D6.5 - Phase 2 Test Site Platforms and Deployments Report

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Document History

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0.1	2018-05-08	UNINOVA	First draft.
0.2	2018-10-10	UNINOVA	Description of the S4G components deployed in phase 2
0.21	2018-10-11	LIBAL	Comments and some changes in the text
0.22	2018-10-11	UPB	Contribution to chapter 2 and chapter 5
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0.24	2018-10-15	ENIIG	Contribution to chapter 4
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0.3	2018-11-06	UNINOVA	Addressed partners comments and added information regarding phase 2 deployment in Fur/Skive test site
0.9	2018-11-28	UNINOVA	Addressed reviewer comments
1.0	2018-12-28	UNINOVA	Final version, ready for submission to the EC

Internal Review History

Review Date	Reviewer	Summary of Comments
2018-11-07 (v0.3)	Marco Baldini (EDYNA)	Approved: • General minor corrections
2018-11-06 (v0.3)	Orlando Tovar (ISMB)	Approved: • The document is well presented and structured. • The content is in line with DoA. • General minor corrections and comments are written in the document.

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Executive Summary

This deliverable evaluates the phase 2 (M13-M24) deployment status in all three S4G test sites (Bolzano, Bucharest, and Fur/Skive) based on the plans detailed in D6.2 – "Phase 2 Test Site Plans" [S4G-D6.2]. It is an update version of D6.4 – "Phase 1 Test Site Platforms and Deployments Report" [S4G-D6.4].

Several prototypes were developed for the phase 2 test site platforms, namely:

- D4.2 – "Updated User-side ESS control system" [S4G-D4.2];
- D4.4 – "Initial Grid-side ESS control system" [S4G-D4.4];
- D4.6 – "Initial Cooperative EV charging station control algorithms" [S4G-D4.6];
- D4.9 – "Updated USM extensions for Storage Systems" [S4G-D4.9];
- D4.11 – "Initial Energy Router" [S4G-D4.11];
- D5.1 – "Initial DSF Hybrid Simulation Engine" [S4G-5.1];
- D5.4 – "Updated DSF Connectors for external systems and services" [S4G-D5.4];
- D5.6 – "Initial DSF Predictive Models" [S4G-D5.6];
- D6.8 – "Updated Interfaces for Professional and Residential users" [S4G-D6.8].

With the completion of these prototypes, Milestone 9 (MS9) – "Components ready for integration in Phase 2 Test Site Platforms" could be accomplished and their deployment could proceed in all three test sites, to further evaluate the following three scenarios:

- Storage Coordination (Fur/Skive)
- Cooperative EV Charging (Bolzano)
- Advanced Cooperative Storage Systems (Bucharest)

During phase 2 some issues happened in the test sites. The SMXs SD cards in the Bolzano test site started to fail and had to be replaced. To avoid this issue, the writing frequency in the SD card was decreased.
In the Fur/Skive test site the connection with the selected SMMs needed a different metering mapping and some updates in the SMX. Lastly, in the Bucharest test site, no major issues were encountered, but some lessons learned regarding the DC connection were reported. More detailed information about each test site issues and applied solutions/countermeasures can be found in each test site section.

An issue that happened in some SMXs deployed in the test site, is that, sometimes, it sends the last read SMM data, causing data loss issues in the DSF-DWH. This issue causes to store at the same timestamp same data until the SMX is restarted. The technical partners are tackling this issue and should be resolved during phase 3 (M24-M36).

During phase 3, the main components to be installed are the ESS in the Bolzano commercial test site, the grid-side ESS in the Fur/Skive grid test site, and the single-phase ER in the Bucharest test site. D6.6 – "Phase 3 Test Site Platforms and Deployments Report" will be the final version of this document and is expected to be available in M34 (September 2019).

1 Introduction

This document describes the deployment report of D6.2 – "Phase 2 Test Site Plans" [S4G-D6.2], defined for the three scenarios, one per test site:

- **Cooperative EV Charging** (Bolzano): In this test site, two EV charging cases are tested:
  - *Residential case* - a house owned by a private customer with Storage, PV installation and EV.
  - *Commercial case* - a EVs' parking lot with several EV charging stations.
- **Storage Coordination** (Fur/Skive): A small scale and participative community will be used to test the project solutions in home fitted with PV and storage. A grid case scenario will also be tested.
- **Advanced Cooperative Storage Systems** (Bucharest): a dedicated lab-scale technical scenario, emulating a house, to test the project developments in a controlled environment.

