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D2.7 – Final Lessons Learned and Requirements Report

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0.2	2019-07-03	LINKS	Added minor adaptions to TOC
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2019-09-08	LINKS	• Approved, minor corrections
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Executive Summary

This deliverable presents the final set of requirements and lessons learned based on the storage scenarios depicted in D2.2 Final Storage Scenarios and Use Cases. It also lays the foundation for the innovations expected to materialize from the project work. The main objective is to derive end user requirements from the DSOs and residential users, ensuring that the development work results in solutions that address real-world problems and challenges. As the final deliverable of WP2, this document describes the final lessons learned as well as the corresponding requirements and lists the main findings.

The document describes the processes, workflows, and methodologies involved in the requirements engineering and the lessons learned processes used in S4G. In this project, requirements engineering is implemented as an iterative process that accompanies the project development. That implies that requirements will be continuously collected, validated, and updated to ensure the compatibility of S4G's outcomes and real-life user needs. Concerning requirements quality, requirements are checked with respect to form and content. The requirements engineering process is supported by the collaborative platform JIRA.

Lessons learned can be based on various findings, for example in literature, testing, and integration, or on personal experience. Therefore, lessons learned can reflect either positive or negative findings. They help to support project goals and therefore need to be documented in a dedicated way. In S4G, the collaborative platform Confluence is used for that purpose. Like requirements, lessons learned are collected and documented following an iterative process.

Besides the definition of lessons learned as they are used in S4G, this document also describes the process consisting of 6 steps for knowledge gathering. Additionally, the criteria and categories of lessons learned are highlighted.

1 Introduction

Storage4Grid aims at boosting the uptake of **storage technologies** between the distribution grid level and the end-user level, by developing a novel, **holistic methodology** for **modelling, planning, integrating, operating and evaluating distributed Energy Storage Systems (ESS)**. The Storage4Grid methodology encompasses storage at user premises and storage at substation level, Electrical Vehicles (EV), innovative energy metering and energy routing technologies.

In three different test sites, S4G examines the collaborative use of ESS and EV combined with hardware allowing to optimize and control the usage of energy:

- **Advanced Cooperative Storage Systems**: this vision depicts a local AC/DC network environment formed by a neighborhood consisting of self-resilient prosumers owning storage and a RES as well as consumers. The potential of this scenario will be observed in the MicroDERLab facilities in Bucharest, Romania.
- **Cooperative EV Charging**: here, the role of EVs and EV charging stations in a smart grid environment equipped with both storage and RES is observed with respect to commercial and residential users. This will be deployed and tested in Bolzano, Italy.
- **Storage Coordination**: this test site investigates the benefits of distributed and grid-connected storage with the goal to increase the influence of RES-based electricity in existing grid settings, by avoiding grid-strengthening methods (cables, transformers). This will be built upon the test site used in the GreenCom[i] project on the Island of Fur, Denmark featuring five houses equipped with RES and storage and in the municipality of Skive, where at grid site storage is installed.

1.1 Scope

This deliverable presents S4G's final set of requirements as well as final lessons learned. The final lessons learned were collected from previous projects with related topics (where S4G consortium members have been active) as well as from experiences during the initial phase of the S4G project.
The requirements elicitation process builds upon the use case descriptions documented in D2.2 Final Storage Scenarios and Use Cases, as well as upon the findings in several S4G internal workshops. They were continuously maintained and specified, closely following the development cycle of S4G. Corresponding to that, lessons learned were refined and added to a repository on Confluence which was shared with the whole consortium.

1.2 Related documents

ID	Title	Reference	Version	Date
D2.1	Initial Storage Scenarios and Use Cases		1.1	2017-02-28
D2.2	Final Storage Scenarios and Use Cases		1.0	2018-05-31
D2.5	Initial Lessons Learned and Requirements Report		1.0	28-02-2017
D2.6	Updated Lessons Learned and Requirements Report		1.0	07-06-2018
D6.10	Phase 1 Evaluation Report		1.0	02-05-2018
D6.11	Phase 2 Evaluation Report		1.0	02-05-2019

2 Requirements

In S4G, a user-centered design (UCD)[ii] approach was chosen to lead the way through requirements elicitation. The UCD approach can be combined with technology-driven methods and ensures that the project's outcomes will be able to address future potential of storage towards peak load shaving and the integration of high numbers of electric vehicles (EVs) into smart grids as well as to solve current issues such as voltage problems caused by the integration of renewable energy sources. Additionally, as this approach involves the user from the beginning, it intrinsically reduces the risk of user rejection in later stages of the technology deployment. The UCD approach focuses mainly on user needs and problems. Besides the involvement of end-users such as prosumers and energy final users, also the perspective of battery providers as well as the DSO's perspective are considered. Technical issues and constraints are modelled with the help of the external stakeholder group (ESG) and addressed to ensure a coherent and flexible handling of storage applications in future smart grid solutions. The ESG delivers insights from external, independent specialists with different kinds of expertise. This ensures that the project's requirements and outcomes are aligned with a vast pool of knowledge from diverse fields, such as standards as well as market and technology trends.

2.1 Methodology & Tools

The UCD process as shown in Figure 1 is carried out iteratively to adapt to changing user needs and requirements as well as to limitations and problems which may occur during the project development at any stage. It is composed of four different phases:

- *Understand:* Understand and specify the context of use; this phase also identifies user groups and their needs.
- *Specify*: Specify requirements based on previous analysis; this phase requires filtering the gathered requirements according to priority and feasibility.
- *Prototype*: Produce minimal feasible design solutions to meet requirements; this phase is used to portray and prototype knowledge which was gained from the previous phases.
- *Evaluate*: Evaluate design against requirements; this stage usually involves gathering direct user feedback.

Iterations can happen between any phases in the process, but are usually triggered after evaluation.

