components.
More technical components have been developed in year 1: The initial prototype of the User-side ESS control system, the extension connector (SMX), which is needed in the Unbundled Smart Meter (USM) and the two connectors, namely the Data Dispatcher and Fronius Cloud Connector. All components have been tested in laboratory facilities. Furthermore, the Data Warehouse has been developed and data collection has been started. A main issue in this work has been data protection, which is an on-going activity throughout the project.

MS5; Period 1 Platform operative in test sites and ready for evaluation, MS6; Data gathering from test sites in Bolzano and Fur started and MS8; Period 1 complete. These Milestones are all related.
The platforms in the test sites in Bolzano and Fur have been made ready for monitoring. Although, due to issues with a) the purchase of meters and b) the communication between Smart Meter (SMM) and the Smart Meter Extension (SMX), the platforms were not ready for evaluation.

MS7; Period 1 Lessons Learned (LL) available. A large number of LL is reported. These address all phases of the development process, as well as components and interaction with end-users and security.

All Technical Objectives (TO) have been achieved, except TO2 which focuses on predictive algorithms. Studies for defining the algorithms have started, but are not yet finished. All Strategic Objectives (SO) have been achieved in year1 (targets in parenthesis):

- ✓ TO1: Prototypes supporting S4G interfaces and models for storage coordination (4)
  - 2 prototypes have been developed and implemented,
  - 2 prototypes are developed as initial versions v0.1
- TO2:
  - Sets of distributed and centralized storage control algorithm prototypes developed (2);
  - Systems embedding S4G predictive control algorithms (1);
  - Systems considered by the S4G predictive control algorithms (Residential storage)
- ✓ TO3:
  - Test deployment of Unbundled Smart Meter prototypes (Bucharest);
  - Systems fully integrated with the Unbundled Smart Meter for "Home" deployment (production and consumption)
- ✓ TO5:
  - Availability of DSF components (most of the components of DSF are available)
  - DSF Features supported (analysis by simulation)

- ✓ TO6: Number of different cases evaluated in test sites Bucharest/Bolzano/Fur (1)
- ✓ SO1: Number of residential/professional users engaged in test sites (5 residential, 2 professional)
- ✓ SO2: Number of Business cases proposed/evaluated (1)
- ✓ SO3: Number of complete techno-economic planning cases analyzed using the DSF (early proof of concept using DSF)
- ✓ SO4: Number of inputs proposed to EU or regional policy- related, traditional or open standardization initiatives (early gap analysis internally available)
- ✓ SO5: Number of inputs, Lessons Learned and recommendations published towards security- and privacy-related initiatives (early inputs internally available) (only LL available)

1 Introduction

This deliverable summarizes the **phase 1 evaluation** in all the three S4G test sites, resulting from the analysis activities performed by the Milestones (MS):
MS1; First reference scenarios, use cases and key requirements available, these are carried out in:

- Task 2.1. Storage scenarios and Use Case Definition and reported in [1]
  - D2.1. Initial Storage Scenarios and Use Cases,
- Task 2.2. Business Models and Ecosystems, reported in [2]
  - D2.3. Initial S4G Business Models
- Task 2.3. Requirements Specification and Refinement reported in [3]
  - D2.5. Initial Lessons Learned and Requirements Report

MS4; Technical evaluation of components, the milestone is carried out in the following deliverables [4], [5], [6], [9]:

  - D4.1. Initial User-side ESS control system
  - D4.8. Initial USM Extensions for Storage Systems
  - D5.3. Initial DSF Connectors for external systems and services
  - D6.7. Initial interface for professional and residential users

MS5; Period 1 Platform operative in test sites and ready for evaluation. This milestone is carried out in

- Task T6.1 "Test Sites and Cases Planning", and reported in [7]
  - D6.1. Period 1 Test Site Plans

MS6; Data gathering from test sites in Bolzano and Fur started
MS7; Period 1 Lessons Learned available
MS8; Period 1 Complete

Furthermore, the evaluation will follow up on year1 Key Performance Indicators (KPIs) both Technical Objectives (TO) and Strategic Objectives (SO).

1.1 Scope

This deliverable will in first place execute functional test and evaluate plans devised for test sites in task T6.1. Test Sites and cases planning. Starting from such test results, evaluation activities performed by T6.5 Evaluation will then take a broader perspective, contextualizing the results in light of the requirements framework set up by WP2 and general project and impact KPIs, so to devise and follow a complete evaluation framework. The evaluation framework will thoroughly document results and insights on LL in each yearly iteration so to facilitate the overall iterative process in taking re-design decisions, find solutions to errors and detected inefficiencies, and identify the solutions with the highest potential for impact.
The evaluation will cover both practical, technical and economic aspects, so to demonstrate potential benefit for stakeholders in terms of cost efficiency and added-value information.

1.2 Related documents

ID	Title	Reference	Version	Date
D2.1.	Initial Storage Scenarios and Use Case v1.1.	[1]	1.1.	2017-10-06
D2.3.	Initial S4G Business Models	[2]	1.0	2018-02-28
D2.5.	Initial Lessons Learned and Requirements Report	[3]	1.0	2017-05-30
D4.1.	Initial User-side ESS Control System v1.0	[4]	1.0	2017-09-06
D4.8.	Initial USM Extensions for Storage Systems v1.0	[5]	1.0	2017-09-06

D5.3.	Initial DSF Connectors v1.0	[6]	1.0	2017-09-06
D6.1.	Phase 1 Test Site Plans v1.0	[7]	1.0	2017-08-23
D6.4.	Phase 1 Test Site Platforms v1.0	[8]	1.0	2018-01-15
D6.7.	Initial interfaces for professional and residential users v1.0	[9]	1.0	2017-08-23
D8.1.	POPD Requirements No.1	[10]	1.0	2017-03-29

2 Technical evaluation of initial components year 1

The S4G innovative Technical Objectives (TO) have been pursued in deep correlation with a set of long-term Strategic Objectives (SO). These TO and related KPI's foreseen for the entire project are summarized below, the status is reported in chapter 6:

TO1: pre-design the S4G interfaces, namely a set of interfaces and a joint Common Information Model (CIM) suitable for monitoring and control of heterogeneous storage systems.

KPI1: Prototypes supporting S4G interfaces and models for storage coordination (minimum 4)
Key interfaces have been specified, see Table 1.

Table 1 - Summary of all the key interfaces of the S4G system.

Interface ID	Interface ID	Interface ID
1. DSF-Adapter#DSF-SE	7. DSF-SE#GESSCon	12. GESSCon#GUI
2. DSF-Adapter#EB	8. DSO-SCADA#LESSAg	13. GEVChCon#GUI
3. DSF-Adapter#GESSCon	9. EB#LESSAg	14. GEVChCon#LEVChAg
4. DSF-DWH#EB	10. EVChCon#EV-SCADA	15. GUI#LESSAg
5. DSF-DWH#DSF-SE	11. GESSCon#LESSAg	16. LESSAg#LEVChAg
6. DSF-SE#GUI		

The interfaces are described in D3.1 Initial S4G Components, Interfaces and Architecture Specification Chapter 4 Information View. See overview in Table 1.

Interfaces associated to year 1 technical evaluation have the following corresponding deliverables:

- D4.1 Initial User-side ESS control system
- D4.8 Initial USM Extensions for Storage Systems
- D5.3 Initial DSF connectors
- D6.7 Initial interfaces for Professional and Residential users

The prototypes supporting S4G-interfaces are presented below:

- LESSAg to DSF
  DSF is receiving and recording data from SMX in JSON format messages.
- LESSAg to SMXCore
  MQTT messages were tested by simulation in order to verify the internal data transmission.
- Main SMX meter MQTT communication to submeter SMX
  MQTT communication was tested between two meters, a main one and an additional one.
- SMX to ER

The SMX is communicating with the ER using the IEC61850 standard.

TO2: develop a set of predictive control algorithms suitable to perform real-time optimization of distributed storage system in existing low and medium voltage grids.

KPI2.1: Sets of distributed and centralized storage control algorithms prototypes developed (minimum 2 algorithms);

In the first year, most of the work has been devoted to the LESSAg developed in Bucharest test site as an important distributed storage algorithm for controlling power on Point of Common Coupling (PCC). The development of consumption forecast predictive algorithms for GESSCon has been started and are ongoing as well as the requirement specifications for GESSCon including detailing of features for the predictive algorithms.

KPI2.2: Systems embedding S4G predictive control algorithms (1)
Some efforts were dedicated to develop predictive control algorithms (GESSCon, LESSAg) , but none of them is mature enough in year 1, to be embedded in any S4G system

KPI2.3: Systems considered by the S4G predictive control algorithm
In this case S4G considered the residential storage system as predictive control algorithm.

TO3: establish an Unbundled Smart Meter (USM) extending existing Automated Meter Interface (AMI) standards in open fashion to allow local "plug-in" integration of interfaces providing information about storage control, EV charging and local user interfaces to enable interaction with users.

KPI3.1: Test deployment of Unbundled Smart Meter prototypes.
The USM prototype has been installed in the UPB laboratory.

KPI3.2: Systems fully integrated with the unbundled smart meter.
The SMM and SMX were integrated and are functional in Fur residential case.

TO4: establish a fully integrated Energy Router allowing an easier integration of DC home grid, renewables and electric vehicles in a smart grid ready approach.

Significant work has been done; however, during the first year there is no KPI related to companion of the tasks associated with this objective.

TO5: develop a decision-support tool for analyzing, planning, forecasting and optimizing the use of distributed storage in the low and medium voltage grid.

KPI5.1: Availability of DSF components.
Most of the related components were implemented (as can be seen in D5.3 [6]).

KPI5.2: DSF features supported: analysis by simulation.
The decision to use OpenDSS simulation framework has been made.

TO6: To propose and apply an evaluation methodology that assesses the technical feasibility of the developed technologies & solutions as well as evaluates the user acceptance while considering the multiple actors and stakeholders within a smart grid.

KPI6: Number of different cases evaluated in test sites Bucharest/Bolzano/Fur (1)
In Bolzano, an evaluation based on questionnaires and user interviews was conducted. Important information which is relevant for the users was discovered with the help of 9 participants.

In the following chapters, components already developed and tested in the S4G foreseen demo cases are detailed.

2.1 User-side ESS control system (D4.1)

D4.1 – "Initial User-side ESS control system" describes the initial user-side ESS control prototype implementing some control features. The User-side ESS control system is composed by the LESSAg and the LEVChAg (when EVs are present).

The interaction between an emulated cloud component, a LESSAg, and the ER controller was executed. The cloud component that will interact with the LESSAg is the GESSCon. Due to its ongoing development, for this deliverable, it was considered to be a simple application which issues commands to the LESSAg.

The SMX interacts with the ER using an ER Connector. This connector is deployed on the trusted zone of the SMX and exchanges information with the SMX Core using the Trusted EB. The LESSAg is deployed on the untrusted zone of the SMX and receives commands from the cloud components through a VPN, and sends it to the SMX using the LESSAg EB, as show in Figure 1.

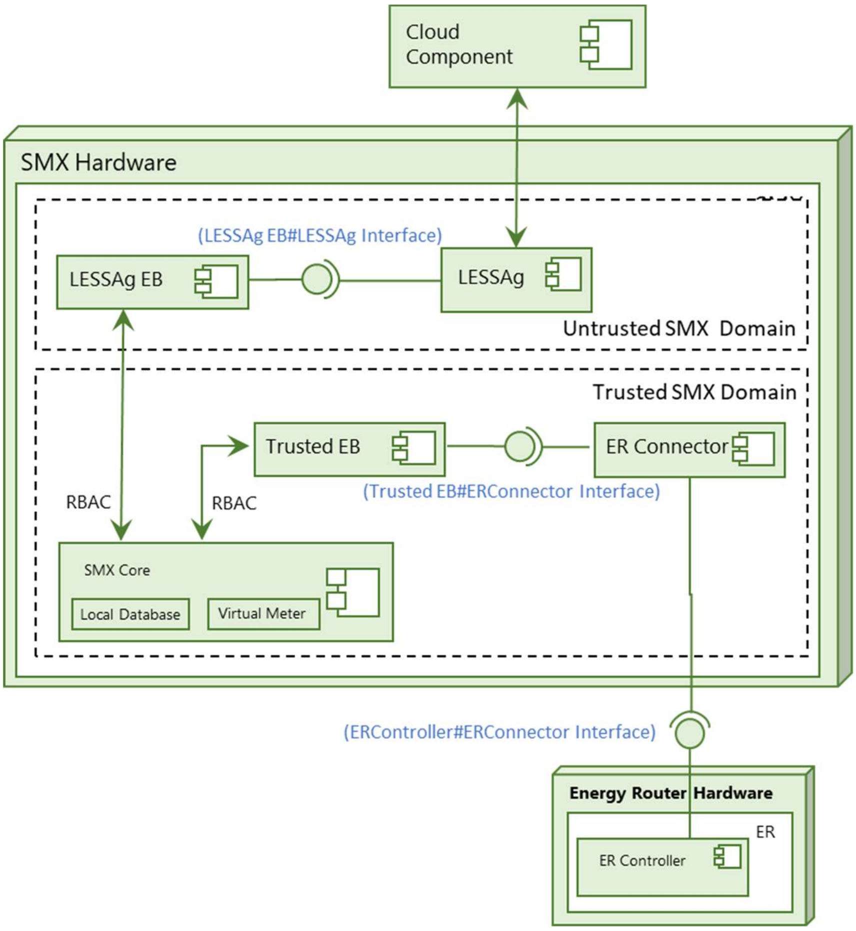


Figure 1 – D4.1 prototype diagram

For testing purposes, an algorithm[i] was implemented in the ER connector to manage the unbalanced loads in the AC grid. This algorithm measures the active power values per phase and balances the phases accordingly. To initiate the algorithm, the LESSAg receives a "LoadBalancing" command.