1.1 Scope

This deliverable presents the phase 2 results of Task 6.2 – "Test Sites Integration" [S4G-D6.2] and Task 6.4 – "Test Sites Deployment and execution". Phase 3 report is expected to be delivered on M34 (September 2018), with all the deployments achieved during the project.

1.2 Related documents

ID	Title	Reference	Version	Date
D3.2	Updated S4G Component Interfaces and Architecture Specification	[S4G-D3.2]	1.0	2018-08-31
D4.1	Initial User-side ESS control system	[S4G-D4.1]	1.0	2017-08-30
D4.2	Updated User-side ESS control system	[S4G-D4.2]	1.0	2018-06-14
D4.4	Initial Grid-side ESS control system	[S4G-D4.4]	1.0	2018-08-30
D4.6	Initial Cooperative EV charging station control algorithms	[S4G-D4.6]	1.0	2018-08-14
D4.8	Initial USM extensions for Storage Systems	[S4G-D4.8]	1.0	2017-08-31
D4.9	Updated USM extensions for Storage Systems	[S4G-D4.9]	1.0	2018-08-31
D4.11	Initial Energy Router	[S4G-D4.11]	1.0	2018-11-02
D5.1	Initial DSF Hybrid Simulation Engine	[S4G-D5.1]	1.0	2018-02-22
D5.3	Initial DSF Connectors for external systems and services	[S4G-D5.3]	1.0	2017-09-04
D5.4	Updated DSF Connectors for external systems and services	[S4G-D5.4]	1.0	2018-09-03
D5.6	Initial DSF Predictive Models	[S4G-D5.6]	1.0	2018-08-30
D6.2	Phase 2 Test Site Plans	[S4G-D6.2]	1.0	2018-12-28
D6.4	Phase 1 Test Site Platforms and Deployments Report	[S4G-D6.4]	1.0	2018-01-15
D6.8	Updated Interfaces for Professional and Residential users	[S4G-D6.8]	1.0	2018-08-23

2 Phase 2 S4G components

To enable the deployment of the S4G prototypes developed during phase 2, several S4G components were deployed to enable their integration. Table 1 shows the S4G components deployed during phase 2 according to the D6.2 test sites plans [S4G-D6.2]. For a better reading of the table: "✓" deployed with success, "×" deployment not finished/ongoing, and "-" means that that specific prototype was not planned to be deployed in that test site during phase 2.

Table 1. S4G components deployed during phase 2.

	Architectural Layer	Bolzano (IT)	Fur/Skive (DK)	Bucharest (RO)
Control broker	Communication layer	✓	✓	✓
Data broker	Communication layer	✓	✓	✓
OGC Sensor Things Server	Communication layer	✓	✓	✓
Professional GUI	Service layer	-	✓	-
DSF-SE	Service layer	-	✓	-
GESSCon	Service layer	✓	-	-
DSF-DWH	Service layer	✓	✓	✓
GridDB connector	Service layer	✓	✓	-
Energy price connector	Service layer	✓	✓	-
Fronius cloud connector	Service layer	✓	✓	-
Weather forecast for PV production connector	Service layer	✓	✓	✓
DSF-DWH connector	Service layer	✓	✓	✓
Solar radiation connector for PROFESS or PROFEV	Edge layer	✓	✓	-
Residential GUI	Edge layer	✓	-	-
Aggregator broker	Edge layer	✓	✓	✓
OGC wrapper	Edge layer	✓	✓	✓
PROFESS	Edge layer	✓	✓	-
Aggregator DWH	Edge layer	✓	✓	-
Technical GUI	Device layer	✓	✓	✓
Dispatcher	Device layer	✓	✓	✓
SMX broker	Device layer	✓	✓	✓
SMX core	Device layer	✓	✓	✓
SMM	Device layer	✓	✓	✓
ER SMX SB connector	Device layer	-	✓	-
Three-phase ER	Physical layer	-	✓	-
EV charger	Physical layer	✓	-	-

Several prototypes were developed for the phase 2 test site platforms, namely:

- D4.2 – “Updated User-side ESS control system”, M18 [S4G-D4.2];
- D4.4 – “Initial Grid-side ESS control system”, M20 [S4G-D4.4];
- D4.6 – “Initial Cooperative EV charging station control algorithms”, M21 [S4G-D4.6];
- D4.9 – “Updated USM extensions for Storage Systems”, M21 [S4G-D4.9];
- D4.11 – “Initial Energy Router”, M23 [S4G-D4.11];
- D5.1 – “Initial DSF Hybrid Simulation Engine”, M15 [S4G-5.1];
- D5.4 – “Updated DSF Connectors for external systems and services”, M21 [S4G-D5.4];
- D5.6 – “Initial DSF Predictive Models”, M21 [S4G-D5.6];
- D6.8 – “Updated Interfaces for Professional and Residential users”, M21 [S4G-D6.8].