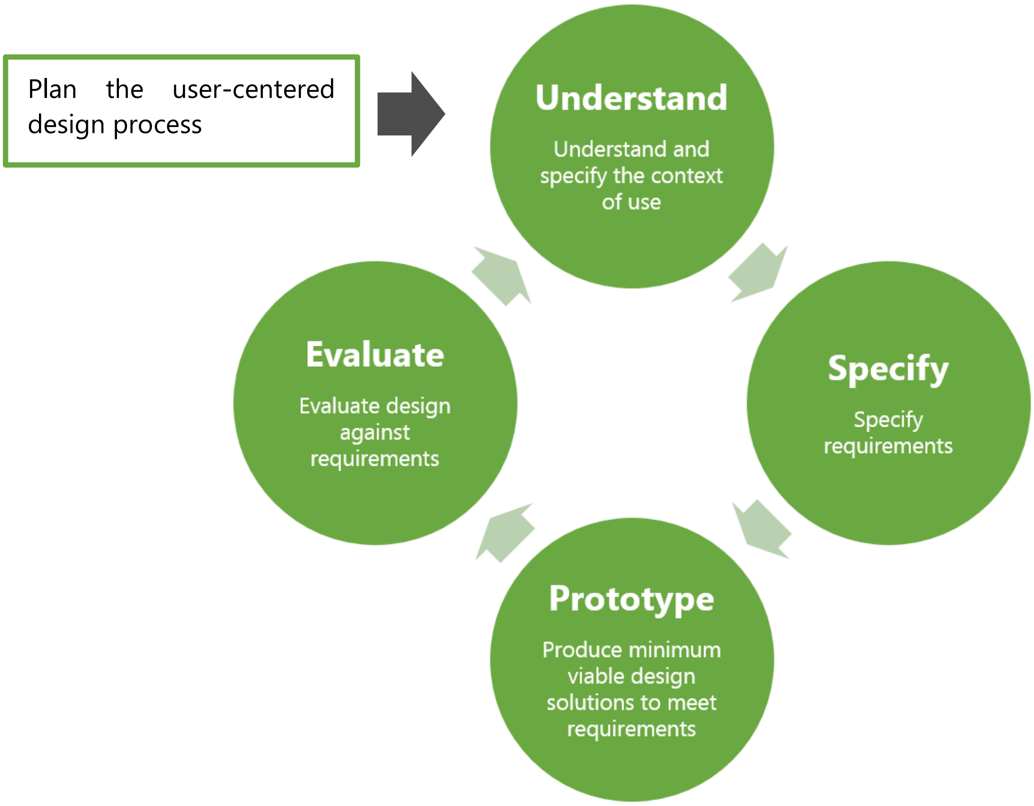

Figure 1 – The UCD process adapted from the standard ISO 9241-210:2010 [v]

In Storage4Grid, end-users (prosumers and consumers as well as owners of EVs) are especially involved in the test site of Fur, Denmark and in Bolzano, Italy. These two test sites will provide input for user-centered needs and requirements analysis using different methods, such as interviews and questionnaires. The analysis phase will be executed with respect to projects and reports from the smart grid domain to aim for the best possible results in specifying needs and concerns in the application field of smart grids (see [iii], [iv], [v], [vi]).
S4G's test site in Bucharest, Romania can be seen as a technical demonstrator that focuses on the potential capabilities and boundaries of specific low TRL hardware and software solutions.
Besides end-users, several stakeholders were identified. They are represented by project partners and the ESG.

All project partners agreed to use the JIRA, a web-based support tool that allows implementing and tracking the workflow of the Volere schema[vii] which is described in detail below.

2.1.1 Sources and Derivation of Requirements

For the initial vision and technical scenarios as well as for the use case development, information was gathered from the DSO partners EDYNA and ENIIG as well as from S4G's research partners UPB and UNINOVA to ensure a goal-oriented project development. The ESG as well as the end-users will play a more important role in future iterations of the requirements gathering and specification process.

The scenarios and use cases were documented in detail in D2.1 Initial Storage Scenarios and Use Cases. Most of the requirements elicited so far are based on the work done in D2.1. After the specification of use cases in tabular form containing all the steps necessary to run the use case, requirements were derived from the described steps. An example of a use case in tabular form related to HLUC-1-PUC-2 can be seen in D2.1, table 10. For the requirements derivation, several online workshops with the partners involved in all pilot sites were conducted.

The requirements elicited from use cases may relate to various aspects of the system and its use, and have been classified according to the Volere schema [vii].

Functional requirements give the specification of the product's functionality, derived from the fundamental purpose of the product, whereas non-functional requirements are the properties of the product, the qualities and characteristics that make the product attractive, usable, fast or reliable. Non-functional requirements can be grouped according to following subcategories:

- Look and feel requirements (intended appearance for end users)
- Usability requirements (based on the intended end users and the context of use)
- Performance requirements (how fast, accurate, safe, reliable, etc.)
- Operational requirements (intended operating environment)
- Maintainability and portability requirements (how changeable it must be)
- Security requirements (security, confidentiality and integrity)
- Cultural and political requirements (human factors)
- Legal requirements (conformance to applicable laws, including specific regulatory environment)

Look and feel, *usability* and *cultural requirements* are of secondary relevance for the assessment of requirements for a software platform, but are of high importance for the assessment of qualities and aspects of the user interfaces to be developed. The current set of user requirements can be found in Section 2.2 of this deliverable and has been made accessible for all project partners and traceable for evaluation of design solutions through the use of the JIRA tool.

2.1.2 The Volere Schema

The workflow to ensure that all necessary details and procedures in the Volere schema are adhered to is rather complex. S4G partners agreed to let this process be supported with a tool to which all partners have access. The JIRA tool is a web-based issue tracking system that allows implementing and tracking the workflow of the Volere schema. Figure 2 shows a screenshot of JIRA with a list of open requirements.

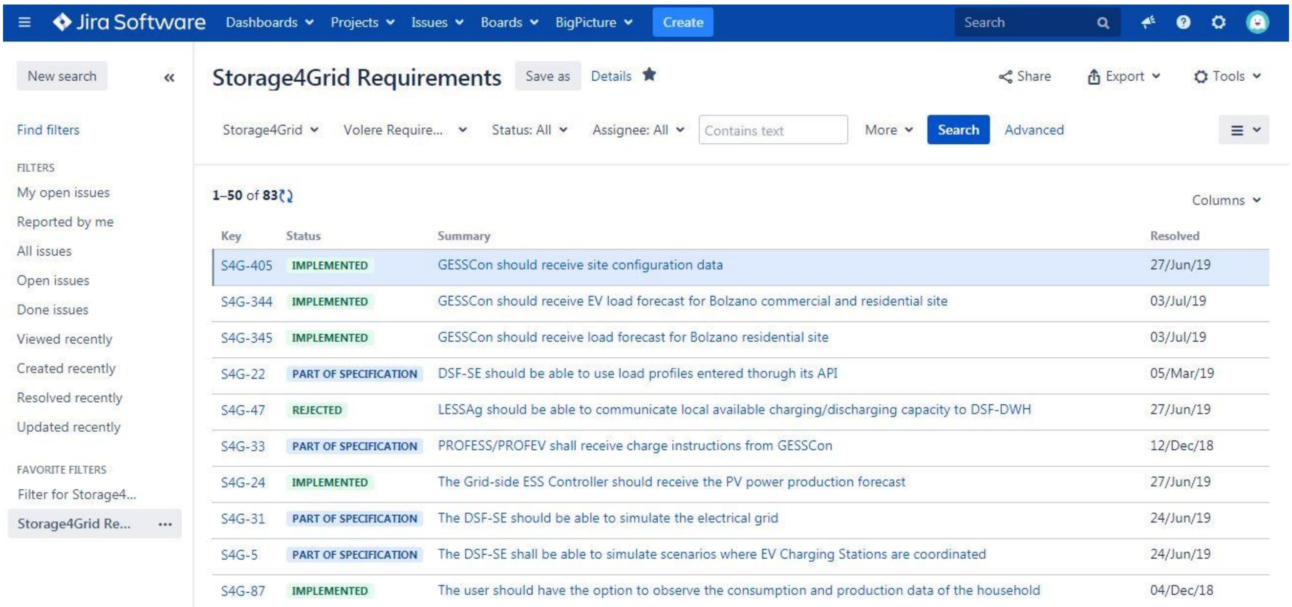

Figure 2 – Screenshot of JIRA with a list of S4G requirements

The description of some of the Volere requirement fields are given in the following.

- Summary: it contains a description of the intent of the requirement and should be clear and brief, usually a one-sentence description.
- Rationale: it provides the reason why the requirement is important and the contribution it makes to the product's purpose. The rationale contributes to the understanding of the requirement.
- Fit Criterion: it is the quantified goal that the solution (i.e. the realization of the requirement) must meet. This field describes how to determine if the requirement is met. It should be written in a precise and quantifiable manner.
- Priority: it defines the relevance of this requirement in relation to other requirements. The priority of a requirement is based on several important aspects included in the Volere schema, e.g. the requirement's source, the component the requirement is associated to, if the requirement is within the scope of the project, etc.
- Source: it defines if the requirement was raised by primary or secondary stakeholders, or through discussions/workshops within the consortium, by vision and technical scenarios, by ESG members, etc.