Since the ER hardware was not developed at the time of the evaluation, it was only possible to test the communication and the messages flow between the software components. The *LoadBalancing* command message was successfully sent to the SMX core, translated from JSON, and set-points were sent to the ER controller using the IEC 61850 protocol.
For testing purposes, a dedicated GUI interface has been additionally developed by the UPB team, enabling real-time display of the active power on each phase [W], energy [kWh], voltage [rms values], and current [rms values]. The interface will allow easy track of the information (recording by meter extension, SMX) related to the energy flow.

2.2 USM Extensions for Storage Systems (D4.8)

2.2.1 EV Charging Point Connector

A dedicated extension, namely the "EV Charging Point Connector", has been developed to integrate controllable charging points compatible with the OCPP open standard.

Such controllable charging points are normally deployed in public charging stations, but within the S4G project one of those charging points is also planned for deployment in a residential scenario.
Details are provided in D4.8, which describes the "Initial USM Extensions for Storage Systems" prototype, developed by the Storage4Grid project. Similar to other prototypes, this document provides minimal technical documentation necessary to understand the functionalities, structure and deployment instructions for the prototype of interest.

In order to preserve operation of pre-existing EV SCADA systems, this extension works as a "transparent proxy", allowing in-bound connection from the EV SCADA systems, which are transparently forwarded to the charging point. The "transparent proxy" mode has been introduced because many commercial charging point implementation only allow one single in-bound connection.

The deployment schema for the extension is depicted in Figure 2, where the full list of components involved in this type of scenarios for EV charging (e.g. the Event Broker, the Data Warehouse, etc.), together with the main remote components to be deployed when the "EV charging Point Connector" extension is used.

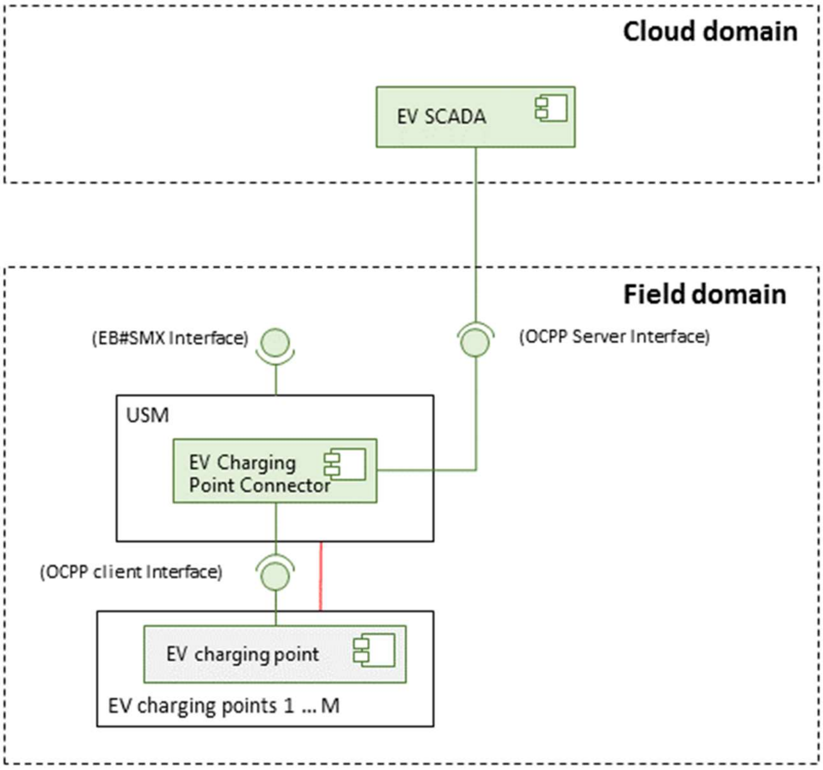


Figure 2 – Deployment schema of EV Charging Point Connector

There are three interfaces designed for this extension, which is named EV charging point connector. They are OCPP client interface, OCPP server interface and EB#SMX interface as shown in Figure 2. For this version, only the OCPP client interface and the OCPP server interface are defined. EB#SMX will be defined in the next version of the extension.

2.2.2 GESSCon#LESSAg Interface

The interface for the storage controls at user premises is given in D3.1 Section 4 Information View. The GESSCon will send a recommended load profile (DC Power) to the user side ESS Control. The user side ESS control will prioritize the charge and discharge of the battery locally with recommendation from the GESSCon.

2.2.3 GESSCon#SMX Interface

If a USM is needed without storage controls this interface shall be used only measuring active and reactive power as well as grid voltages. This interface is detailed in D3.1.

2.2.4 Extensions for integration with Residential ESS (HLUC–2 and HLUC–3)

A dedicated extension, namely the "Fronius ESS connector", has been developed to inter-connect the USM to pre-existing Fronius Hybrid inverters (and the associated storage systems) available both in the residential parts of the Fur and the Bolzano test sites.

The deployment schema for the extension is depicted in Figure 3.

Such extension is typically deployed on-board a dedicated USM (USM1), which is in-term acting as a slave of the main USM (0), hosting the LESSAg. Alternatively, the connector implements one of the interfaces available on-board the Fronius system e.g. the solarweb API or the Fronius Modbus specifications.

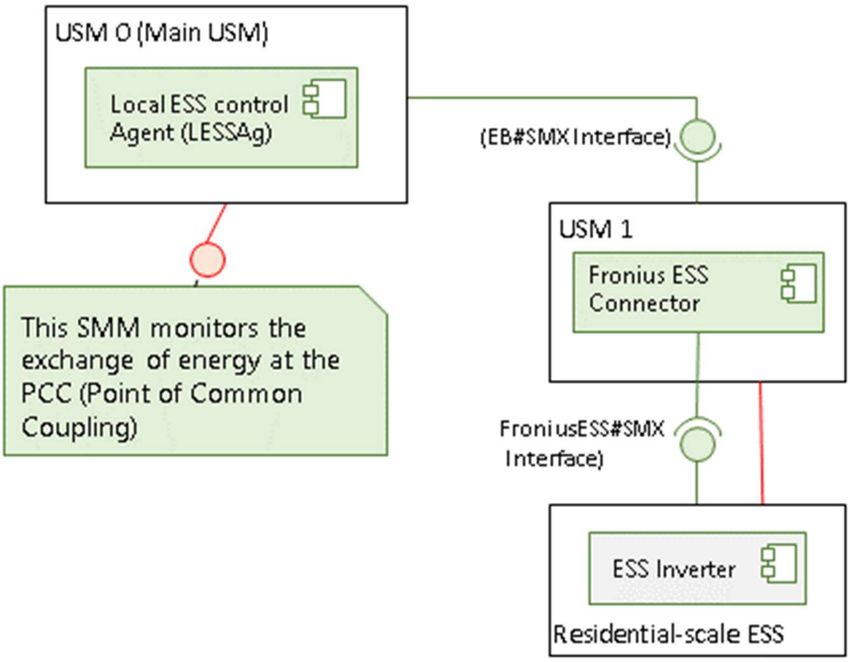


Figure 3 - Deployment schema for integration with Residential ESS

2.3 DSF Connectors for external systems and services (D5.3.)

D5.3 – "Initial DSF Connectors for external systems and services" documents the initial set of DSF connectors to be deployed in the test site. The DSF connectors include the Data Dispatcher and the Fronius Cloud Connector. Besides the two connectors, the Data Warehouse is designed as a central cloud services which acts as a data storage and analysis platform.

The DataDispatcher resides in the untrusted domain, in which extra TLS-based security strategy is adopted when it needs to publish messages to Event Broker in the cloud side via the EB#SMX interface. DataDispatcher interacts with SMX core via SMX API. The process is explained in Figure 4.

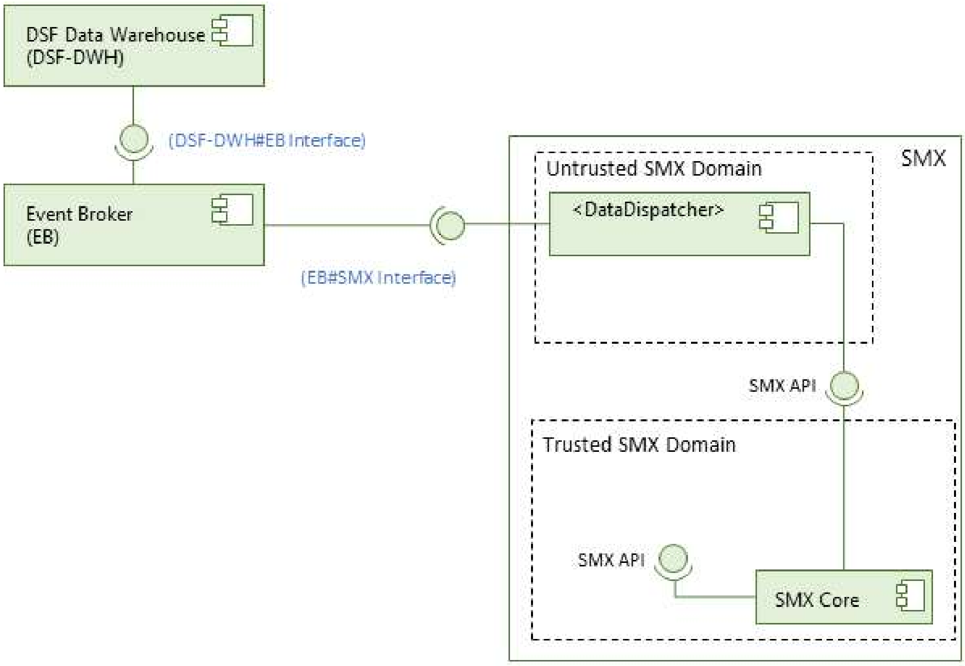


Figure 4 – Data Dispatcher Structure

As depicted in Figure 5, the Fronius Cloud Connector runs in the cloud side with the functionalities that fetching information from Solar.web which is a Fronius Hybrid System Web backend. During the interaction with Solar.Web backend, Fronius Cloud Connector collects all Fronius Hybrid System deployed in Fur and Bolzano test sites. Currently, this connector serves as a quick overview of the Fronius data collection for all test sites, which does not involve the control loop for the local Fronius Hybrid system. From Fur and Bolzano residential test site, this connector fetches all Fronius hybrid systems installed in 6 houses, these variables consist of power, home load, injected power into battery, power generated by PV and SoC. The next step is to develop a local connector which interacts with the local ESS system with control features in mind, by implementing Modbus interfaces for Fronius hybrid system

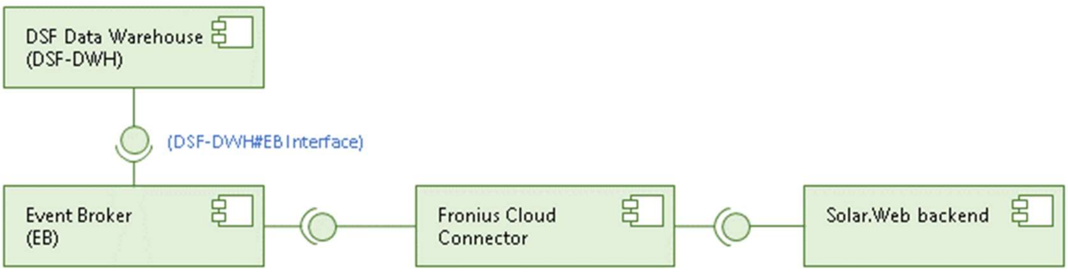


Figure 5 – Fronius Cloud Connector Structure

DSF Data Warehouse is deployed in the cloud side, running in ISMB premise. It is a key component supporting the S4G test site. As explained in D5.3, currently, Data Warehouse supports time-series data collection and virtualization. As the project proceeds, Data Warehouse will further enhance its data analysis module.

2.4 Graphical User Interfaces (D6.7)

The professional and residential interfaces were designed based on user needs collected through semi-structured interviews, through questionnaires as well as observations. The user groups and interviewees as well as the method applied to gather information are listed in Table 2, where the main results are summarized with focus on the interviews (12 participants).

Table 2 – Residential end-users split by nationality, technical set-up, and method applied for GUI development

	Method								
Group	Online Questionnaire			Interview V1			Interview V2		
PV					1		3		
PV + EV					2				
PV + Storage	4						3		
PV + EV + Storage		1							
EV						1	2		
	DK	IT	DE	DK	IT	DE	DK	IT	DE
	Current residence								

2.4.1 Residential User Interfaces

For residential interfaces, 16 end-users (one user answered the questionnaire and was additionally interviewed) were involved in the development of the prototype. The residential interfaces developed in phase 1 are further described in D 6.7 and are currently in the state of digital mock-ups. Figure 6 describes the devices used by the participants to query information about their system (interviews only, 12 participants in total). Based on the results, a web-application will be developed which is adaptable to at least smartphones and PC / laptops.