With the completion of these prototypes, MS9 – “Components ready for integration in phase 2 Test Site Platforms” could be accomplished and its deployment could proceed in all three test sites (Bucharest, Bolzano, and Fur/Skive). The following sub-sections described where each prototype was deployed or is available.

2.1 Updated User-side ESS control system

D4.2 [S4G-D4.2] describes the PROFESS, that was successful deployed and integrated in the **Bolzano, and Fur/Skive** test sites.

2.2 Initial Grid-side ESS control system

D4.4 [S4G-D4.4] describes the GESSCon, that was successful deployed, integrated and available in the cloud to the **Bolzano** test site.

2.3 Initial Cooperative EV charging station control algorithms

D4.6 [S4G-D4.6] describes the optimization model developed for the control of the EV charging stations at EDYNA premises, to be used by PROFEV that will be only available and deployed during phase 3 in the **Bolzano** test site.

2.4 Updated USM extensions for Storage Systems

D4.9 [S4G-D4.9] is composed by several software components, namely:

- *ER SMX SB connector:* deployed in the **Fur/Skive** test site;
- *ESS (Modbus) SMX SB connector:* this component was not yet deployed due to some issues with the ESS connection;
- *Weather forecast and load prediction connector:* deployed in the three test sites;
- *GESSCon connector:* deployed in the **Bolzano and Fur/Skive** test sites.

2.5 Initial Energy Router

D4.11 [S4G-D4.11] describes the three-phase ER, that was successful deployed and integrated in the **Fur/Skive** test site.

2.6 Initial DSF Hybrid Simulation Engine

D5.1 [S4G-D5.1] describes the first architecture of the DSF-SE, which is deployed into a docker container on a server at Fraunhofer FIT. An API-Gateway called Linksmart-Border Gateway together with an Identity Provider

(Keycloak) were deployed for achieving authorisation and authentication. It was integrated with the S4G components and prototypes in the **Fur/Skive** test site.

2.7 Updated DSF Connectors for external systems and services

D5.4 [S4G-D5.4] is composed by several components, namely:

- *Dispatcher:* deployed in all three test sites within SMXs;
- *OGC wrapper:* deployed in all three test sites within SMXs;
- *GridDB connector:* available in the cloud to **Bolzano and Fur/Skive** test sites;
- *Energy price connector:* available in the cloud to **Bolzano and Fur/Skive** test sites;
- *Fronius cloud connector:* available in the cloud to **Bolzano and Fur/Skive** test sites;
- *Weather forecast for PV production connector:* available in the cloud to three test sites;
- *DSF-DWH connector:* available in the cloud to the three test sites;
- *Solar radiation connector:* deployed in the **Bolzano and Fur/Skive** test sites within PROFESS and PROFEV;
- *Connector Enabling Hybrid Simulation:* a first version of this connector is ready in phase 2, but the single-phase ER and the ESS at Fur/Skive grid test site will only be available during phase 3.

2.8 Initial DSF Predictive Models

D5.6 [S4G-D5.6] describes a first draft of the developed predictive models that are used in DSF and GESSCon. In phase 2, the PV production forecast (DSF connector) was available in the cloud to **Bolzano** and **Fur/Skive** test sites. The remaining predictive models will be available during phase 3 as DSF connectors.

2.9 Updated Interfaces for Professional and Residential users

D6.8 [S4G-D6.8] is composed by two components, namely:

- *Residential GUI:* deployed in the **Bolzano** test site within the residential SMX.
- *Professional GUI for GRID Planner:* available in the cloud to **Fur/Skive** test site.

2.10 Prototypes deployment status

Table 2 summarizes the deployment status of the S4G prototypes developed during phase 2. For a better reading of the table: "✓" deployed with success, "×" deployment not finished/ongoing, and "-" means that that specific prototype will not be deployed in that test site during phase 2.

Table 2. Deployment status of phase 2 prototypes.