To express dependencies and conflicts among requirements, JIRA allows the definition of links between two or more requirements.

In order to better track the development progress in the project, deliverables were entered into the JIRA data base and linked with the respecting requirements. By doing so, the implementation status per prototype was visible and easy to check.

Figure 3 shows a screenshot of JIRA with a requirement in edit mode:

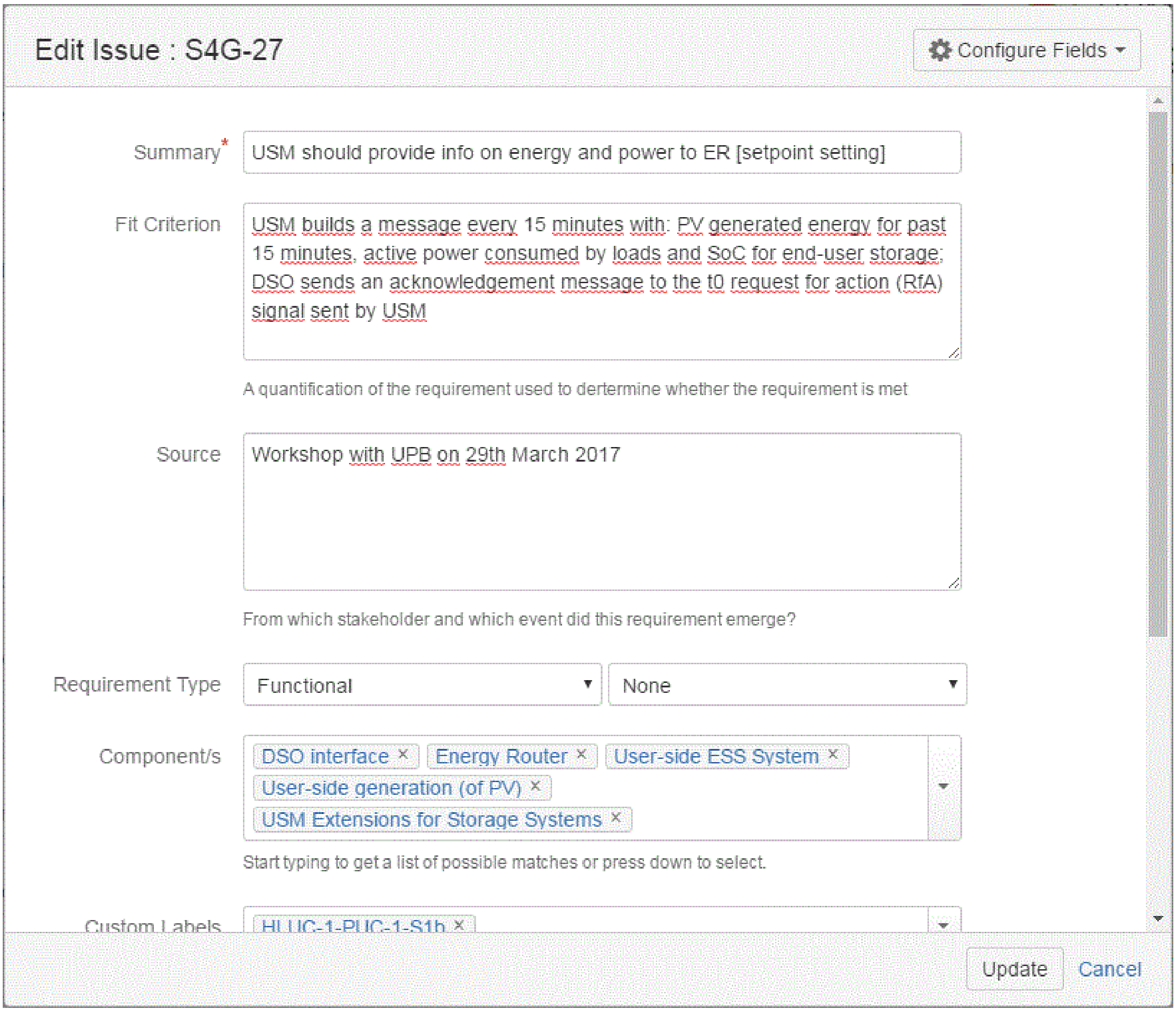

Figure 3 – Screenshot of JIRA with a requirement in edit mode

2.1.3 Requirements Workflow

Two different user groups are involved in the requirements process:

- Reporters: This group contains all project members, since anyone participating in the project is allowed to create a requirement.
- Assignees: an assignee is the person responsible for a given requirement at a given point in time as the requirement evolves in its workflow.

Figure 4 displays the workflow of a requirement in the way it has been defined in S4G. It shows all statuses a requirement can be in as well as all possible transitions between statuses.

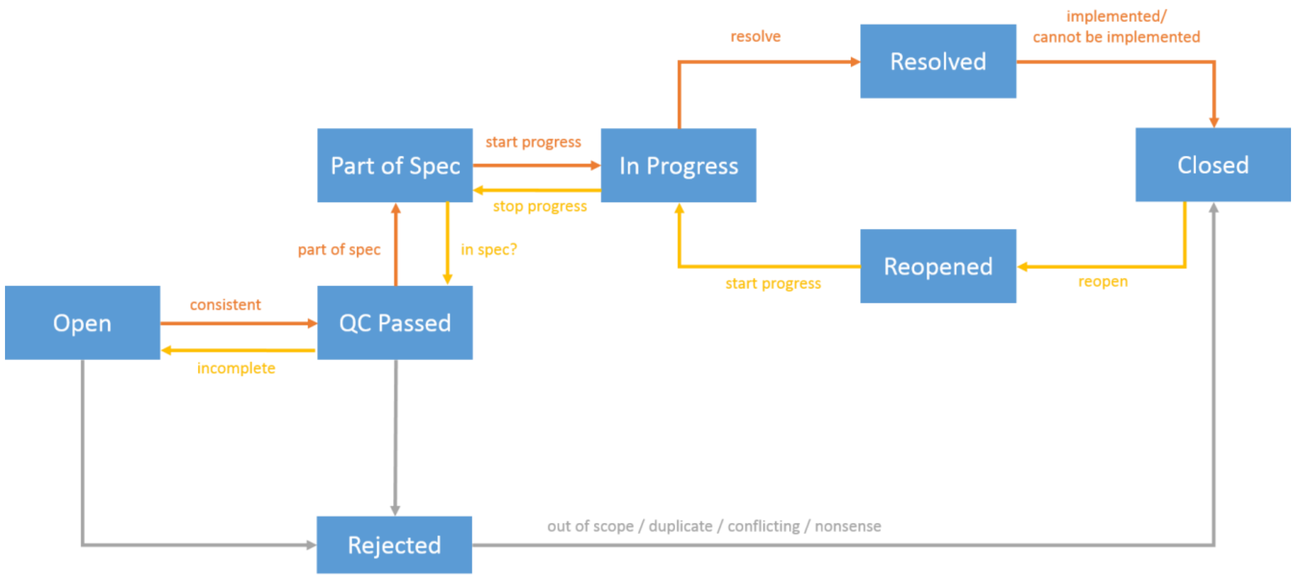

Figure 4 – Structure of the Requirements Workflow

When a requirement is entered by a reporter, it gets assigned the status *open*. A project member assigns the requirement to an assignee. If it is complete and unambiguous, the assignee changes the requirement's status into *quality check (QC) passed*. Ideally, the assignee and the reporter are different project members. A quality check passed requirement has its text fields filled in sensibly, with appropriate values chosen from the drop-down lists. The priority must be selected to make it possible to rank requirements in relation to each other.