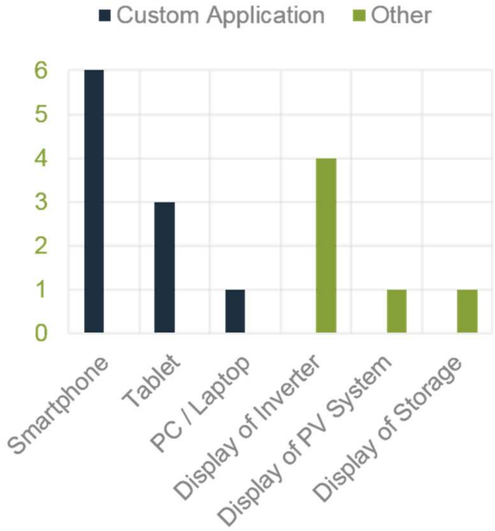


Figure 6 - Devices used by end-users to query information about the system state

Investigation on a minimum set of functions for the residential GUI

Furthermore, residential users were asked about the functionality they are using on their current interfaces, as well as positive and negative aspects of their software in use. Additionally, future functionality, such as remote-controllable storage operated by the DSO were discussed with the end-users to gain knowledge about the level of control and insight they perceive as being necessary, as well as different settings for the charge and discharge behavior of the batteries. This activity resulted in a set of functions that should be implemented in phase 2 and 3, such as “maximize self-consumption” or “prioritize car charging”. The results with respect to GUI functionality will further be described in deliverable D6.8 (M21). However, the minimum set of functions is as follows:

- Option to observe at least production, household consumption, self-consumption, energy redirected to the grid, SOC of the local storage system (must-feature, if storage is available), SOH of the local storage system (nice-to-have-feature if a local storage system is available)
- SOC of the car battery (nice-to-have-feature if the technical requirements for its implementation can be fulfilled)
- Option to analyze data over freely configurable time frames, maybe including advanced settings for highly experienced users (compare last 12 months to data before that, quarterly report, compare production according to a calculated prediction, …)
- Option to draw monthly reports about DSO accessing storage + archive of that information
- With respect to S4G’s aim: Option for energy distribution behavior / storage operation modes: maximize self-consumption (default setting), minimize cost, maximize battery lifetime, share energy with the neighborhood in case of surplus energy, prioritize car charging
- Energy flux behavior as a daily statistic (nice to have, will probably result in either updating this information to real-time information or discard it)

Evaluating DSM and energy optimization approaches regarding storage and cooperative scenarios
Further evaluation was conducted with respect to ideas investigated by the S4G project, such as cooperative energy distribution optimization in neighborhoods, storage operated by the DSO and demand side management (DSM). This evaluation was conducted with 12 to 8 users. The main results are as follows:

12 users asked (interview V1 and V2):
- Having the DSO operating the storage was ok for 7 users as long as they do not suffer drawbacks
- Investing in storage was seen skeptical by 4 of the 12 users asked; this is due to the high costs and short lifetimes of current storage systems

8 users asked (interview V2):
- Participating in a DSM program with either conventional characteristics (cheaper energy prices for certain time slots), an energy flat rate based on the flexibility provided by the user, or a cooperative approach where surplus energy is distributed within a neighborhood is ok for 8 users asked as long as there is no financial or comfort disadvantage for them
- Using the EV as additional storage system at home was ok for 6 of 8 users asked
- Offering flexibility through DSM with medium to high comfort reduction is in general ok for the users asked as long as they can define the comfort reduction themselves

2.4.2 Professional User Interfaces

The professional user interfaces were developed in collaboration with one grid planner from EDYNA (observation and semi-structured interview) and five grid planners from ENIIG (questionnaire and semi-structured interviews).

Professional GUI for grid planners and operators – DSF GUI
The resulting digital mock-up is focused on the workflow for planning future grid development and grid strengthening jointly with possible expansion simulation. This results in a graphical user interface for the

decision support framework (DSF) enabling the user to simulate different levels of penetration of storage, PV and EV in the current grid in order to proof the stability of the grid regarding voltage.
Furthermore, for grid operators, an interface to oversee the operational status of the batteries in the grid (binary information: works, does not work) will be developed.

Professional GUI for the storage coordination scenario in Bolzano
The professional user interfaces for the storage coordination scenario in Bolzano are also on a conceptual digital mock-up level. Hereby to identify users for proper evaluation is challenging. Currently, there are two possible application scenarios for a potential graphical interface: Managing the EV carpark for EDYNA, meaning that cars can be prioritized, fast-charged or charged with maximum battery-friendly behavior, as well as being charged according to the current PV production, for specific distances or percentage of battery charge. However, this functionality is hindered by the fact that the cars' APIs are not yet standardized; therefore, not every EV model supports 3rd party application interfaces. This is why crucial information like the current state of charge of the EVs in question might not be available and this application scenario is not realizable. The second possible scenario is similar to the residential GUI described in previous paragraphs, featuring load data analysis over different time frames as well as different charging and discharging algorithms for the EVs' charging points and storage systems.

3 Test site Bolzano: Cooperative EV charging

This test site features **two scenarios**: a **residential** case and a **commercial** case.

3.1 Description of Phase 1 test site and Deployment status

Residential case

The Test Site is executed in a private house close to Bolzano. The house has already a PV plant on the roof with the following technical features:

- Rated (maximal) power: 9.6 kWp;
- Average year production: approximately 11 MWh.

The PV structure in the residential case can be found in Figure 7.

Figure 7 - Test site for the residential case (Bolzano test site)

The wiring diagram of the original PV plant is depicted in Figure 8.

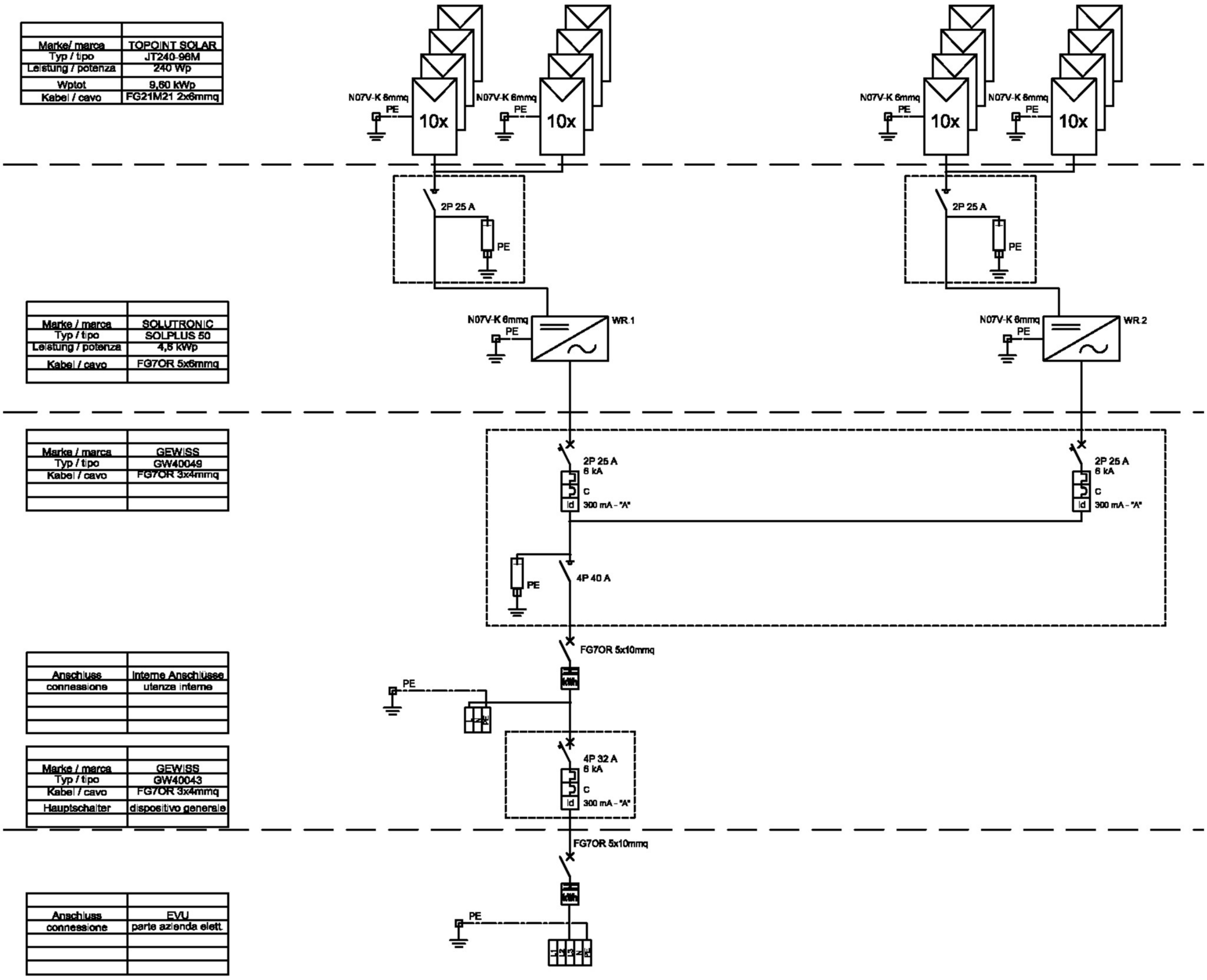


Figure 8 - Wiring diagram of the PV roof plant (Bolzano test site)

The owner of the house has got an EV with the following technical features:

- Citroen C-ZERO (02/2013);
- Li Ion Battery – capacity 14,5 kWh;
- Charger 15 A, 230 V;
- Yearly EV use: approximately 10.000 km/year;
- Range: 80/90 km (winter); 130/140 km (summer).

The EV is normally loaded at the electrical system of the house through a single-phase plug (in the house garage) as shown in Figure 9.

Figure 9 - Plug for the EV charging (Bolzano test site)

An electrician has made the necessary modifications in the customer's house to install the storage system and its inverter.

The inverter is a *Fronius Symo Hybrid 5.0-3-S*, that has a:

- 5 kW of power in discharge mode;
- The storage is a *Fronius Solar Battery* of 12 kWh, with usable capacity of 9,6 kWh

as shown in Figure 10.

Figure 10 - Inverter Fronius Symo Hybrid (Bolzano test site)

The electrician has completed the plant with a charging station of ASM, a Wall Box single phase 7.4 kW (see Figure 11), and the first LANDIS & GYR smart meter. In the coming months three more LANDIS & GYR meters will be installed. The total four LANDIS & GYR meters will be installed in parallel with the three existing EDYNA meters M1 (interconnection point), M2 (PV plant), M3 (storage) and at the charging station (no preferential load). See the installation in Figure 12.

Figure 11 - The new charging station

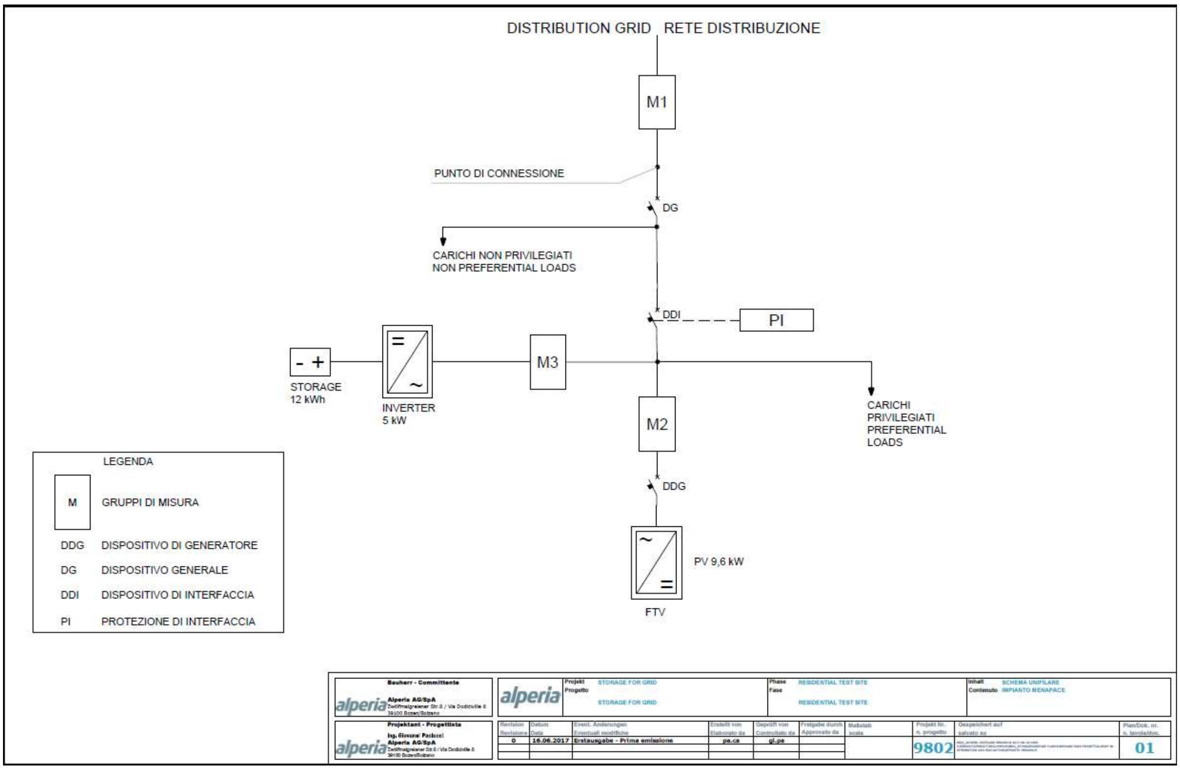


Figure 12 - Wiring diagram with EDYNA meters (Bolzano test site)

For the communication of the meters, ALPERIA is going to install a dedicated internet connection, separate from that of the owner of the house.

Commercial case

We are developing the commercial case in the garage of the South-Tyrol DSO EDYNA. Actually, EDYNA has a fleet of eleven electric vehicles: Ten VW eUP and one Nissan van. Each of these has its own place in the garage with a charging station (Figure 13). EDYNA is going to increase its electric auto park in the next years.
On the roof of the EDYNA building are installed two PV plants: one of 50 kW (peak power) and the other 99 kW (peak power). The PV plants belong to ALPERIA Green Power, a subsidiary company of ALPERIA. The energy produced by these plants goes directly into the distribution grid and can therefore, not be directly used to recharge the fleet of EV. Nevertheless, within the project, EDYNA will install two more USM in order to measure the energy produced by the PV plants and simulate the case of the direct use of this energy.
A storage unit will be installed during Phase 2 to optimize the energy supply to charging stations.

Figure 13 - EDYNA garage, the test site with the charging stations installed

3.2 Evaluation of Phase1 test site Residential

3.2.1 Interaction with local house owner

- New contract with house owner (prosumer) about installing a local energy storage system.

  A specific agreement for storage management was set up by the ALPERIA legal office. The storage installed at the residential test site remains in fact owned by ALPERIA. The agreement was presented to the house owner and have been signed by the involved parties.
  The preparation of the agreement took time due to the difficulty in complying with the Italian laws.

- Purchase and installation of the storage system.

  The storage provided by ALPERIA was installed in the test site by the electrician who had built the PV plant. There were no problems neither in the purchase nor in the installation. In the garage there is enough space for the storage and its inverter (Figure 10). The house owner is satisfied by the storage operation: now he can use the power produced by his PV for its own use, including the recharge of the electric car.