Prototype	Bolzano (IT)	Fur/Skive (DK)	Bucharest (RO)
D4.2 – Updated User-side ESS control system	✓	✓	-
D4.4 – Initial Grid-side ESS control system	✓	✓	-
D4.6 – Initial Cooperative EV charging station control algorithms	x	-	-
D4.9 – Updated USM extensions for Storage Systems	✓	✓	✓
D4.11 – Initial Energy Router	-	✓	-
D5.1 – Initial DSF Hybrid Simulation Engine	-	✓	-
D5.4 – Updated DSF Connectors for external systems and services	✓	✓	✓
D5.6 – Initial DSF predictive models	✓	✓	✓
D6.8 – Updated Interfaces for Professional and Residential Users	✓	✓	-

All the phase 2 prototypes were successful deployed and integrated, except D4.6 that only describes the optimization algorithms that will be used by PROFEV (planned to be deployed in phase 3).

3 Cooperative EV Charging Scenario: Bolzano (IT) test site

This scenario is composed by the residential and the commercial case. The residential case is a private house near Bolzano, which has PV panels, an Electric Vehicle (EV), an EV charging station, and an ESS with its respective inverter. The commercial case is in the EDYNA's headquarters garage, where 11 EVs can be charged. There are also PV panels which are directly connected to the distribution grid. The phase 2 deployment diagram is available in D6.2 [S4G-D6.2].

3.1 Summary of Phase 1 deployments

During phase 1, several installations in the residential case were made, namely:

- 1 ESS and its inverter
- 1 single-phase EV charging station
- 4 Landis+Gyr meters
  - 1 in the interconnection point
  - 1 for PV panels
  - 1 for the ESS
  - 1 in the EV charging station
- Dedicated internet connection
- Data dispatcher (described in [S4G-D5.3])
- Fronius cloud connector (described in [S4G-D5.3])

As for the commercial case, the main activities were:

- Connection to DSO grid using a DSO meter
- Installation of cables switchboxes and utility pole's protection
- Installation of 3 single-phase and 2 three-phase EV charging stations
- Evaluation of the ESS to be installed on the site
- Installation of 10 Landis+Gyr meters
  - 1 per EV smart charging station – 5 in total
  - 1 for all dummy charging stations
  - 1 in the interconnection point (EDYNA loads + 1 PV plant)
  - 1 for the ASM interconnection point (total of EV chargers + future ESS)
  - 1 per PV panels installation – 2 in total
- Installation of the garage's internet connection

3.2 Phase 2 deployments

During phase 2, the S4G software prototypes deployed in Bolzano test site were D4.2 [S4G-D4.2], D4.4 [S4G-D4.2], D4.9 [S4G-D4.9], D5.4 [S4G-D5.4], D5.6 [S4G-D5.6], and D6.8 [S4G-D6.8], as shown in Table 2.

No new hardware components were deployed in phase 2. Only the purchase of the EES for the commercial case has gone ahead and will be installed in phase 3.

3.3 Phase 2 issues and lessons learned

During phase 2, some problems emerged on the internet connection of the residential test site: due to the low voltage on one phase, the installed internet router for the project often stopped working. To solve this problem a small UPS was installed. The low voltage problem also affects the new EV charger installed by ASM. One of the reasons for this issue might be that the PV panels are not directly connected to the Fronius system but connected to two-phases (using two inverters) of the three-phase residential grid, causing the previous mentioned issue. This unbalanced voltage issue is one of the reasons why the house owner wanted to participate in the S4G project, so the voltages per phases can be balanced. One

Another issue encountered during phase 2 was that the majority of the SMXs SD cards started to fail. The technical partners analysed the problem and decided to replace all SD cards and increase the log files recording time to 5 seconds (instead of 2 seconds). Before the SD cards started to fail, there was an increase of the SMXs temperature. The technical partners are not sure if the temperature increase was due to SD cards issues, or in the other hand, the high SMXs operating temperatures damaged the SD card. The temperatures are now being closely monitored and weekly backups of the log files are being executed to avoid losing the collected data.

It was also observed in the DSF-DWH that some SMXs stopped reading the SMM data and give the last readings until the SMXcore application is restarted, causing a data gap in the DSF-DWH because it is a time-based database. This issue is being tackled both in the SMXcore application and in the DSF-DWH with some improvements so far, but without a satisfactory resolution. Also, sometimes the SMXs starts to send wrong timestamp, making the DSF-DWH recording data with wrong date. During phase 3, these issues will be further investigated, and other approaches will be used.