A requirement can fail to pass the quality gateway for three reasons:

1. A requirement can be incomplete; some fields may have meaningless entries like '?'
2. A requirement can be ambiguous; certain terms are not clearly specified
3. A requirement is too general or does not make sense at all; this can happen for example when the reporter of the requirement does not include enough detail information in order for another person to understand the reasoning behind it.

If a requirement fails the quality check, it stays in the state *open* and is to be updated before it can be quality checked. Eventually, all requirements will pass the quality gateway. The next step is to decide whether a requirement becomes part of the specification, or whether it is to be rejected. A requirement is to be rejected in case it is a duplicate of another requirement, if it is out of the project's scope, if it conflicts with another requirement or if it is nonsense.

It has been agreed that S4G's Quality Manager reviews the requirement and decides on changing its status into quality-check passed or to reassigning it to the reporter for updating. When the requirement has reached the quality-checked status, it is assigned to the WP leader of the related main S4G component. The WP leader will, if necessary together with the Technical Manager, decide if the requirement is to be made *part of specification*.

If a requirement's status is *part of specification*, it means that it will be implemented and validated before it is closed. Requirements in this state can no longer be modified unless they are reopened.

2.1.4 Requirements Implementation using Scrum

The requirements are being implemented by adapting the lightweight Scrum framework[viii] to the project's needs. In Scrum, the implementation follows an iterative cycle. During implementation phases (=sprints), the team works on implementing user stories and tasks. In S4G, the length of a sprint ranges from 3 to 5 weeks.
The implementation team is organized by the role of the Scrum Master (SM), who coordinates regular meetings. In S4Gs case, those are weekly stand-ups, in which the implementation state of currently worked on issues is discussed in the group to identify potential blockers. Doing this, the risk of the implementation process being delayed is minimized. Additionally, the Product Owner (PO) takes care of determining which tasks need to be implemented at which point in time in order to meet the milestones described in the Definition of Action (DOA). The PO coordinates the sprint planning sessions which are held at the beginning of a new sprint and after the Sprint Closing Sessions coordinated by the SM. Sprint Closing Sessions are marking the end of a sprint and are held in order to reflect on problems (= Retrospective Time) that occurred during the implementation phase. During the Retrospective Time, appropriate lessons learned are documented on Confluence in order to enhance the quality of the next sprint.
In S4G, each team member is asked to split his/her assigned requirements into user stories and subtasks and document them in the sprint backlog in Jira. The PO then checks if the issues are aligned with the milestones and adds them to the next sprint. Hereby, it is important that user stories and subtasks are always linked to existing requirements in order to indicate if a requirement is being worked on or not. In general, only user stories and subtasks are to be added to a sprint, if they can be closed before the sprint ends. Every developer is then asked to indicate the issues he is working on by either marking them as being *open*, *in progress* or *done*. A developer is only allowed to mark a user story or sub-tasks as done, if it fulfills the "Definition of Done" (DoD), which is an agreement of all the S4G partners:

An issue is done if

- its result / the developed software fragment is tested
- its result / the developed software fragment is working
- the author is able to demonstrate it
- the author has documented how it can be installed/ how to use it (only very short documentation, nothing official)
- somebody else is able to demonstrate (ideally and if possible)

The Scrum roles were not permanently assigned to a specific partner. The consortium was free to reassign the role of SM and PO to any of the involved partners at any time in the development process. However, only the role of PO was handed over from LINKS to UNINOVA; the role of the SM was constantly assigned to FRAUNHOFER

2.2 Final Requirements

The list of final requirements describes the feature set of developed software in S4G. Throughout the project, requirements were kept alive using regular workshops to maintain and update the features and components documented in JIRA. This dynamic way of allowing requirements to be discarded, updated and newly created after the first requirements elicitation ensured the relevance of the developed artifacts regarding research results, technology development and new findings. Various methods were applied to improve our understanding of the user needs and to improve the user-perceived qualities of the prototypes.

The current overall status of the requirements is depicted in Figure 5. In total, 83 requirements have been collected. The final state of requirements will be documented in D6.12 Phase 3 Evaluation Report.

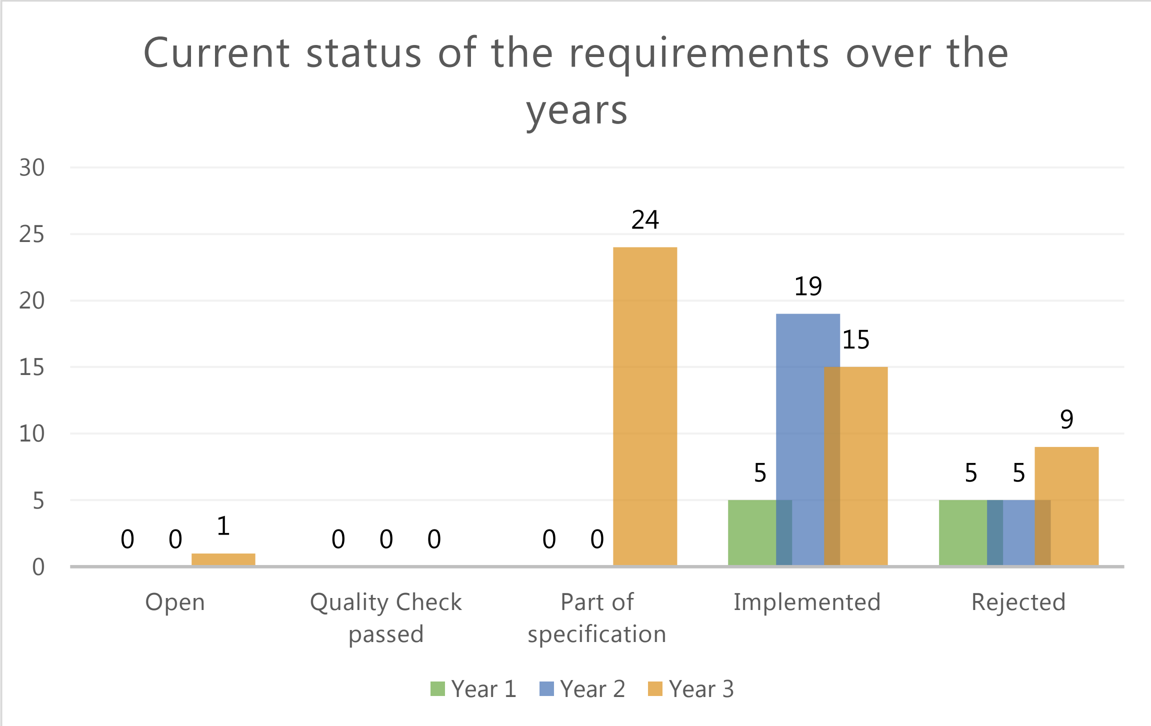

Figure 5 – Development of the requirements from year 1 to year 3 – situation on 05.08.2019.