Initially, the house owner complained about the storage calibration cycle: in fact, weekly, the storage performs a complete recharge and discharge cycle to recalibrate itself. Unfortunately, at the beginning this operation took place at night, when storage is discharged and without PV production. So, storage has absorbed the power from the network, in contrast to the will of the owner and the purpose of the S4G project. A simple scheduling of the storage solved this problem.

- Installation of specific EV charger.

  For the charge of the EV, the house owner already owned a dedicated electric socket. However, this is a simple socket without control or monitoring system. For this, a new EV charger with remote control was provided by ASM and a commercial contract for its usage was stipulated.
  The new charger does not satisfy the house owner: to use it is necessary to activate it with a card supplied by ASM, whereas with the old charger it is enough to connect the socket with the car. For this reason, the house owner prefers to continue to use the old charger. Resulting from this, the real use of the new charger needs to be observed in order to be able to exactly determine when the car is being charged and how much electricity is used.

- Installation of specific meters in connection with USM extension.

  The L+G E550 meter, positively tested by UPB, was requested to the project. The purchase of these specific meters was a problem, because this meter is not sold in Italy.
  A similar meter for the real time measures, the ISKRA MT831, is available in EDYNA. The use of this meter was tested, but the results were negative.
  To solve this problem, the meters was bought in Austria through a local dealer. While waiting for their arrival, a meter provided by UPB was installed.

- A problem in the residential test site is the space: the meter compartment is already full with the fiscal meters, and the first L+G meter was installed at the bottom of the near wall (figure 15). However, here there is not enough space for the other 3 meters to be installed.

Figure 14 - The first L+G installed

- Another problem is the distance between the meter and the SMX placed inside the meter compartment as depicted in Figure 15: due to the position of the meter, the passage for the cable made by the electrician is longer than 2 m, when the cable provided by UPB is 1.8 m long. This is a special cable with a RJ45 and RS232 connectors on the two ends, the first for the meter and the other, through another connector RS232-USB, for the SMX.

Figure 15 – The meter compartment

For these reasons, the cable provided by the electrician and fixed in the wall was used for the first test, replacing at one end the RJ45 connector with the RS232.

- Implementation of DSF connectors, Access to local ESS managing system, Installation of gateway for communication

Initially the internet connection of the house was used, waiting to have an independent internet connection for the transmission of the data.
The software supplied by the manufacturer, SolarWeb and SolarLog, are used for PV production and storage data (power and state of charge). There were no problems for this data (examples in Figure 16 and Figure 17).
The data transmission from the SMM gave some problems. As previous described, these data are transmitted through the SMX, a Raspberry PI, sent to EDYNA already programmed by UPB. The first day the transmission was working, both with the cable modified by EDYNA and with the one sent by UPB (the second laid temporarily on the ground). However, already at the end of the day the data transmission was interrupted. In the subsequent intervention, the data transmission was not restored, neither with SMM nor with SMX. A subsequent analysis conducted by the experts of ISMB, UNINOVA and UPB has shown that the main problem is the connector between RS232 and USB, which tends to plug off itself by gravity.
For the next tests, it will be important to care to this connection.
To be noted that verification of the SMM functionalities relevant for this use case consists in checking the correct data acquisition and information storage via the log file in SMX. As the communication layer of the measurement information in the USM is subject of progressive developments, the continuous operation of the testing phase is considered successful when providing project useful data by reaching continuous data record of at least one week for each measurement point, not necessarily simultaneous for all measurements, in order to provide input data for the algorithms to be developed/proven.

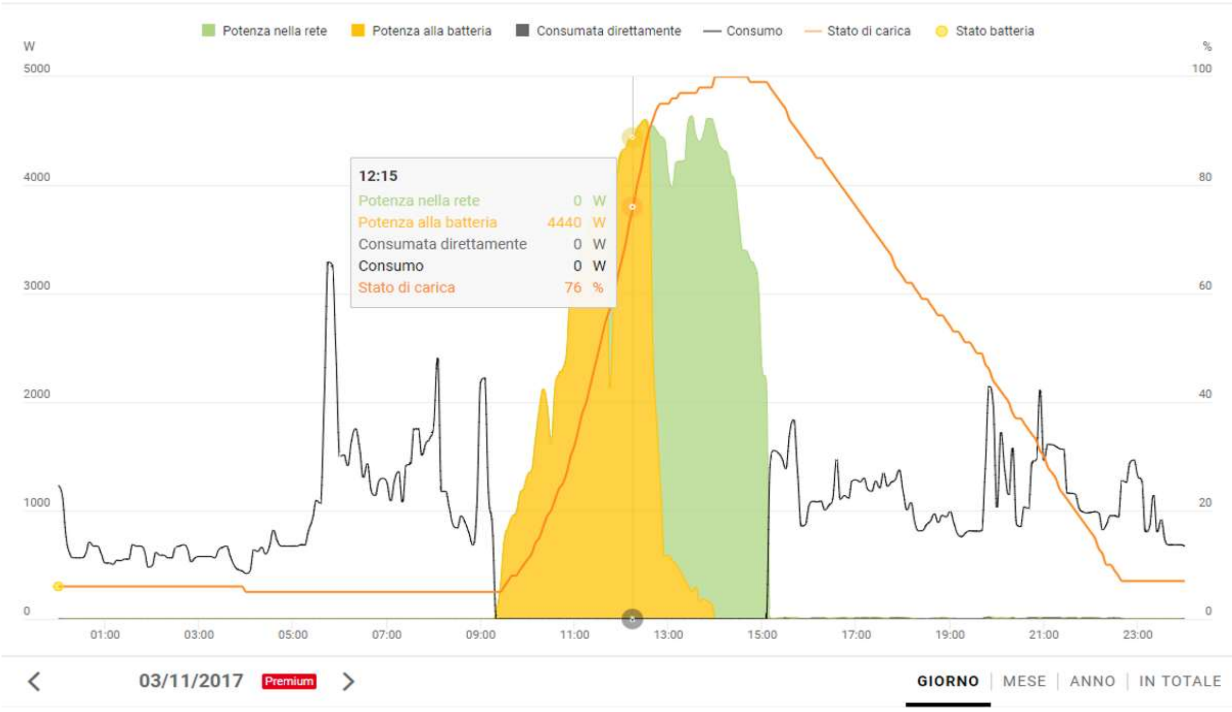


Figure 16 – SolarWeb

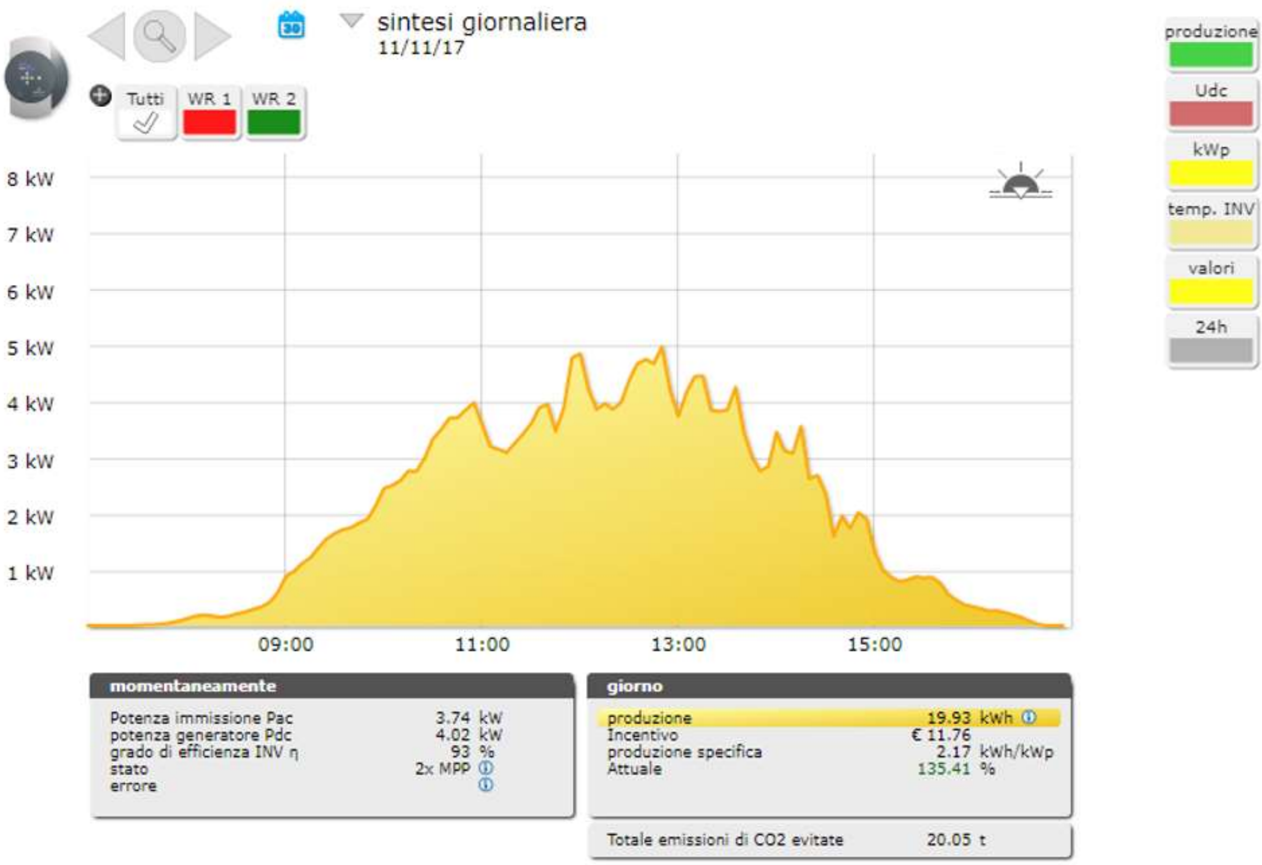


Figure 17 - SolarLog

- Introduction to local GUI for residents

  The GUI has not yet been introduced to the house owner. The presented GUI show in Figure 16 and Figure 17are the GUIs from the Fronius system.

3.2.2 Interaction at DSO, legislation

- Adjustment of the electrical circuit (Italian Technical Standard CEI 0-21)

  For the installation of the ESS in the residential test site the rules defined by the Italian Technical Standard (e.g. CEI 0-21) had to be respected, which delayed the test site installation more than expected. According to the standard and the law, it is not possible to leave temporary connections in the test site.

- Management of the administrative practice for the grid connection (EDYNA, GSE, Terna)

  The same electrician responsible for the installation of the ESS and the SMM was in charge of managing the bureaucratic procedures. The overall process was slightly delayed, but all of the plans were finally executed: the DSO (Edyna), the TSO (TERNA) and the GSE (which pays the incentives for the RES) are now informed about the new ESS installed.

3.2.3 Monitoring of available residential components deployed in the test site, using USM and DSF connector implementations.

As already described, it is not yet possible to monitor the measurements acquired from the SMM due to the problems encountered in the connection between SMX and SMM. A debugging plan has been issued for accessing directly the meter data directly, by using *GURUX DLMS Director*, which is an open-source program enabling testing of meter functionalities independent from the SMX development.

The only measures available are the productions of the PV and the state of the ESS provided by SolarWeb and SolarLog.

3.2.4 Evaluation of the first Use Case HLUC-2-PUC-1

The goal of the residential test case is to enable the house owner to maximize the self-consumption of his own production, especially to charge the EV in order to reduce the money spent on energy bought from the grid.
Although the control system is not yet ready, the owner is already satisfied with the savings obtained by being able to store his own energy. The savings will increase as soon as the peak load can be better controlled. Moreover, the same DSO will benefit in the grid management (lower power flows, lower voltage drops).

3.3 Evaluation of Phase1 test site Commercial

3.3.1 Interaction with commercial test site

- New contract between parking lot owner (EDYNA) and ALPERIA Smart Mobility about installing new wall boxes for EV charging

  For the installation of new wall boxes for EV charging a new connection with the grid for the necessary power was necessary. The new point of connection (POD) is already active and this procedure closed.

- Purchase and installation of the charging boxes

  For the project, the existing EV chargers were replaced with five smart chargers: three mono-phase of 7.4 kW and two three-phase of 22 kW (Figure 18). In addition, six non-intelligent (non-controllable) chargers are installed.

Figure 18 - The new smart charger provided by ASM

- Installation of specific meters in connection with USM extension in one or more boxes

  For the monitoring of the boxes in the project the installation of six SMM is planned: one for each smart charger and one for all the non-intelligent boxes.
  The required SMM were not yet installed due to a delivery delay.

- Implementation of DSF connectors

  This task is not yet done: in addition to the SMMs, the SMX need to be delivered. This task will be accomplished when the SMM are in place.

- Installation of gateway for communication

  For the communication, a 4G internet connection will be installed. The router and the internet key are already ready, only the SIM card is missing. Then everything will be installed in the test site.

3.3.2 Interaction with DSO

- Management of the administrative practice for the grid connection (EDYNA)

  The administrative practice for the grid connection are completed. Now ASM has its own POD. No problems encountered at this stage.

- Access to the managing system of the charging points

  ASM is able to monitor charging points using its software provided by Siemens. The EDYNA Control Room has the ability to monitor the data of all ASM charging stations, because the control room offers the assistance service to ASM customers.

3.3.3 Monitoring of available components deployed in the test site, using USM connector implementations.

As already described, the USM and the connectors are not yet installed (at the date of reporting phase in this deliverable, M16). This means that monitoring is not yet possible.

3.3.4 Evaluation of the first Use Case HLUC-2-PUC-2

The commercial case aims to evaluate the possibility to recharge a fleet of company EV with the help of a storage system. In this way, it will be possible to have the energy needed for vehicles without stressing the DSO grid.
Currently it is not possible to make any assessment of this case, since only the charging boxes have been installed, while the USM and ESS (to install in phase 2) are missing.