Some alert applications implemented in the SMX are not working properly in the Bolzano test sites due to the proxy configuration. The consortium is trying to solve this issue, taking into consideration that the Bolzano commercial test site must be secure, to avoid some kind of cyber-security attack or to cause malfunctions in the company internet network.

4 Storage Coordination Scenario: Fur/Skive (DK) test site

This scenario features a residential test site (Fur), a grid-side ESS (Skive), and the deployment of the ER at ENIIG premises (Skive). The residential case is composed by 5 houses fitted with PV panels, ESS and its respective inverter. The grid case is one grid-side ESS installed behind the meter in the sports arena.
The phase 2 deployment diagram is available in D6.2 [S4G-D6.2].

4.1 Summary of phase 1 deployments

During phase 1, the Unbundled Smart Meter (USM) was installed in one house at Fur/Skive. The USM in Fur/Skive is composed by the SMX and one Landis+Gyr E550 meter. Moreover, the Fronius cloud connector [S4G-D5.3] and the data dispatcher connector [S4G-D5.3] were also deployed is also providing information about the ESS.

4.2 Phase 2 deployments

During phase 2, the S4G software prototypes deployed in Fur/Skive test site were D4.2 [S4G-D4.2], D4.4 [S4G-D4.4], D4.9 [S4G-D4.9], D5.4 [S4G-D5.4], D5.6 [S4G-D5.6], and D6.8 [S4G-D6.8], as shown in Table 2. The three-phase ER was installed in the residential test site, as described in D4.11 [S4G-D4.11]. Two USMs were also installed during phase 2, one near the three-phase ER (Figure 1), and the other in one of the Fur residential houses that participates in the S4G project (Figure 2).

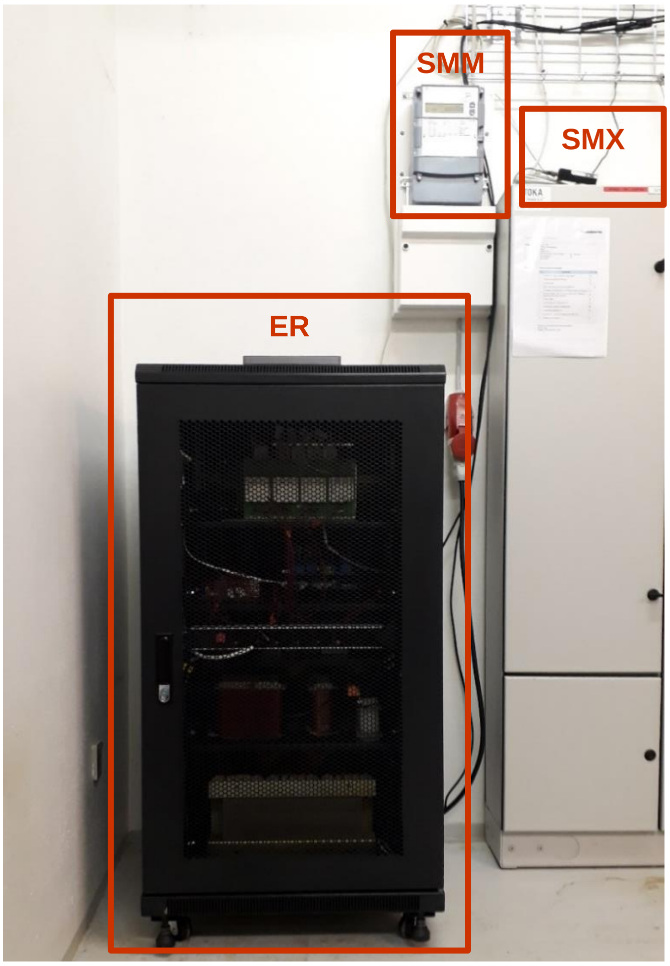

Figure 1. Three-phase ER and USM deployed in the residential test site (Skive, DK).