2.2.1 Functional Requirements

Requirements that explicitly refer to the functionality of the future S4G system are called functional requirements.

The following table provides an overview of the updated functional requirements.

Table 1 - Functional requirements as documented in phase 3

Key	Summary	FIT Criterion	Rationale
S4G-1	The Smart Meter Extension should be able to publish and subscribe to the Event Broker	To allow to get data from local entities like USM and ER to generic cloud-based systems and, vice-versa, convey DSO signals	Information exchange signals are sent in near-real time (< 10 seconds from decision moment)
S4G-2	The SMX shall be able to receive signals from the DSF	To allow for data and set-point communication between the ER and the DSO	Signals are received in real time (< 3 seconds)
S4G-3	The Smart Meter Extension should communicate with the Energy Router using the ER#SMX interface	To allow for data and set-point communication between the ER (Energy Router) and the DSO (via DSF-DWH), see Fig. 13 D3.1	Signals are forwarded in real time (< 10 seconds)

S4G-4	The strategic grid planner shall be able to evaluate cost of a simulated scenario with distributed or centralized storage systems	To allow for determining the better solution in different scenarios with and without storage systems.	The strategic grid planner (or a generic decision-maker) can evaluate the economic feasibility by means of the total cost of ownership (TCO), deploying storage systems in the grid both in centralized or decentralized storage systems.
S4G-5	The DSF-SE shall be able to simulate scenarios where EV Charging Stations are coordinated	To allow development of control systems which aim at maximizing the charging services with respect to constraints in each scenario: PV production, local and grid storage status and network constraints	Charging stations can be added to the topology to be simulated. A simulation can run using the added charging stations
S4G-6	The PROFEV shall consider the preferred EV charging policies specified by the residential user	To allow the residential user to adapt the system's priority according to his/her needs.	The residential user is able to set preferences concerning the EV charging policy. The PROFEV regulates the system accordingly.
S4G-7	The strategic grid planner shall be able to select the portion of interest of the grid topology to be used as scenario to calculate optimal ESS positioning	From a given grid topology, the grid planner needs to select which part of the grid is going to be involved in the simulation.	The DSF Simulation Engine is able to receive as input a model of the subset of interest for the grid. This subset of the grid is the scenario where the DSF-SE can optimize the storage positioning.
S4G-8	The strategic grid planner shall be able to import and select historical data of interest in the DSF-SE	To investigate in energy demand and fluctuation of grid portions based on real data or data specific for a certain region.	The strategic grid planner launches the DSF, clicks on "Grid Topology". He can see the grid to which he has access to. He can select a part of the shown grid. He is able to choose the load profiles on which the simulation is going to be based on by selecting one of his available databases. Those databases offer either real data for the specific grid and/or data specific for that region/country). Energy consumption and production are shown for that specific substation and time interval in the past.
S4G-12	The DSF-SE shall be able to integrate and coordinate inputs from different specialized simulators	To avoid re-implementing existing tools.	Architecture design of the DSF component include a standard pattern for federation of existing simulators.

S4G-15	The S4G project should use standardized data models if applicable (i.e. from IEC, ISO, CENELEC or similar standards)	To allow a standardized approach	Use standard models for the communications between components
S4G-16	The S4G components/systems and its interactions should be based on open standards (as much as possible).	Protocols based on open standards enable a broader acceptance of the products developed within the S4G project.	All S4G components/systems implement open protocol/standards that allow third parties to interact with the S4G systems.
S4G-17	A Local ESS control agent shall be available to coordinate energy flows between ESS, EV, ER and grid	A local entity must be available to control the ESS set points, EV charging points, ER.	The Local ESS control agent is able to monitor and send commands to local ESS, EV charging points, ER via the USM interfaces
S4G-18	A DSF Adapter shall be available to enable monitoring and control EV charging points	Integration with EV charging points is needed to implement HLUC-2-PUC-2. This functionality can be achieved in two ways: (1) integration with the Siemens backend for communication available in EDYNA/ALPERIA; (2) direct communication with CP through the OCPP protocol. Both possibilities are potentially valid, but with different advantages and disadvantages to be evaluated.	All information made available by the CP can be collected by any authorized (local or remote) third party system through the DSF-DWH
S4G-20	PROFESS shall consider the preferred ESS charging/discharging policies specified by the residential user	To ensure that the system is operated according to the users' needs.	PROFESS applies ESS charging/discharging policies given by the residential user
S4G-22	DSF-SE should be able to use load profiles entered through its API	To ensure the availability of data needed for the correct execution of the simulations	Different load profiles can be added to the simulation if needed. The load profiles will be netered through the API of the DSF-SE
S4G-23	Professional users shall be able to view simulation results from the DSF-SE	DSF-SE needs to display the result and export them in open / standard format.	DSF-SE is able to analyze and display the simulation results for HLUC-2 and HLUC-3 use cases; the following data must be contained in the simulation results: - general grid topology (nodes, length and material of cables,

			houses, storage, EV charging stations) - installed storage (models) - voltage levels per node (3 phases, min and max over the simulation duration) - max current per line - losses per line
S4G-24	The Grid-side ESS Controller should receive the PV power production forecast	To allow for avoiding grid congestion in a grid feeder line by executing appropriate steps	The grid side ESS control receives PV power production forecast from DSF
S4G-25	The Grid-side ESS controller shall send charge schedules to PROFESS	To avoid grid congestion in a grid feeder line	The Grid-side ESS controller can send charge instruction to PROFESS so the battery can charge during peak PV production
S4G-26	Grid-side ESS controller should receive electricity price forecast from DSO or spot market	To improve economy of battery systems	The Grid-side ESS controller can send charge instruction to the Local ESS control Agent so the battery can charge during low electricity prices
S4G-27	USM should provide energy and power information to ER [setpoint setting]	Depending on the DSO data and energy transfer planning, we need to derive the setpoint[s] for the Energy Router as a function of local generation for the past 15 minutes, the SoC and other constraints (for example curtailment avoiding scenario)	USM builds a message every 15 minutes with: PV generated energy for past 15 minutes, active power consumed by loads and SoC for end-user storage; DSO sends an acknowledgement message to the t0 request for action (RfA) signal sent by USM
S4G-28	ER shall deliver information on the State of Charge (SoC) to SMX	To allow for the establishment of the set-point for the Energy Router (ER).	ER delivers to SMX every 15 minutes SoC signal which is further sent to DSF-DWH for deriving setpoints.
S4G-29	PROFESS of the grid-connected USM shall receive external messages about maximal power	To be transferred to the grid for the next 60 minutes (average)	PROFESS processes external information on power to the grid with a specified update rate. If signal is not received, PROFESS keeps the last value received (power to be transferred to the grid)
S4G-30	The professional GUI should help the DSO-Grid-Planner to test the placement of new ESS	To allow the evaluation of the best use of ESS at different grid levels	The system enables the DSO grid planner to determine the best possible placement of the storage system in the grid on at least Low Voltage Level by displaying how storage affects the voltage level in the grid