3.4 Evaluation of KPIs indicated in D6.1

The first set of tests for the Bolzano use-case focus on the communication between components. The KPIs are related to successful communication between the following components:

- Unbundled Smart Meter (USM) and the Smart Meter eXtension (SMX), at reporting rates of 1 to 10 seconds
- SMX and cloud applications: MQTT messages between SMX client and simulated remote MQTT client, with messages at reading rates of 10 seconds to one minute
- SMX driver for inverters, in communication with inverter, at reading intervals of 1 second to 10 seconds, with maximum accepted one minute, if the inverter interface does not allow higher (0,1 frames/s) reporting rates.

At the moment, with the communication not yet active in neither site, it was not possible to test these requirements. The evaluation is postponed to the second phase.

3.5 Lessons Learned in Bolzano test site

Problems in the smart meter supply: the Landys+Gyr meter, proposed by the University Politehnica of Bucharest, because already tested with their software, is not easy to purchase in Italy. The other meter, ISKRA, that is already available in EDYNA, does not communicate with the SMX software already developed by UPB. In EDYNA, we use the ISKRA meter with the official software, and we have no problem; however, the SMX connectivity, which is essential for the S4G project (as support for the intelligent agents), has to be ensured.

A few problems with the electrician, who did not immediately understand what he should do. Therefore, it was necessary to have more meetings with him.

Problems about the space in the residential test site: here there is not enough space for all meters to be installed and the passage for the cable between SMM and SMX is longer than the cable provided (1.8 m).

The physical connection between SMM and SMX is resulted not enough robust, so it tends to plug off and it breaks the connection. A first solution is to securely connect the two USB and RS232 connectors with duct tape or similar.

Difficult to understand the competence borders of each subject (DSO, Service Provider, Final Customer) in order to correctly state the position and ownership of the elements (meter, storage system, charging station and PV plant).

4 Test site Fur: Storage coordination

This test site features **two scenarios**: a **residential** case (year 1) and a **grid** case (year 2-3). This evaluation will focus at the residential test site and the first house, which have been selected for the first installations.

4.1 Description of Phase 1 test site and Deployment status

The test site consists of a residential house, which has already been equipped with PV plants with Fronius Hybrid inverter and Fronius battery energy storage system.
The system was originally equipped with a normal PV inverter but this was replaced with a Fronius hybrid inverter and battery energy storage in August 2015.
The system has the following specifications:

- PV: 16 modules of 195 Wp each, resulting in a total of 3.12 kWp – yearly production approx. 2,950 kWh
- Fronius Symo Hybrid 5.0-3-S
- Fronius Solar Battery 4.5 with usable energy capacity of 3.6 kWh
- Fronius Smart Meter

As an add-on to the already existing installation, the USM is installed at the Point of Common Coupling (PCC). The USM consist of a Landis+Gyr E550 smart meter that has been installed in parallel to the already existing smart meter for billing and the Fronius Smart meter and the SMX. See Figure 19 for details.
The L+G meter has been installed to give accurate measurements of P, Q and I for both upstream and downstream directions.
The SMX has been installed to pass information for the L+G meter to project database so the Fronius system can be controlled according to the use cases.
The SMX was connected to the wireless network of the customers' existing Wi-Fi router.

Figure 19 - PV modules; Electrical switchboard with Fronius Smart Meter, Fronius inverter, Fronius battery (Test site Fur)

4.2 Evaluation of Phase1 test site Residential

In this first phase, the system will be up and running in one house for preliminary test before installation in other houses. The first couple of months the system has been running without any problems.

4.2.1 Interaction with local house owner

Results from the first interaction with the first local house owners is reported in the following. The focus is at the entire process from getting the contract signed to the full installation and final data collection.

- New contract with house owner (prosumer) about controlling voltage level:

  - The contract has been presented for the first house owner. The house owner signed the contract without any complains or questions. The contract is presented in [10].
- Installation of specific meters in connection with USM extension in one house:
  - Regarding the physical installation of the Landis+Gyr meter there was a small issue regarding available wall space at the installation site. The PV inverter had to be moved a little to have enough wall space for the meter installation. Fortunately, all cables to the inverter were long enough for the moving, so this was a small issue at this site, but could potentially be a problem in other sites. Details are depicted inFigure 20.
  - 

Figure 20 - Installation of Landis+Gyr meter before and after the installation

- Implementation of DSF connectors, Installation SMX as gateway for communication, see details in Figure 21.

Figure 21 - Installation of SMX at Fur test site

- There is concerns regarding the installation of the cable connection between the SMX and the Smart Meter. The Smart Meter has a modular connector which gives access to the meters by using the RS232 interface. The SMX has a USB connector. To connect these, UPB sent us the following:
    - Cable with USB connector in both ends
    - Ethernet cable with modular connector in one end and a RS232 female connector soldered to the other end. Also the Modular connector was not crimped properly.
    - A RS232 to USB adapter (the most convenient solution)
- The SMX had already been used at UPB site, so it was preconfigured. However, when not having worked with Raspberry Pi before, there was some learnings in getting used to the command prompt and the commands in this. Also, the guides and wikis required at least some experience in the field of programming.
  This setup is not suited for installations at test sites in private homes, as it is delicate and could break. An example for installation, however, has been suggested from in-site home deployments in Bucharest, as show in Figure 22.
- Regarding the OpenVPN access to the PC, there was some problems as the operator has not used it before and did not know the architecture of it. But when the right client files for the PC was provided and understood the architecture of all PCs and SMXs being clients everything worked fine.

Figure 22 – Example of home deployment in Bucharest

- Introduction to local GUI for residents:
  - The GUI has been introduced to the house owner as preliminary mock-ups.

The actual installation at the customer was relatively easy and only with minor problems.

To be noted that verification of the SMM functionalities relevant for this use case consists in checking the correct data acquisition and information storage via the log file in SMX. As the communication layer of the measurement information in the USM is subject of progressive developments, the continuous operation of the testing phase is considered successful when providing project useful data by reaching continuous data record of at least one week, in order to provide input data for the algorithms to be developed/proven.

4.2.2 Interaction at DSO, legislation.

- Introduction to professional GUI for DSO employees
  - The GUI has been introduced to the professionals as preliminary mock-ups.

- Set-points for voltage level set by the DSO
  - The target is to keep the voltage (rms) deviation from the rated value (ΔU) within +/- 10% of 230 V (single phase connection point PCC) due to legislation and regulation demands. (207V to 253 V). Different control bands can also be considered in answer to the operation conditions of the DSO.

4.2.3 Monitoring of available residential components deployed in the test site, using USM and DSF connector implementations.

- Monitoring voltage level and controlling the battery

In Figure 23 and Figure 24 is show actual curves from the first test house. The first curve is power, the second one is voltage and the last one is current, all three phases are shown. Data is collected by the SMX, which is a required step for the second phase of the project, where the control logic (**LESSAg**) for monitoring and controlling the Fronius battery system is being implemented.

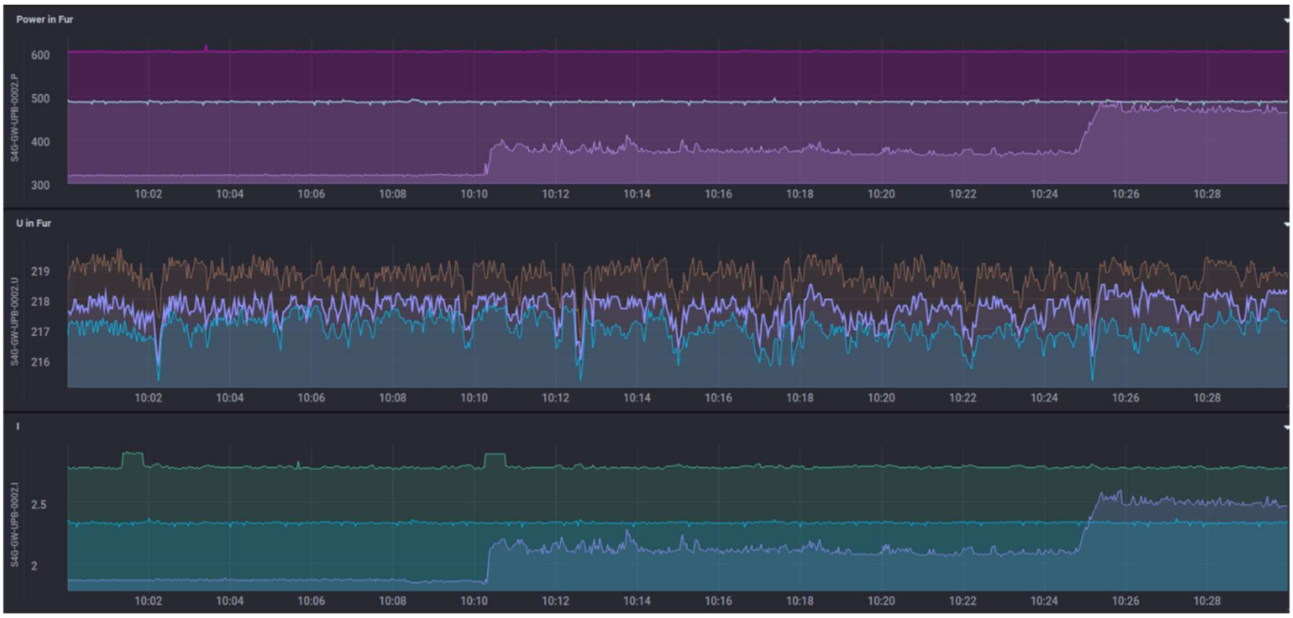


Figure 23 - Measurements from the first test house in Fur

Figure 24 - Measurements from the first test house in Fur

- **Power in Fur**: Power being taken from the grid (negative means power is being fed in the grid)
- **U in Fur**: Voltage level taken from the grid
- **I**: Actual current level in the test house
    - The power is very dependent on the current, so naturally these curves look very much alike. One phase seems to be the ordinary consumption in the house. The two other phases are almost constant consumption and may be electric heating. No investigations about how consumable are installed at the three phases has been carried out (and is not part of the project).
    - The voltage level is between 215 V and 221 V, which is inside the required threshold.

- Monitoring the combined PV and storage information given by the Fronius HI (Hybrid Inverter)

As shown in Figure 25, it is an example from the Solarweb for one house in Fur test site (we have five houses connected to SolarWeb). All the measurements are given by the Fronius SolarWeb interface. These houses have been up and running from the former project GreenCom since 2015.

Figure 25 - Measurements from the first test house in Fur

Parameters' meanings are listed as follows:

- **P_Grid**: Power being taken from the grid (negative means power is being fed in the grid)
- **P_Load**: Home load (Negative means: house is consuming energy)
- **P_Akku**: Power being injected in home by battery (negative means charging, positive means discharging)
- **P_PV**: Power being generated by the PV (always positive)
- **SOC**: percentage available in the battery (0-100%)

4.2.4 Evaluation of the first Use case HLUC-2-PUC-2; Simulation of private households investing in residential storage

This use case involves private households investing in residential storage to increase their self-sufficiency; local storage allows them to obtain more use of their own produced electricity from PV panels. These prosumers do not report the installation to Eniig and the DSO has no access or knowledge about these installations. The BMS for these storages are autonomous and run independent from the grid. The DSO cannot remotely access the different storage systems; the local settings of the consumers are regulating the energy flow. On days where the energy production of RES is higher than the local consumption, the produced overhead is first directed to the residential storage. If the storage is fully charged, the prosumer's energy is fed back into the LV grid. On the other hand, the prosumer will first use his residential storage if the energy production from the RES is lower than the actual consumption. If the storage is empty, the prosumer will consume energy from the grid. This positively affects the costs for the prosumer, since his demand is lower compared to households without storage and RES. These local storages and BMSs run independent from the grid.

Results from the former EU-project Greencom[ii] are:

- Yearly average self-sufficiency is 38% in 2016 (Aug 74% and Dec 2.6%)
- The houses consumes in average 60% of own produced electricity in 2016
- The storage reduces typically the peak-load in 50-70% (autonomous)
- The storage runs one cycle a day.

The PV systems are between 4.68 kWp and 5.85 kWp. The yearly consumption in the houses is between 4.365 kWh/year and 6.460 kWh/year. Storage is 3.6 kWh effective.

This business model is up and running. Storage4Grid monitors voltage, current and power in the first house. By establishing the voltage control, this business model is ready to be evolved to HLUC-3-PUC-4-BM-1 “Autonomous” voltage control at household battery”.

4.3 Evaluation of KPIs indicated in D6.1.

The first set of tests for the Fur use case were focused on the communication between components. The KPIs therefore relate to successful communication between the following components:

- Unbundled Smart Meter (USM) and the Smart Meter eXtension (SMX), at rates of 1 to 10 seconds
- SMX and cloud applications: MQTT messages between SMX client and simulated remote MQTT client, with messages at rates of 10 seconds to one minute

The communication between these components has been implemented with successfully.

- SMX driver for inverters, in communication with the hybrid inverter, at rates of 1 second to 10 seconds, with maximum accepted one minute, if the inverter interface does not allow higher rates.

This driver is postponed to phase 2.

4.4 Lessons Learned in Fur test site

Purchasing the first meter turned out to be quite a challenge. The recommended Landis+Gyr meter is not easy to purchase in Denmark, because it cannot be used for billing purposes and is therefore not allowed in Denmark. Due to the problems with sourcing a useable meter, UPB was kind to lend us a meter that could be used for test phase 1.
The physical installation of the meter also turned out to be a challenge. Since there was not enough wall place for the new meter we had to move the inverter to get enough room.
We also faced some issues about setting up the SMX, since the guidelines have been written for professionals and we had not worked with any such before. This was also true for the OpenVPN access to the PC.

5 Test site UPB: Cooperative Storage System Scenario

5.1 Description of Phase 1 test site

This test site is executed in a laboratory setting and features a home hybrid energy system with DC bus, which will support prosumer functionality, including resilience and services the DSO operation. The energy exchange in point of common coupling (PCC) is monitored 24/7. The equipment to be deployed are USM (SMX + meter), energy router, and telecommunication equipment which may also allow different services to support the grids. To ensure that the local DC grid will be able to supply its critical (local) loads also during small AC voltage interruptions or during black-outs (the inverter connection to the grid will be kept un-operational during this period) it needs to be implemented a local agent which can control the local resources, including the storage.