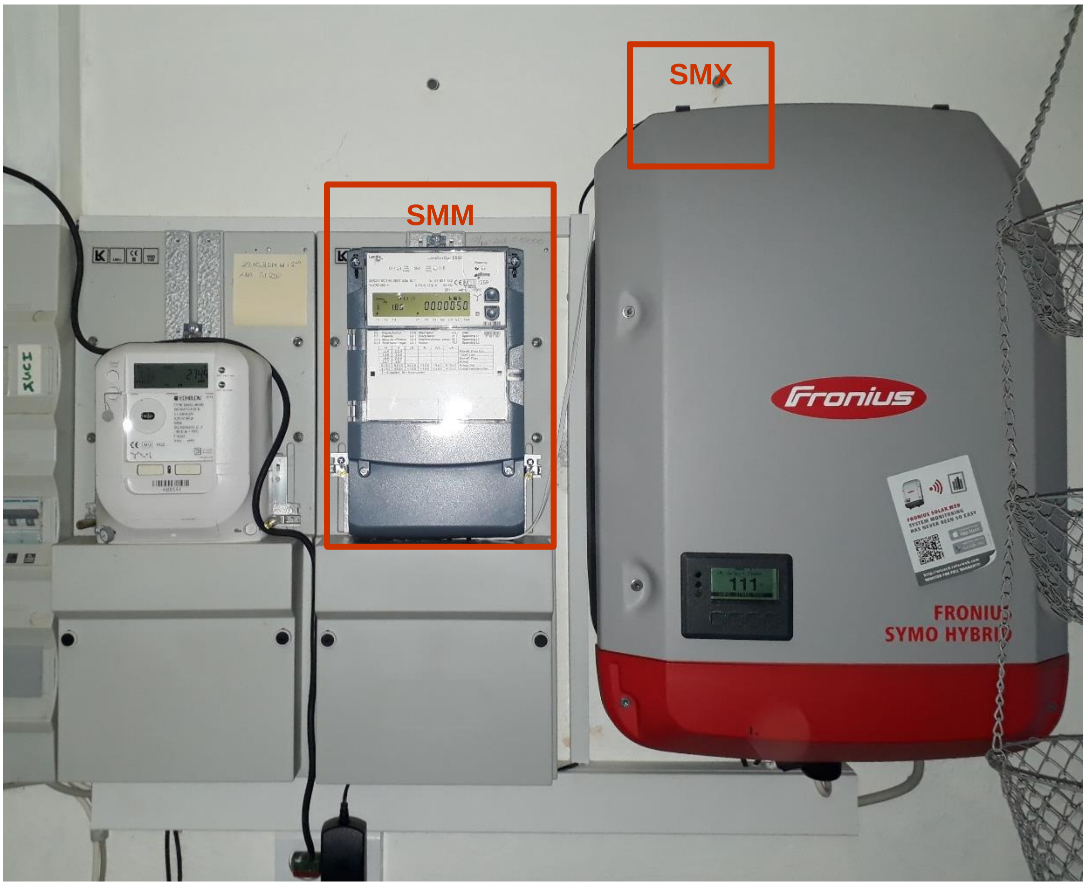

Figure 2. USM deployed in the residential test site (Fur, DK).

4.3 Phase 2 issues and lessons learned

Two *ZMD310CT44.07 S3a B31* Landis+Gyr meter were installed during phase 2 in the Fur/Skive residential test site. The connection with these meters required a different metering mapping and some updates in the SMX. Moreover, it was not possible to install other USM in the Skive building Point of Common Coupling (PCC) due the necessity cutting the switchboard busbar. During phase 3 it will be studied the possibility to connect the SMX with the already available SMM, or the installation of a different SMM.

During the three-phase ER deployment it was observed that the ER transformer had suffered a mechanical deformation during the transportation to the test site. However, it did not affect its deployment and the on-site tests [S4G-D4.11]. Due to this deformation, there is a very small possibility that the transformer creates a hot spot and causes a fire in the room. Since the security of the persons in the building is the top priority, the ER was left disconnected from the grid. The ER correct operation can be verified at any time, with human supervision in the ER room. The ER transformer is planned to be replaced with a new one in the very near future.

5 Advanced Cooperative Storage System Scenario: Bucharest (RO) test site

This scenario is composed by a laboratory test site where some S4G prototypes are evaluated before the field deployment. Moreover, a home hybrid energy system with DC bus will be also evaluated. The phase 2 deployment diagram is available in D6.2 [S4G-D6.2].