S4G-31	The DSF-SE should be able to simulate the electrical grid	To be able to perform a power flow simulation of an electrical grid	The DSF-SE performs a power flow simulation of an electrical grid, whose topology is received through an input interface, and returns information about voltage, current and power losses of the grid
S4G-32	The SMX should send the operation mode to the ER using the ER#SMX interface	This information is needed on the ER from the Local ESS Control Agent (LESSAg).	This interface information is translated in commands for the Energy Router (ER).
S4G-33	PROFESS/PROFEV shall receive charge instructions from GESSCon	To charge when electricity price is low or charge during peak PV production based on the evolution of forecasts in the grid side ESS control	PROFESS/PROFEV are able to receive charge/discharge instructions from GESSCon
S4G-35	The Grid-side ESS control system shall be able to implement scenarios where EV Charging Stations are cooperatively coordinated with ESS	To maximize the charging services with respect to PV production, local and grid storage status and network constraints	Number of charging services increases by at least 20%
S4G-43	The DSF-SE shall offer a dedicated API	To allow programmatic access for defining a grid, changing an already existing grid in the system, and running simulations	The professional GUI interacts with the DSF-SE through the DSF-SE's APIs.
S4G-45	A DSF Data Warehouse component shall be available for raw data storage	To allow for training predictive models and running simulations	A component named "DSF Data Warehouse" (DSF-DWH) is available to store raw data (time series + associated meta-data) collected from the field. This is a scalable, open, secure non-relational database.
S4G-47	LESSAg should be able to communicate local available charging/discharging capacity to DSF-DWH	To inform DSF on the local ES conditions, using DSF-DWH	The LESSAg comunicate the status of ES according to HLUC-1-PUC-1-S1b and HLUC-1-PUC-1-S2.
S4G-48	LESSAg should be able to communicate local available generation (excess) capacity to DSF-DWH	To ensure that surplus energy is not lost through curtailment due to grid limitations and in order to keep the grid voltage in the acceptable band	The LESSAg communicate the status of energy storage according to HLUC-1-PUC-1-S1a.
S4G-49	The SMX shall be able to receive measurements from the Energy Router	Signals from ER regarding the energy from different sources, loads and energy storage are used by the SMX to further communicate to DSF-DWH.	The SMX receives measurements from the ER according to HLUC-1-PUC-1-S1.

S4G-53	A DSF connector shall communicate with Siemens system	To enable monitoring and control of Charging Points	The DSF connector is integrated with the Siemens server. It is used only in Bolzano's commercial test site. It enables components, at the EDGE layer, such as PROFEV to: - know the charging status (charging, not charging); - set, periodically, the vehicle's charging power; - know initial battery SoC; - monitor power in real-time. Furthermore, based on the real-time measurements, it will estimate the SoC in real time.
S4G-54	A Remote, cloud-based DSF Adapter shall be available	To enable monitoring of CP connected to the local Siemens EV system	The DSF connector can connect to the Siemens back-end system in ASM and retrieve information (active/non-active, instant consumption) about connected CPs
S4G-87	The user should have the option to observe the consumption and production data of the household	To be able to control the level of self-consumption	The system allows the user to query - production of PV system - consumption of energy from the grid - consumption of energy produced by the PV system - over production
S4G-88	The residential GUI user should be able to analyze the production and consumption data over various time frames	To be able to observe changes in the production and consumption data over time	The user is able to freely analyze information over time frames, ranging from 1 day (min) to # of available years (max)
S4G-89	The residential GUI user should be able to query the state of charge of the storage system	To be able to plan or spontaneously use a higher amount of energy (e.g. EV charging for long distance travel, starting dish washer, ...)	The user can access the always up-to-date state of charge of the storage system. The values displayed on the user interface represent the real world values of the storage system
S4G-90	The residential user should be able to see the health status of the system	To be able to get a repair service as soon as the system starts to fail or is down	The user has options to health-check - the PV system - the battery
S4G-91	The residential GUI user is able to see the remaining charging time of the EV	To be able to see when the EV will be fully charged	The remaining charging time is present on the GUI as soon as the EV is plugged in the charging

			station and updated according to the live SoC.
S4G-92	The residential GUI user should be able to choose between demand management options according to his needs	To be able to schedule activities according to his/her plans and goals	The user is able to switch between the options: - maximize self-consumption (default value) - maximize self-consumption, but prioritize car charging (nice to have and not a mandatory feature) - minimize the price
S4G-93	The residential GUI user must be able to see the status of his system	To be able to change settings or initiate measures if needed	The user is able to query status information about - current behavioral mode set - if an EV is plugged in (and charging or not) - if PV is producing - current production and consumption - current battery behavior and SOC
S4G-115	The professional user shall be able to see the status information of the storage available in the grid	To be able to locate and address issues and failures	The professional user can see the battery systems' working state as binary information (ok / not ok)
S4G-116	The professional user is able to take into account the real-world topology when he works on the grid topology	To be able to adapt and evaluate his simulation or solution attempt according to environmental factors	The user is able to evaluate his solution / simulation with respect to the actual environment
S4G-150	The residential user shall be able to export data of interest	To be able to archive it or perform further analysis not supported by the GUI	The user is able to de/-select data of interest and export it as Excel file. The user is able to de/-select at least consumption, production, and SOC (storage). The selected data is filtered according to a time frame specified by the user (at least "data of the last month")
S4G-151	The residential user shall be able to see when his/her storage has been used by the DSO	To allow for checking when the storage has been accessed as well as the amount of energy charged / discharged from the battery	The user is able to - see when (date, start and end times) his storage has been used by the DSO - see the amount of charging / discharging - include the data in his / her exports defined by S4G-150
S4G-219	The DSO SCADA information should	To allow DSO SCADA data integration in the DSF.	Data is read from a DSO SCADA file and sent to the DSF-DWH. The

	be integrated in the DSF		DSO SCADA information is based on the IEC 60870-5-4 standard.
S4G-304	The professional GUI should be able to use scaling factors for the penetration level of elements in the grid	To investigate in the stability of a given grid topology	The penetration level for each grid element (PVs, ESS, EVs) is entered as a value in the simulation panel. This value defines to what extend the existing elements are penetrating the grid. "Existing" also includes newly added elements which are defined by the professional user.
S4G-305	Data shall be collected, stored and protected based on EU and national legislation in Italy and Denmark	To ensure the compliance of data handling with privacy regulations	The procedures of data collection, storage and protection are implemented as described in D8.1. 1) Interviews to collect "personal details" and "preferences": "Personal details" are stored in paper form in EDYNA and ENIIG archives. Moreover, users have signed consent forms and information sheets. Users "preferences" are available in Confluence. Every user related information shared in Confluence should use an anonymized identifier by user. 2) Automatic Data Collection procedures: Data is directly measured by automated devices and transmitted using a secure media to a local gateway. 3) Data Storage Procedures: measurements and infrastructure-related data is hosted in dedicated relational and non relational data-bases built upon well-known solutions. 4) Data protection procedures: All data managed by the project is protected according to State-of-the-art security standards.
S4G-309	The professional GUI should enable the user to export simulation results in an open data format	To store the results and/or import them to other programs for further investigation	The user presses a download button. If a simulation was performed, the simulation results are being downloaded to the professional users' PC in an open data format (e.g. CSV, JSON, ...).
S4G-328	SMX should have a configuration aligned with phase 3	In order to achieve the needs of phase 3 development, some	A structure that support the phase 3 test sites needs.