5.2 Evaluation of Phase 1 test site Bucharest

5.2.1 Evaluation of the set-up

In the phase 1 test site only a part of the entire components was installed or adapted for the use cases of the project:

- 2 SMX which communicate in both downstream and upstream directions (Figure 26), as follow:
    - Downstream to the ER, the SMX has the role of emulating (in a first phase) communication of set points to ER, allowing in this way to send and read information.
    - Downstream to a single-phase meter - Landis+Gyr with the scope of acquiring the measurement values (voltage - U, power – P, etc.) every 10 seconds from the system.
    - Upstream, using Message Queuing Telemetry Transport (MQTT) messages towards cloud applications, e.g. GessCON.

Figure 26 – SMX box and details of SMX

- Landis+Gyr ZMG310 meter was installed to measure the point of common coupling ()Figure 27. The additional meter and SMX are available in the laboratory to test meter to submeter communication (main USM to another USM).

a) b)

Figure 27 - Landis+Gyr meter (a) uninstalled and b) installed and connected to a Raspberry PI)

- Eight PV panels of 130 W each – *Kyocera*, mounted four in series and the two sets in parallel (Figure 28). The power of this system is 1040 W, approximately 1 kW. The revised setup of the laboratory is considering two different PCCs of the available PV, each of 500 W (peak power), in order to test the efficiency of the proposed components (with ER) and solution against an existing use with industrial MPPT.

Figure 28 – PV panels (UPB Electrical Engineering Faculty rooftop)

- Four valve-regulated lead-acid (VRLA) batteries *Ultracell UCG* with a nominal voltage of 12V and a nominal capacity of 250Ah ()Figure 29.

Figure 29 – VRLA battery

- One Steca Tarom hybrid charge controller (Figure 30) which represents a temporary setup before ER will be delivered, in order to test basic functionalities.

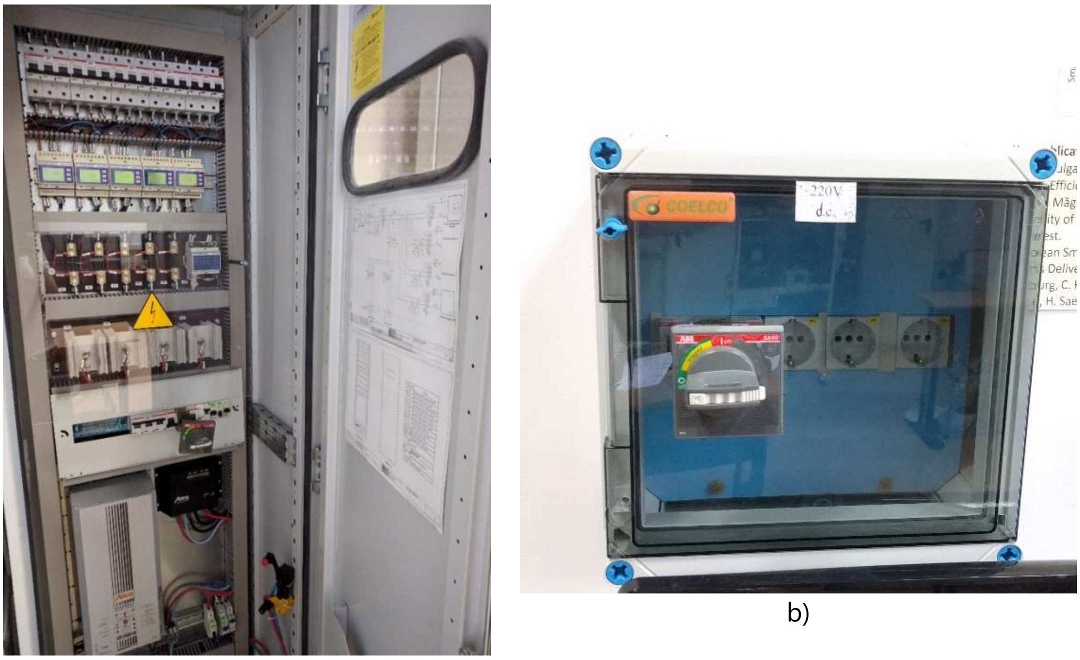
Figure 30 –Steca Tarom hybrid charge controller

- ER communication driver is implemented in SMX (based on RPI3 single-board computer) which communicates with the ER intelligence (ER communication controller) as being a RPI3 with a pair driver (Figure 31). It is thus simulated in an early stage the communication between SMX and ER.

Figure 31 - ER communication microcontroller

- First version of the local agent – LESSAg, storing measurements and other information, as a local data collection of the data which will become available during the development (State of Charge (SoC), number of cycles - N, etc.). LESSAg runs on the SMX of the main USM (mounted at PCC). The local agent is in an initial stage of development and is built around general modules of SMXCore with added specific intelligence in module implementing LESSAg functionality. The LESSAg functionality is intended to be moved in a separate software module and communicate with SMXcore, as its development is progressing.

- DC bus with local loads (directly connected to DC) for ensuring local resilience (Figure 32).



a) b)

Figure 32 – a) DC bus with local loads and b) DC plugs

- Neighbor laboratory where an additional DC bus will supply loads appropriate for being supplied in DC (approximately 300m from primary laboratory), demonstrating the "resilient community" feature (Figure 33).

Figure 33 – Neighbor laboratory to host the second DC-bus

In a first phase, the loads are connected to the AC bus only and the entire laboratory will be controlled as "load only".

- Subcomponents to be used in modules for transmitting energy in DC between the main laboratory and the neighbor laboratory (Figure 34).

Figure 34 – Subcomponents for DC-DC conversion

In the first phase, the UPB test site focused on the scenario HLUC-1-PUC–2, where the prosumer (ASRP) is only seen as a load (consuming as much as possible from his RES energy production) and will not back-generate surplus energy (becoming a Uni-directional Resilient Consumer - UniRCon). This will accomplish based on the optimal management of all components or actors implicated: ER, PV panels, batteries, DC loads, and AC loads. The energy management will be implemented in such a way that the energy consumed (Pconsumed) by the DSO will always be either null or higher than zero (≥0). The use case HLUC-1-PUC–2 will be emulated in a numerical program for a set of variables emulating 24 hours of operation (96 intervals of 15 minutes).

5.2.2 Evaluation of simulation, data collection, monitoring and results

- First, UPB will establish the studied scenario- HLUC-1-PUC–2;
- Then a simulation will be made for one data set (generation data collected for 15 minutes from the PV), will be executed;
- Emulation of the transferred data between equipment – UPB will ensure that the information exchange channels are functional;
- In final stage, the results will be compared to the results obtained from the simulation;
- In the end, UPB will repeat all steps for other selected data sets typical for one day (set of variables emulating 24 hours of operation containing 96 intervals of 15 minutes).

5.2.3 Evaluation of the first use-case/business case HLUC-1 PUC–2

This use case introduces a new approach for managing the energy transfer towards prosumers making use of a smart management of the local energy storage. The proposed grid design (including storage dimensioning procedure) is based on several operation scenarios in which the prosumer is operating as a "load only" entity (from grid perspective) exhibiting self-resilience and higher energy efficiency. One of the major advantages of this restriction in prosumer operation is the preservation of resilience against changing regulatory environment. This case is taking in consideration three possible aspects: the customer is buying PV and storage with the intention of receiving from the state green certificates (for PV). However, when the state plan is ending, the intention is to maximize the initial investment by using the price differences between the local generation grid-based consumption. This situation is enabled by grid parity attendance (local generation becomes cheaper than grid-supplied energy); the customer is buying PV and storage systems because he does not want to remain without energy in case of a voltage gap/blackout. With this solution, he aims to become resilient or even immune to grid outages, being locally supplied until entire local stored energy is used. The green certificates are not seen as an objective; the customer is buying PV and storage because he does not want to consume energy from the grid and support this market which involves reduction of green gas emissions. He wants to use as much as possible only RES-based electricity energy sources.

The solution resulting in ensuring a load-only pattern on distribution grid side for an existing prosumer, by adding the storage unit and an intelligent ER, is superior to classic net-metering, with or without storage behind the meter, in the following main aspects: savings attractiveness through complete self-consumption of own renewable energy in a grid-parity environment and in resilience against grid power outages changes.

5.3 Evaluation of KPI's indicated in D6.1.

The first set of tests for the Bucharest use case focused on the communication between components. The KPIs are related to successful communication between the following components:

- Smart Meter (USM) and the Smart Meter eXtension (SMX), at reporting intervals of 1 to 10 seconds
- SMX and cloud applications: MQTT messages between SMX client and simulated remote MQTT client, with messages at rates of 10 seconds to one minute
- SMX driver for the energy router (ER), in communication with the energy router, at rates of 1 second to 10 seconds. This rate of communication will be possible based on the fact that ER is developed in the project and can fulfil high level requests as requirements for the ER design.

To be noted that verification of the SMM functionalities relevant for the UPB use cases consists in checking the correct data acquisition and information storage via the log file in SMX. As the communication layer of the measurement information in the USM is subject of progressive developments, the continuous operation of the testing phase is considered successful when providing project useful data by reaching continuous data record of at least one week for each measurement point, not necessarily simultaneous for all measurements, in order to provide input data for the algorithms to be developed/proven.

5.4 Lessons Learned in Bucharest test site

As being in preparations for a first setup, a first problem is related to the DC connection between the two laboratories. The team is working to find appropriate pathways for the DC connection at a distance of around 300 meters, such that it does not disturb communication cables and can be easier mounted. Lessons Learned will follow based on the solutions which will allow proper transmission of power while not disturbing other activities.

A second problem that our team faced in the initial activities concerning the test site deployments consisted in an over voltage level in initial connection of PV, destroying some input protection components (a diode/Steca charge controller), the components needing to be changed. The team considers adding an overvoltage protection between the PV panels and the power electronics.

A third problem was related to the total voltage of batteries, which is now 48 V (four 12 V batteries in series) and need to be doubled, such that the DC-DC convertor voltage between the local DC bus and batteries are in a proper ratio, meaning less than 3 to 1. This requires additional four batteries to be connected in series, in order to attend 96 V DC, which should allow a more efficient connection to the DC bus.

6 Status of year 1 KPI's

Table 3 gives the status of Key Performance Indicators for the first year.

Table 3 – KPIs for first year

Obj.	Main WPs and partners Involved	Indicator	Y1 Target	Status
TO1	WP4, WP5, WP6	Prototypes supporting S4G interfaces and Models for storage coordination	4	These 4 prototypes have been developed: D4.1-v1.0; Initial User-side ESS control system D4.8 - v0.1; Initial USM Extensions for Storage Systems D5.3 v1.0; Initial DSF Connectors for external systems and services D6.7 - v0.1; Initial Interface for Professional and Residential users
TO2	WP4	Sets of distributed and centralized storage control algorithms prototypes developed	2	This KPI is achieved in Bucharest test site by simulating a simplified local storage control algorithm for an advanced self-resilient prosumer becoming UniRCon (HLUC1-PUC2)
TO2	WP4	Systems embedding S4G predictive control algorithms	1	This KPI is not achieved
TO2	WP4	Systems considered by the S4G predictive control algorithms	Residential storage	This KPI is not achieved
TO3	WP4 (T4.4) + WP6	Test deployment of Unbundled Smart Meter prototypes	Bucharest	T03 is fulfilled This KPI is reached in Bucharest Test site
TO3	WP4 WP4 (T4.4) + WP6	Systems fully integrated with the unbundled smart meter	Home (production and consumption) meters	This KPI had been achieved as follows: Fur in the Point Common Coupling (net-metering) Bolzano in the Point Common Coupling (net-metering)
TO4	WP4 + WP6	Test deployments of Energy Router prototypes	0	No KPI's in year 1
TO5	WP5	Availability of DSF components	most of components of DSF are available	This KPI had been achieved
TO5	WP5	DSF Features supported	Analysis by simulation	This KPI had been achieved (D5.1. Initial DSF Hybrid Simulation Engine)
TO6	WP2, WP6	Number of different cases evaluated in test sites Bucharest/Bolzano/Fur	1	Evaluated implementation of use cases on user side based on paper prototypes and interviews
SO1	WP6	Number of residential/professional users engaged in test sites	5 residential 2 professional	1 residential in Fur and 1 residential in Bolzano are engaged and have both got installed the new meter. Furthermore, are 4 more residential's in Fur ready. Residential in both test sites (ENIIG (12) and EDYNA (4)) have both provided input to the residential GUI Professionals in both test sites (ENIIG (5) and EDYNA (1)) have provided input to the professional GUI.
SO2	WP7	Number of Business cases proposed/evaluated	1	In the Bolzano test site was made an evaluation based on questionnaires and user interviews.
SO3	WP6	Number of complete techno-economic planning cases analyzed using the DSF	(early proof of concept using DSF)	The Baseline has been defined

SO4	WP3 (T3.1 and T3.4) WP7 (T7.3)	Number of inputs proposed to EU or regional policy- related, traditional or open standardization initiatives	Early gap analysis internally available	This KPI has been achieved and reported in D3.1.
SO5	WP2 (T2.3), WP3 (T3.4), WP7 (T7.3, T7.4)	Number of inputs, Lessons Learned and recommendations published towards security- and privacy-related initiatives	Early inputs internally available	Lessons Learned for Year1 is available, No Recommendations have been published

7 Summary of year 1 Lessons Learned

7.1 The S4G Lessons Learned Process

The Storage4Grid Lessons Learned process has six steps:

1. **Collection**: focuses on collecting LL from many sources internal and external to the project. To be undertaken in all WPs. The LL are collected and maintained centralized on a Wiki page: https://confluence.fit.fraunhofer.de/confluence/pages/viewpage.action?spaceKey=S4G&title=Lessons+Learned+Repository
2. **Verification**: all LL must be verified for correctness, significance, validity, and applicability. The verification will be performed by the corresponding WP leaders. The WP leader will decide to add and remove Lessons Learned for the related WP as necessary.
3. **Storage**: LL will be stored on this wiki page.
4. **Dissemination**: all project workers are encouraged to continuously consult the LL repository, not only with the purpose of reporting, but also to continuously follow LL reported by other project partners. LL will also be documented in D2.5, D2.6, and D2.7.
5. **Reuse**: the WP leaders have a responsibility to consult the LL repository regularly and at least before any major decision affecting the scientific work and the project outcomes is to be made.
6. **Identification of improvement opportunity**: from the Lessons Learned, relevant new and/or updated requirements will be extracted. The concerning Work Package Leader will evaluate and describe the impact on the future development work arising from the re-engineered requirements and report this in the deliverable which follow the present one, namely D2.6 and D2.7 (Updated as well as Final Lessons Learned and Requirements Report).