5.1 Summary of phase 1 deployments

During phase 1, several installations were made, namely:

- 2 SMXs
- 2 Landis+Gyr ZMG310 meters
- 8 PV panels (Kyocera KC130GHT-2)
- 4 valve-regulated lead-acid (VRLA) batteries (Ultracell KC130GHT-2)
- 1 Steca Tarom hybrid charge controller
- DC bus with local loads
- Neighbour laboratory
- Subcomponents to be used in modules for transmitting energy in DC
- ER connector (described in [S4G-D4.1])
- SMM connector (described in [S4G-D4.8])

5.2 Phase 2 deployments

During phase 2, the S4G software prototypes deployed in Bucharest test site were D4.9 [S4G-D4.9], D5.4 [S4G-D5.4], and D5.6 [S4G-D5.6], as shown in Table 2. A control board (Figure 3) was realized in order to have a central point for optimizing the energy flow in the UPB test site. It connects to PVs, batteries, DSO, neighbour and to the ER (in phase 3).

Figure 3. UPB Physical Control Board.

5.3 Phase 2 issues and lessons learned

During phase 2 the integration lessons learned can be summarized as following:

- Rules for connecting the components to continuous voltage must be formulated and included in the practice of electricians. In Romania it was difficult to find a certified company and therefore electricians for DC components integration;
- In order to have a high level of control and safety the board presents 3 circuit connection layers: automatic switch, switches and terminals;
- Because the UPB test site is a laboratory where the students have classes, a clear delimitation with warning tape is mandatory in order to teach in a safe environment;
- The DC link to the neighbourhood required an approval from both Electrical Engineering Faculty and Power Engineering Faculty authority. An explained request and persuasion speech were needed for connecting the two points;
- Although the DC bus and components, the electrical board and other technical aspects are efficient in the teaching process, a much higher engagement of the students (but not only) can be achieved through animation techniques, simulations with visual impact.

6 Conclusions

The deployment report of each scenario was presented in this deliverable. The deployments were made according to the test site plans of phase 2 in D6.2 – "Phase 2 Test Site Plans" [S4G-D6.2]. Table 2 summarises the prototypes deployment status during phase 2. Some issues happened in the test sites during phase 2, namely:

- **Cooperative EV Charging Scenario (Bolzano, IT):**
  - The SMXs SD cards start to fail and had to be replaced;
  - The internet connection was not stable in the residential case due to a low voltage issue, and an UPS had to be installed;
  - Some SMXs stopped reading the SMM data and give the same readings until the restart of the SMXcore application, or give wrong timestamp causing data loss. This issue is being tackled in the DSF-DWH and in the SMX to improve the data collection in all test sites;
  - Regarding the Fronius system electrical connection, the situation is still under analysis because the solution needs to comply with the Italian electrical standards.

- **Storage Coordination Scenario (Fur/Skive, DK):**
  - A new SMM mapping was incorporated in the SMXcore, to enable the integration of the Landis+Gyr SMM used in the Fur/Skive test site;
  - The ER transformer suffered a mechanical deformation during the transportation to the test site and may need to be replaced, however, the three-phase ER operation can be demonstrated at any time.

- **Advanced Cooperative Storage System Scenario (Bucharest, RO):**
  - DC connection rules should be written and available to electricians;
  - A safe environment is mandatory in the laboratory since the space is shared between students and researchers;
  - The neighbourhood DC link required an approval from both Electrical Engineering Faculty and Power Engineering Faculty authority, taking some time to solve the necessary administrative requirements. An explained request and persuasion speech were needed for connecting the two points;
  - A higher students' engagement regarding the DC bus and its components can be achieved through animation techniques.

During phase 3, the main components to be installed are the ESS in the Bolzano commercial test site, the grid-side ESS in the Fur/Skive grid test site, and the single-phase ER in the Bucharest test site. D6.6 – "Phase 3 Test Site Platforms and Deployments Report" will be the final version of this document and is expected to be available in M34 (September 2019), reporting the deployment of the final version of the S4G prototypes.

Acronyms

Acronym	Explanation
DSF	Decision Support Framework
DSF-DWH	DSF Data Warehouse
DSO	Distribution System Operator
ER	Energy Router
ESS	Energy Storage System
EV	Electric Vehicle
MS	Milestone
PCC	Point of Common Coupling
PROFESS	Professional Realtime Optimization Framework for Energy Storage Systems
PROFEV	Professional Realtime Optimization Framework for Electric Vehicles
PV	Photovoltaic
S4G	Storage 4 Grid
SD	Secure Digital
SMM	Smart Metrology Meter
SMX	Smart Meter eXtension
UPS	Uninterruptible Power Supply
USM	Unbundled Smart Meter
VLRA	Valve-Regulated lead-Acid

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