		minor configuration needs to be done.	
S4G-329	DC link should be completely connected to ER	To ensure that ER is connected to our laboratory and link to neighbor, through DC link.	The interaction between ER and the rest of the components mentioned in description can be analyzed. The ability to command the ER according to a resilience profile on DC level and to see a proper activity of the components is an objective for this requirement.
S4G-337	ESS Status Prediction must be available	Aimed for data analysis and simulations.	An online prediction provides day-ahead performance status of the ESS. The produced data contains information about battery state, SoC and eventually controller entity (owner or grid side controller). Such prediction might be used by the Grid Side Controller that for instance, needs to have estimation of how many ESS's in the feeder are willing to hand their storage control to the DSO/Aggregator as a cooperative action, in the day-ahead. Data will be available for specific time interval (e.g. 24 hours) thus as time-series. The carried information will have the following shape for specific point of time: ["timestamp": "15/01/2019 - 14:15", "state": "idle", "power": "0.0", "unit": "kW", "controller": "GESSCon", "SoC": "0.5",]
S4G-389	The strategic grid planner shall be able to see the estimated battery life-time per ESS	To evaluate the long-run investment for DSO	The strategic grid planner selects one of the different operational modes. Based on that, the overall ESS lifetime will be estimated and displayed.

2.2.2 Non-functional Requirements

Non-functional requirements address the operation of the future S4G system and are classified by various criteria according the Volere schema: usability, performance, operational requirements, maintainability, scalability, legal, standards related, etc.

In the following table, an overview of the updated non-functional requirements is described.

Table 2 – Non-functional requirements as documented in phase 3

Key	Summary	Rationale	Fit Criterion
S4G-13	Pilot site users with smart metering, storage and/or EV charging solutions installed should provide written authorizations regarding monitored data management	To ensure that the project is aligned with the Data Protection Directive 95/46/EC	A signed contract per user should be obtained, meeting the requirements specified in S4G deliverable D8.1
S4G-19	Battery inverter shall be able to apply with legal requirements for the Grid-level battery system in Bolzano	Legal grid requirements are necessary	That the battery inverter comply with Grid requirements
S4G-37	The S4G information view and data models should cover privacy aspects	To allow to keep track about ownership and privacy constraints	Dedicated descriptors (meta-data) must be available to annotate collected data when this is possibly associated with privacy constraints. The S4G information views reflect the D8.1 constraints for each use cases as described in section 2 of D8.1.
S4G-38	Data shall be kept as close as possible to the user site and be secured	To ensure data safety and prohibit data transfer to cloud systems if it is not desperately needed	Only the useful sub-set of data is transferred from local gateways to centralized data warehouses. Local debug data is only accessed when this is required by maintenance tasks.
S4G-39	Data handling shall be compliant with EU and national legislation in Italy and Denmark	To ensure the compliance of Data handling with privacy regulations	The procedures of data collection, storage, protection, retention and destruction are described in D8.1.
S4G-40	Upon any data import operation, the DSF user shall be aware about privacy constraints associated with secondary re-use of data.	To inform the user about potential privacy constraints associated with data he/she is using	When DSF adapters are used to import existing data, the user is made aware about constraints related to "further processing of previously collected personal" specified in D8.1 e.g. by accepting a license.
S4G-41	Access to data shall be protected	To prohibit users to see other than their own sensitive data (residential case) or data not needed to fulfill their task	It is not possible to access grid data without username/password combination. - Residential user can only access own data. - Professional user can only access the

			sub-set of data that they need to accomplish their specific use cases.
S4G-51	The residential user interfaces should be usable on different devices and screen sizes	To allow for easy access to information provided by the system	The interface is supported by and usable on a standard smartphone (e.g. Samsung Galaxy S8, Iphone 7, no matter the operating system) and a desktop PC
S4G-306	Procedures are available for data destruction and exploitation based on EU and national legislation in Italy and Denmark	To ensure the compliance of Data handling with privacy regulations	Procedures for data destruction and exploitation are defined according to D8.1. They are available on confluence.

3 Lessons Learned

This section presents S4G's definition of a lesson learned (LL), the S4G LL process, the LL verification criteria, the categories a LL can be related to. Moreover, it lists the current lessons learned so far per work package. The amount of lessons learned documented in the wiki per work package is depicted in Figure 6. Even though the lessons learned collection officially ends in M33, there might be additional findings during the evaluation period of phase 3. Those potential newly created lessons learned will be documented in D6.12.

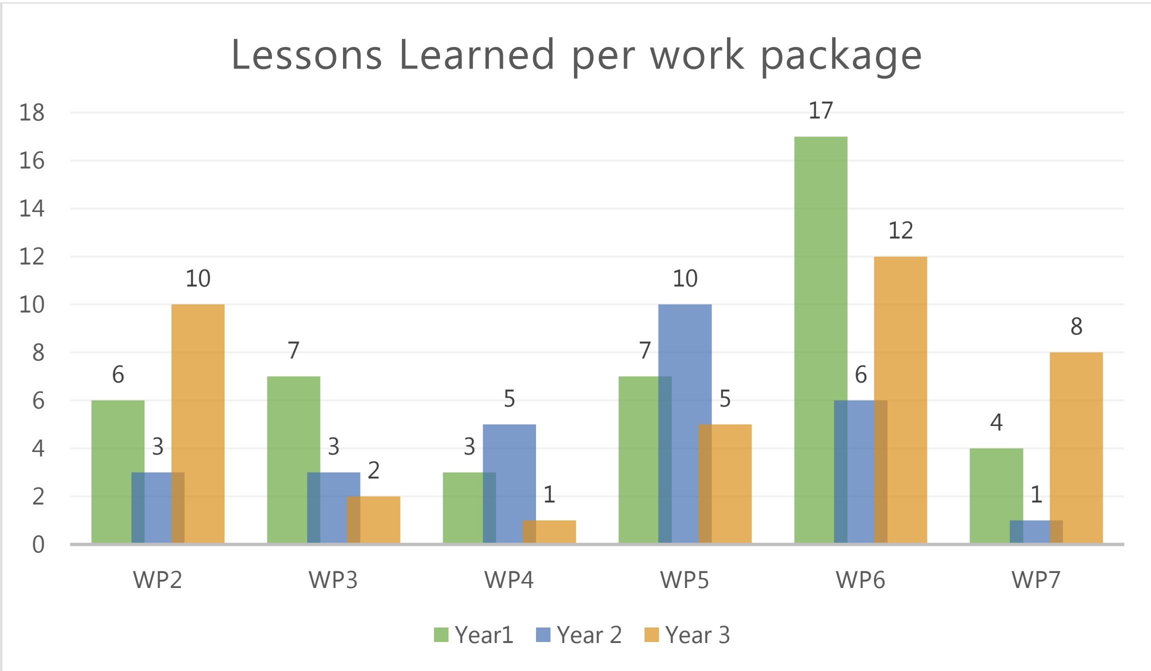

Figure 6 – Lessons Learned documented per work package – situation on 05.08.2019

3.1 What are Lessons Learned?

Lessons Learned (LL) belong to a project culture committed to Knowledge Management. Lessons are learned during project RTD work, during testing and integration, as a part of the validation of project prototypes and during literature search and technology watch. Lessons can thus be learned throughout the project work. As such, Lessons Learned constitute both individual and organizational knowledge and understanding gained by experience, either negative (missed targets, solutions that do not work as expected, wrong choice of technology) or positive (easier implementation than expected, faster response time, more interoperable devices than expected).