After the successful completion of a prototype cycle, each work package will analyze and report their development results, experiences, Lessons Learned in the development and integration work and other relevant knowledge gained during the development cycle. Moreover, knowledge gained from formal testing and system integration will be collected together with the latest developments in technology, regulatory affairs and markets, which influence Storage4Grid and its exploitability.

As part of the continuous improvement program adopted by the Storage4Grid project, a systematic and continuous collection, indexing and dissemination of Lessons Learned will be undertaken in WP2.

7.2 The S4G Lessons Learned (LL) Criteria & Category

For the purpose of verification (step 2 described above) following **criteria** are to be analyzed:

- Relationship with the project flow
- Relevance to the project outcome
- Significance in terms of quality parameters such as robustness, ease of use, functionality
- Research aids used
- Systemic process issues.

When creating LL into the LL repository in the Wiki, the following codes for **category** are to be used:

- RTD: Research oriented
- PRO: Process oriented
- SWD: Software development experience
- ARC: Architecture oriented
- NET: Network oriented
- SEC: Security oriented

- TST: Testing result
- INT: Integration experience
- VAL: Validation experience
- REG: Regulatory
- IWU: Interaction with (end) user
- DIS: Dissemination and Exploitation.

7.3 WP2 Lessons Learned

Table 4 - WP2 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s)affected
PRO	ENIIG	The process of deciding when to reinforce in the low voltage grid is not well described.	The decision of when to reinforce is subjective.	We need to decide a process and framework for decision in order to be able to use it as baseline and decision Tool.	S4G-4 - Authenticate to see issue details
PRO	Edyna	To elaborate an optimal business case several competences are needed.	Is difficult to involve the people with different competences in an advanced stage of the project	Various departments inside the company should be involved from the beginning of the project: technical department, legal and regulatory department, trading department and business development department.	
PRO	FIT	For high-quality requirements, regular workshops are needed.	It is difficult to involve partners into requirements gathering without supervising.	After a first set of initial requirements has been collected, regular meetings and workshops with all partners involved are necessary to spread the knowledge and enhance the quality of the collected requirements.	

PRO	FIT	Initial steps for requirements elicitation and documentation need to be done collaboratively with all partners involved.	It is necessary for all partners to be involved in initial requirements documentation and get a sense of ownership.	The work package regarding requirements elicitation is led by one partner who is more experienced in the process, but the contents should be provided by all partners.	
PRO	FIT	A tool for organizing and maintaining requirements is mandatory (in our case JIRA).	Organizing, documenting and maintaining requirements is much easier with the support of a dedicated software tool.	When several partners in geographically distributed teams work in a project, requirements elicitation should be supported by a software tool, otherwise the whole activity can get out of control. The transition to the software development phase is much easier.	
PRO	FIT	An introductory training workshop to JIRA is mandatory for all partners.	Partners need to learn how to operate and use the requirements organizing tool to an extent that they are able to fill, understand, and maintain their requirements.	As an ice-breaking measure an introductory training to JIRA results in more commitment from the partners to actively use the tool. Overall, it is good invested time (one hour or so).	

7.4 WP3 Lessons Learned

Table 5 - WP3 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s) affected

RTD	UPB	There are functionalities which need components at different levels: local control, DSF, ESS and cooperative charging	Clarify split of functionalities between local control, DSF, ESS and cooperative charging	Clear split is needed in the architecture phase	S4G-all
PRO, RTD	UPB	The way how to manage the power equilibrium onof the local DC bus of Energy Router (ER) in HLUC1 not yet well clarified.	There are several ways of controlling a DC bus functionality	We need to use an initial approach and to decide on future variations, based on tests made.	S4G-27
RTD	UPB	The way how to manage DC energy exchange with neighborhood is not well clarified	There are several ways of controlling a DC bus exchanging energy with neighborhood	We need to use an initial approach and to decide on future variations, based on tests made.	S4G-27
RTD	UPB	A local integration of storage control for EV chargers is difficult because of proprietary software for its control	Control of proprietary EV chargers with storage resources may need the interaction with the software of the provider. It is needed that at purchase of the solution to be asked as mandatory such possibility of interaction	A control functionality can be made through a software portal of the charging points solution	S4G-35
ARC, SWD	FIT	Following standards while designing the software architecture increases the reusability and conformance of the end product.	Using the accepted ISO/IEC/IEEE 42010:2011(E) standard to describe software architecture pays off.	There is a bit of a learning curve of the standard, but it is steep enough. When all partners are committed to it, the work flows smoothly and there is a clear, common language amount partners.	
PRO	FIT	For the initial architecture, a physical face-to-face-meeting with a dedicated workshop over several hours is necessary, ideally within the first 6 months after project start.	It is important to clear out doubts and design the SW architecture early enough.	Before partners initiate SW development activities, it is important to set a common ground on the SW architecture. This can still be changed, but it shouldn't need radical changes. So enough time for face-to-face discussions in the light of described scenarios should be foreseen.	

PRO	FIT	It is helpful if one person with a high expertise in system architecture coordinates the initial architecture workshop.	Ideally, somebody with SW architecture expertise should lead the work on SW architecture.	SW architecture work is important and should be handled as such. Radical changes in SW architecture are difficult to be done because of their implications are manifold, so they should be avoided. Having the architectural work be led by somebody with experience is recommended.	

7.5 WP4 Lessons Learned

Table 6 - WP4 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s)affected
RTD	UPB	It is not clear yet well how the Grid-side ESS control can take advantage of both grid-ESS and local ESS and what data is needed from DSF	A clear setup of the typical ESS usage is needed: grid-ESS points and capacity, local ESS, network topology and constraints, scaling method to simulate high RES penetration and corresponding high ESS	Investigate situations how the grid-side ESS is useful for high penetration of RES –based electricity production and avoidance of network reinforcement. Provide KPIs	S4G-31 S4G-33
RTD	UPB	It is not clear yet well how the cooperative charging can be applied for an EV charging station	A clear setup of the typical charging station is needed: charging points, available local storage, network constraints	Investigate situations how the cooperative behavior is useful for high level of charging services and avoidance of network reinforcement. Provide KPIs	S4G-5
PRO	FIT	Continuous collaborative work is very important to clarify open questions and misunderstandings already in the concept phase.	An open and direct communication between all involved partners is important while analyzing and developing the system. Doubts, misunderstandings	Expansion of communication ways such as teleconferences, personal meetings, common documentation tools (e.g. Confluence), etc.	

			and implementation problems can be successfully treated and optimal solutions can be found		

7.6 WP5 Lessons Learned

Table 7 - WP5 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s)affected
ARC	ISMB	While designing control-oriented use cases, it is difficult to distinguish what should be estimated by simulation and what can be directly implemented by control strategies.	In general, control strategies can benefit from receiving information from DSF tools e.g. "optimal" set-points. This can be done by specifying some pre-defined parametric simulations, which can be programmatically activated (e.g. via some open APIs) by remote components	The role of DSF components and ESS control systems must be clearly detailed to avoid confusion and make scenarios very complex. It is also important to be aware about the complexity of the chosen "pre-defined parametric simulation", because control systems normally do not expect delayed answers.	S4G-43 - Authenticate to see issue details S4G-44 - Authenticate to see issue details
ARC	ISMB	An open framework (e.g. FMI, HLA or Mosaik) shall be used to coordinate heterogeneous simulators	In order to deliver its objectives, the DSF will need to use several existing simulation tools.	It is important to avoid to "reinvent the wheel" as many (open and proprietary) simulation tools exist which partially cover one or more of S4G use cases.	S4G-12 - Authenticate to see issue details
SEC	ISMB	There should be a definition of personal data, in order to analyse the potential	Directive 95/46/EC (General Data Protection Regulation) defines the concept of personal data, S4G	Once private data is identified and collected, it is important to keep track of its source e.g. by adding some	S4G-15 - Authenticate to see issue details → S4G-37 - Authenticate to see issue details

		private issues with a baseline.	defines four categories of personal data: Personal details, Personal details, Personal details and Measurements, and infrastructure-related data, which in turn could define corresponding data management roles.	meta-data which clearly specify the owner and the privacy sensitivity of data.	
SEC	ISMB	When personal data will be collected, and processed, it will be subject to privacy regulations. This require some automatic procedure to be implemented.	Procedures for data collection storage, protection, preservation, transfer, destruction should be detailed. The user must be aware of these procedures. Creates appropriate data preservation procedures. Procedures related to data-merging or exchange plans need to be detailed. Procedures about commercial exploitation of data sets need to be clarified. Define data safety procedures (protective measures to avoid unforeseen usage or disclosure, including mosaic effect, i.e. obtaining identification by merging multiple sources).	Most of the data is anonymised during the collection process, and treated as anonymous data by the majority of the consortium, the link between anonymised data and identities of associated user is maintained by a limited number of employees of two consortium members. Data collection procedure: Two procedures will be used for data collection, namely "interviews" and "automatic data collection procedures". Through interviews, personal details and preferences are collected. For automatic data collection, data is measured by automatic devices and sent to a private server. Data are stored in three main storage systems: personal	S4G-39 - Authenticate to see issue details S4G-41 - Authenticate to see issue details S4G-42 - Authenticate to see issue details

				details, preferences and measurement and infrastructure-related data. The first two use unstructured data format while the third one uses structured format by exploring time series data mostly. They are periodically subject to back-up in an encrypted way. Data protection procedure: data are secured by using the state of the art standards. Data preservation: S4G project only manages types of data which, according to current regulations, are not affected by data retention obligations. In case users want to quit the project, these users' data should be hard to recover.	
SEC	ISMB	When it involves tracking or observation of participants, ethics issues arise	There is the possibility that the data we collect during the project could be used in the future for enabling methods that can be used for tracking or observing participants, even if we don't do it at the current stage. Because of this, all data must be anonymised and access to all sensitive information must be secured.	Users will not be monitored automatically, nor observed during their usage of the system. Due to technical reason, the project will necessary log technical information which can be in general associated to users (e.g. IP addresses, log-in attempts, etc.). As tracking user behavior, externally is outside the scope and methodology of	S4G-38 - Authenticate to see issue details

				the project, such information will only be used for technical purposes e.g. to verify that no performance problems are affecting the system. Any other types of evaluations will be performed by means of interviews and workshops – where users are directly asked about their preference and expectation, instead of being passively monitored.	
		If further processing of previously collected personal data is needed, ethics issues may arise.	Details on the database used or of the source of the data. Details of your procedures for data processing. Details of your data safety procedures (protective measures to avoid unforeseen, usage or disclosure, including mosaic effect, i.e. obtaining identification by merging multiple sources). Confirm that data is openly and publicly accessible or that consent for secondary use has been obtained (and details of how this consent was obtained (automatic opt-in, etc.)). Confirm permissions by the owner/manager of the data sets.	Due to the research nature of the project, it is likely that preferences or measurements, and infrastructure-related data will be relevant for publication in international scientific journal or papers, as well as in public Storage4Grid deliverables. In such case, all data will be published in aggregated and anonymised form – so that no sensitive data whatsoever is released. Users are informed of these opportunities at the beginning of the project. Beyond research purposes, no commercial exploitation of data collected by the project is foreseen –	S4G-40 - Authenticate to see issue details

				including transfer of data for commercial purposes to third parties. No transfer of data outside the EU is foreseen.	
IWU, RTD	FIT	For developing the DSF, specifying an end-user application scenario is inevitable.	There is already no documented scenario that defines the function of the DSF from a user point of view. It is difficult the development of the DSF by the developer because its function can be really wide.	It is important to define and document both technical and professional scenarios for the DSF, so the development of this tool converge into a system. Otherwise the DSF is going to remain as a general tool, unable to cope with requirements of the users working with it.	

7.7 WP6 Lessons Learned

Table 8 - WP6 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s)affected
PRO	UPB	There is not proper metering on sites in order to implement USM concept.	It is needed a quick investigation for finding the appropriate commercial meter which is compatible with SMX	It is needed to be decided in early stage (M7-9) the solution for a project related commercial meter to be integrated with SMX in each site.	S4G-46
PRO	UPB	Initial activities concerning the test site deployments consisted in an over voltage level in initial connection of PV, destroying some inputs protection components (a diode/Steca charge controller), the components needing to be changed. (based on D6.4)	Always consider protection equipment when important components can be affected in case of an error.	The team considers adding an overvoltage protection between the PV panels and the power electronics.	

PRO	UPB	The total voltage of batteries, which is now 48 V (four 12 V batteries in series) and need to be doubled, such that the DC-DC convertor voltage between the local DC bus and batteries are in a proper ratio, meaning less than 3 to 1. (based on D6.4)	The DC-DC convertor voltage between the local DC bus and batteries needs to be in a proper ratio.	This requires additional four batteries to be connected in series, in order to attend 96 V DC, which should allow a more efficient connection to the DC bus.	
PRO	Eniig	Not possible to buy the recommended LANDIS & GYR meter in Denmark, because it is not legal for billing	We had to investigate in more European countries to find the right meters	The USM concept should be more flexible, and be able to communicate with more meters	
PRO	Eniig	Physical installation: there was not enough wall space to the meter	We had to remove the inverter to find enough place	Be aware of enough wall space for future installations and that cables is long enough when moved	
PRO	Eniig, Edyna	Cable connection between the SMX and the Smart meter The SMX has a USB connector. To connect these, UPB send us the following: 1. Cable with USB connector in both ends Ethernet cable with modular connector in one end and a RS232 female connector soldered to the other end. Also the Modular connector was not crimped properly.	This setup is not suited for installations at test sites in private homes, as it's delicate and could break	Use a modular connector to USB adapter in the future and then use a prefabricated Ethernet path cable in the correct length.	

		3. A RS232 to USB adapter (the most convenient solution)			
PRO	Eniig	Setting up the SMX and the connection to this	As the SMX had already been used at UPB site, this was preconfigured, so this was not a big issue. However, when not having worked with Raspberry Pie before, there was some learnings in getting used to the command prompt and the commands in this. Also the guides and wikis seem to have been writing to people that are used to programming.	Write a more simple guide	
PRO	Eniig	OpenVPN access to the PC, we had some problems as we have not used it before and did not know the architecture of it.	When we got the right client files for the PC and understood the architecture of all PC's and SMX's being clients everything worked fine		
IWU	Edyna	Working in a private house, as in the Bolzano residential case, requires a strong commitment from the owner. Being the project a research project, various problems and difficulties can arise during the demonstration. Therefore, it may happen that Edyna's technicians and	Involving a private in a EU research project, as in the case of the Bolzano Residential test site, needs the establishment of well detailed contract between the involved parties	The private partner should be carefully chosen. The legal office of the company should be involved in early stage.	

		engineers have to spend much more time in the house as originally planned.			
PRO	Edyna	Very difficult to buy the recommended LANDIS & GYR meter in Italy	We had to investigate in more European countries to find the right meters	The USM concept should be more flexible, and be able to communicate with more meters	
PRO	Edyna	In the residential case, the number of USMs to be installed increased from one to four during the project. These meters are additional to the already existing three meters. This caused a problem of space and of changing the existing electrical wiring system	We had to rethink the planning of the installation	Be aware of enough wall space for future installations and that cables are long enough when moved. The USM concept should be more flexible, and be able to communicate with existing meters	
IWU	FIT	Users need to be involved early in the conceptional phase to ensure that their needs are respected.	It should be clear what is driven by research only and what is driven by user needs; there is no point in developing for a potential but non-existent end-user, especially when it comes to evaluation.		
IWU	FIT	It is difficult to reach users for interviews and workshops.	User workshops need to be planned at least 2 months in advance to make them happen.	It is important to announce, prepare and plan workshops involving end-users with enough puffer, so that enough people can be reached. It is probably also helpful to have a set of back-up representations of the end-user target group since the	

				customer contacts of our pilot-site partners are not usable for this purposes due to privacy issues: users, that are representing the group of interest but are not directly involved in the project.	
IWU	FIT	In multi-lingual projects, a translator is needed for the interviews and questionnaires, as well as early interface prototypes.	Especially end-users of advanced age are not able to speak English to an extend where tests can be performed or complex topics can be discussed.	Translating documents and interface prototypes for end-users takes quite some time, this needs to be taken into account while preparing for workshops. Therefore, it is necessary to have a translator available in time to enable further user research when necessary.	
IWU	FIT	When a translator is involved in user interviews, a lot of information is lost.	During interviews, it is not possible to gather subtle feedback due to language barriers.	This needs to be taken into account when planning and performing user tests. In this case, applying methods that focus more on closed questions and less on subtle information result in better outcomes (e.g. more quantitative research than qualitative methods)	
IWU	FIT	Having consent forms translated to the native language of the end users is mandatory.	Especially end-users of advanced age are not able to speak English to an extend where tests can be performed or complex topics can be discussed.	Due to privacy and data security issues, it is important for end-users to understand how the gathered data from user tests, interviews etc. is	

				stored, handled and being published.	
PRO, RTD	FIT	When the results of the end-user research are presented, all partners should be present so that the knowledge is spread and the project does not lose its application focus.	Not all partners are aware of the user needs, the target groups and how this is presented in the system to be developed.	User needs ensure that the final product is relevant and usable. Therefore, it is helpful for all partners to further understand the fears, hopes, needs and characteristics of the target group and how they are translated into functions of the final product.	

7.8 WP7 Lessons Learned

Table 9 - WP7 lessons learned (year 1)

Category	S4G-Partner	Experience and knowledge gained	Lesson Learned	Analysis of Lesson Learned	Requirement(s)affected
DIS	UNINOVA	The project website has experienced low access rates	The dissemination process needs to be targeted since the beginning of the project	A strategy needs to be defined to increase the project's website dissemination, increasing its visibility	
DIS	UPB	The project can be more visible.	Involvement of advisory board members is low.	It will be a good decision to insist on their involvement and advices regarding different approaches.	
DIS	UPB	The project can be more visible.	Collaborations with others projects can be taken into account.	The number of projects (dealing with storage) in progress at the EU level is significant and, if S4G would collaborate with them, we can gain a larger perspective and also visibility. One way of easy gain of visibility is to propose to other project' coordinators to hold the logo (and link to our website) of S4G; we can do the same in exchange;	

DIS	UPB	The project can become more visible.	Each partner should help the project dissemination with not so much effort.	All of us can add the S4G logo in email signatures (even when involved in other projects as well).	

8 Conclusions

This deliverable summarizes the **phase 1 Evaluation** in all the three S4G test sites, resulting from the analysis activities performed by a number of Milestones and status on project KPI's.

MS1; First reference scenarios, use cases and key requirements available;
A large number of use cases, designed as high level (HLUC), and primary use cases (PUC) have been described with focus in each test site (Bucharest, Bolzano and Fur). Related to these use cases has scenarios been described and the technical partners have formulated requirements to be able to start development of required components to obtain the use cases.
The business partners have defined and developed business models related to use cases. More business models have been developed for each use case. The business models are at an initial level and will be developed further in the final deliverable D2.4. Final business models.
A large number of Lessons Learned has also been reported. Lessons Learned related to MS1 is among others, that it is difficult to calculate the baseline for grid reinforcement, the need of different competencies in business modelling and that all partners need to take part of defining the initial requirements and learn how to use Jira.

MS4; Technical evaluation of components.
An initial prototype of the User-side ESS control system has been developed implementing some control features of the User-side ESS control system. For testing purposes, an algorithm was implemented in the ER Connector to manage the unbalanced loads in the AC grid. The functionality of this algorithm was positive and the development will continue in the coming phases.
The extension connectors which are needed in the Unbundled Smart Meter (USM) to support the S4G functionalities has been developed in initial versions and tested in laboratory facilities. A dedicated extension, namely the "Fronius ESS connector", has been developed to inter-connect the USM to pre-existing Fronius Hybrid inverters (and the associated storage systems) available both in the residential parts of both the Fur and Bolzano test sites.
The DSF connectors include Data Dispatcher and Fronius Cloud Connector. Besides the two connectors, the Data Warehouse is designed as a central cloud service which acts as a data storage and analysis platform. DSF Data Warehouse is deployed in the cloud side, running in ISMB premise. It is a key component supporting the S4G test site. Data Warehouse supports time-series data collection and virtualization. As the project proceeds, Data Warehouse will further enhance its data analysis module. The main learnings related to the DSF connector is how to handle data protection.
The professional and residential interfaces were designed based on user needs collected through semi-structured interviews, through questionnaires as well as observations. The residential interfaces developed in phase 1 are in the state of digital mock-ups. Learnings from this part is among others, that it is hard to recruit residential users for interviews and that a lot of knowledge is being lost due to translation.

MS5; Period 1 Platform operative in test sites and ready for evaluation.
This milestone has really been challenged in year 1. Due to purchasing and communication issues, this milestone was delayed in the test sites in Bolzano and Fur. It turned out that the meters from Landis and Gyr were not easy to buy neither in Italy nor in Denmark. However, the test sites were prepared and the meters finally got installed. Then the next problem occurred about communication between SMM and SMX. The communication was up and running in the Bolzano test site for only a few hours and in Fur for almost 1 month. In the Bucharest lab, the communication worked fine. The partners have put a lot of effort in solving this problem and did not solve it in year 1 (but have solved it beginning of year 2). These learnings are reported in Chapter 7. Learnings from the test sites in Bolzano and Fur are very alike and will be taken into account when more private houses are recruited.

MS6; Data gathering from test sites in Bolzano and Fur started
Data was collected in the Fur test site for almost 1 month. Collected data are active power, current (rms)power, current and voltage (rms). voltage. Furthermore, has beendata is collected from the Fronius SolarWeb in Fur and Bolzano sites.

MS7; Period 1 Lessons Learned available
The project group continuously reports Lessons Learned related to each work package.

MS8; Period 1 Complete
The expectation for Year1 was that both test sites were up and running, and the project group is able to collect data in the data warehouse. For both test sites residential users were recruited to participate in the project. For Bolzano, storage was purchased and installed. Fur already owned storage from a former project (GreenCom). The house owners signed contracts about participation. The project partners then discoverd problems about purchasing the suggested meters, this was solved by borrowing meters from Partner UPB. partner UBP. The following issue about the connection of the SMM and the SMX could not be solved in year 1.

Key Performance Indicators:
All Technical Objectives have been achieved, except TO2, which is about the predictive algorithms. Studies for defining the algorithms have started, but are not yet finished. All Strategic Objectives have been achieved in year1. This is reported in Table 10.

Table 10 - KPIs list

Obj.	Indicator	Y1 Target	Status
TO1	Prototypes supporting S4G interfaces and Models for storage coordination	4	These 4 prototypes have been developed: D4.1; Initial User-side ESS control system D4.8 - v0.1; Initial USM Extensions for Storage Systems D5.3; Initial DSF Connectors for external systems and services D6.7 - v0.1; Initial Interface for Professional and Residential users
TO2	Sets of distributed and centralized storage control algorithms prototypes developed	2	This KPI is achieved in Bucharest test site by simulating a simplified local storage control algorithm for an advanced self-resilient prosumer becoming UniRCon (HLUC1-PUC2)
TO2	Systems embedding S4G predictive control algorithms	1	This KPI is not achieved
TO2	Systems considered by the S4G predictive control algorithms	Residential storage	This KPI is not achieved
TO3	Test deployment of Unbundled Smart Meter prototypes	Bucharest	T03 is fulfilled This KPI is reached in Bucharest Test site
TO3	Systems fully integrated with the unbundled smart meter	Home (production and consumption) meters	This KPI had been achieved as follows: Fur in the Point Common Coupling (net-metering) Bolzano in the Point Common Coupling (net-metering)
TO4	Test deployments of Energy Router prototypes	0	No KPIs in year 1
TO5	Availability of DSF components	most of components of DSF are available	This KPI had been achieved
TO5	DSF Features supported	Analysis by simulation	This KPI has been achieved (D5.1. Initial DSF Hybrid Simulation Engine)

TO6	Number of different cases evaluated in test sites Bucharest/Bolzano/Fur	1	Evaluated implementation of use cases on user side based on paper prototypes and interviews
SO1	Number of residential/professional users engaged in test sites	5 residential 2 professional	1 residential in Fur and 1 residential in Bolzano are engaged and have both got installed the new meter. Furthermore, are 4 more residentials in Fur ready. Residential in both ENIIG (12) and EDYNA (1) has both provided input to the residential GUI Professionals in both ENIIG (5) and EDYNA (1) has provide input to the professional GUI.
SO2	Number of Business cases proposed/evaluated	1	In test site Bolzano was made an evaluation based on questionnaires and user interviews.
SO3	Number of complete techno-economic planning cases analysed using the DSF	(early proof of concept using DSF)	The Baseline has been defined
SO4	Number of inputs proposed to EU or regional policy-related, traditional or open standardization initiatives	Early gap analysis internally available	This KPI has been achieved and reported in D3.1.
SO5	Number of inputs, Lessons Learned and recommendations published towards security- and privacy-related initiatives	Early inputs internally available	Lessons Learned for Year1 is available, No Recommendations have been published

Acronyms

Acronym	Explanation
A	Ampere
AC	Alternating Current
Ah	Ampere Hour
AMI	Automated Meter Interface
API	Application Programming Interface
ASRP	Advanced Self-Resilient Prosumer
CIM	Common Information Model
DC	Direct Current
DSF	Decision Support Framework
DSF-SE	Decision Support Framework Simulation Engine
DSO-SCADA	Distributed Service Operator
DSS	Distribution System Simulator
EB	Event Broker
ER	Energy Router
ESS	Energy Storage System
EV	Electric Vehicle
EVChCon	EV Charging Controller
EV-SCADA	Electric Vehicle
GESSCon	Grid ESS Controller
GEVChCon	Grid-side EV Charging Controller
GUI	Graphical User Interface
HLUC	High Level Use Case
I	Current
JSON	JavaScript Object Notation
KPI	Key Performance Indicators
Kw	Kilo Watt
KWh	Kilo Watt Hour
KWp	Kilo Watt Peak
LESSAg	Local Energy Storage Agent

LEVChAg	Local Electric Vehicle Charging Agent
MPPT	Maximum Power Point Tracking
MQTT	Message Queue Telemetry Transport
MS	Milestone
MWH	Mega Watt Hour
OCPP	Open Charge Point Protocol
PCC	Point of Common Coupling
PUC	Primary Use Case
PV	Photo Voltaic
RBAC	Role based access control
RMS	Root mean square
RPI	Raspberry PI
SMM	Smart Metrology Meter
SMX	Smart Meter Extension
SO	Strategic Objectives
SOC	State of Charge
SOH	State of Health
TLS	Transport Layer Security
TO	Technical Objectives
U	Voltage
ΔU	Delta Voltage
USM	Unbundled Smart Meter
V	Voltage
VPN	Virtual Private Network

List of figures

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References

[i] V. F. Pires, O. Husev, D. Vinnikov, and J. F. Martins, “A control strategy for a grid-connected pv system with unbalanced loads compensation,” in 2015 9th International Conference on Compatibility and Power Electronics (CPE), June 2015, pp. 154–159.
[ii] http://www.greencom-project.eu/