Lessons Learned help support project goals in the RTD work of:

- Promoting recurrence of successful outcomes
- Precluding the recurrence of unsuccessful outcomes.

In order to implement a workable Lessons Learned process, it first needs to be defined what is understood by the term "lesson". The following characterization is used for a lesson:

- It must be significant in terms of the project progress and ability to meet its goal
- It must be valid, i.e., the experience gained must be repeatable and/or must be linked to at least one activity or phase of the project
- It must be applicable to the Storage4Grid project
- It may contain or address pertinent info
- It may provide information of interest for existing stakeholders but also for future potential users of separate items/findings of the project.

Not all experiences will qualify as being Lessons Learned and it is important that reported Lessons Learned not merely restate existing information, and/or existing experiences *not* related to the Storage4Grid work.

3.2 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 the wiki page mentioned above in 1. Collection.
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 follows 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 analyzed and reported 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 was 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 was undertaken in WP2.

3.3 The S4G Lessons Learned 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.

3.4 List of final Lessons Learned

This section lists the current lessons learned, both the ones collected outside S4G and the ones related to each work package.

3.4.1 Lessons Learned outside S4G

During the early phases of Storage4Grid, there are only few project internal lessons learned to be mentioned. However, several S4G consortium members already gathered experience in related energy domain projects, such as GreenCom[i], which had a pilot site at the Island of Fur. In order to avoid the same problems, S4G leveraged on a set of relevant lessons learned of the GreenCom[i] project. The set is presented below.

3.4.1.1 LL in GreenCom WP 2 – Business Models and Requirements Engineering

Energy markets can be very different throughout the European Union. It is therefore important to gather as much domain knowledge as possible from member states other than Denmark or participating countries in order to realize the project's full potential with respect to flexible business cases.

3.4.1.2 LL in GreenCom WP 3 – Network and Software Architecture

A proper analysis of standards and open source implementations (libraries) is necessary. The so gathered knowledge has to be shared with the consortium. The Information view of the architecture needs to specify sources, structure, consistency and quality metrics from the beginning to ensure a project result of high quality. The software components to be developed need to be modular and independent to allow for lose coupling. This will result in a flexible software construct which can easily be adapted to changing requirements, regulations and standards. APIs should be as generic as possible, but as specific as necessary to be reusable. Complex components need to implement an extension and configuration mechanism to support various deployment scenarios.

3.4.1.3 LL in GreenCom WP 4 – Building Management Systems

Data quality needs to be one of the priority objectives and should be analyzed in the early project stages. In order to prevent cloud solutions and remote servers from crashing, local gateways should come with a packet transmission limit. This will prohibit data flooding and will reduce traffic.

3.4.1.4 LL in GreenCom WP 5 – Sensors and Actuators

A hardware component assessment should be done a priori during early stages of the project. This includes ensuring the robustness of used components by e.g. talking to manufacturers.

3.4.1.5 LL in GreenCom WP 6 – Energy Generation and Storage Systems

GreenCom developed explicit implementation for monitoring and controlling storage systems as well as the Network Monitor and Control Framework (NMCF) since no generic standard for DER and storage integration was existent.

3.4.1.6 LL in GreenCom WP 7– Data Aggregation, Analysis and Decision Support

An early focus on data quality is as important as fully grasping the ramifications of each requirement. Using an agile approach with a strong focus on working code and small development steps will enhance the software quality. Additionally, contractual consequences should be discussed with consumers.

3.4.1.7 LL in GreenCom WP 8 – Platform Integration and Deployment

To ensure a high project productivity and quality of work, regular meetings, an early development chain, agile collaboration methods and a live and accurate documentation should be established early in the project. It is important that the documentation keeps track of hardware, software and deployment as well as installation procedures and configurations in one central location. Relevant components should implement a version number which is consequently increased throughout the change history.
General deployment issues need to be anticipated and documented in a timely manner to enable early preparations of workarounds and architectural updates. Probes which are to be deployed need to be tested in an isolated setting (e.g. laboratory) before they are rolled out. Technology should be selected with respect to the availability of remote and automated operation as well as estimated maintenance costs.
Recurring, systematic issues should be analyzed and patched as soon as possible to prevent their distribution throughout the test site. Debugging procedures to break down error debugging complexity need to be developed as well as tooling for uniform batch updates for the distributed infra structure need to be developed. Automated monitoring of data flows and deployment states is mandatory.

3.4.1.8 LL in GreenCom WP 9 – Pilot Validation

Stability of the deployed systems and equipment throughout the whole project is important for the final evaluation. Instability affects end users and therefore might cause insufficient evaluation results.

3.4.2 WP 2 Lessons Learned

The following tables present the LL collected during S4G up to the release date of this document. Potential additional LL will be documented in D6.12.
Each ll is described by the following data:

- Category: further described in 3.3 The S4G Lessons Learned Criteria & Category
- Partner: Partner who reported the LL
- Experience and Knowledge gained: Summary of what was experienced leading to the LL
- Lesson Learned: Description of the observation
- Analysis: Deeper analysis of the LL to provide more insight
- Req. affected: list of directly affected requirements

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
Year 1					
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
PRO	EDYNA	To elaborate an optimal business case several competences are needed.	It 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	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	

		all partners involved.		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. All in all, it is good invested time (one hour or so).	
Year 2					
PRO	FIT	Having preliminary system requirements as a basis for development is difficult since they might turn out to be malformed or contradicting standards as the project progresses and the knowledge about the domain and legal limitations increases.	Form initial requirements in a way that they are still applicable as the project evolves to be able to show progress.	Initial requirements turned out to be not applicable after the first architectural and legal drafts and continuously needed to be reworked.	all
IWU	FIT	The quality of the requirements elicitation and testing sessions with end users highly depends on the success in communicating the	It is important to clearly communicate the purpose of testing and requirements gathering methods in order to get good	User tests were not as efficient as expected since motivation and tasks were difficult to communicate.	all

		motivation as well as expected results.	results in end user workshops.		
PRO	EDYNA	The elaboration of a valuable business model requires clear understanding of the Italian regulatory framework, especially for DSOs.	It is important to involve in the project a person with knowledge of the Italian regulatory framework	In this way the elaborated business models are more realistic	
		Year 3			
PRO	LINKS	The requirements definition highly depends on components descriptions	It is important to keep updated the components description according to the latest architecture	Few requirements were not defined representing the actual status due to lack of components descriptions in the Jira tool	
PRO	LINKS	Agile method application for such dynamic research project may not be always an efficient approach	The defined user-stories should be split into very small but certain tasks.	Nature of such research projects that is interdisciplinary jobs and exploring new strategies and models, these cause Agile less efficient.	
RTD	LINKS	Economic modelling for futuristic scenarios requires specialized analyses for various scenarios, and solid knowledge over technical aspects as well as legislations and policies	Many inputs for economic models and scenarios are not already considered by policy makers nor market	Broad studies helps to define efficient while reasonable hypothetical scenarios and proposals.	
PRO	FIT	The maintenance of requirements/user needs need to be less documentation-heavy and more practical / agile	Maintenance and elicitation should take few time and be as flexible as possible, following only a hand-full of rules.	Partners were in denial of following the requirements elicitation and maintenance process since it was loaded with documentation rules	
PRO	FIT	SWE development and requirements elicitation process should be either agile (SCRUM) or waterfall, but not mixed	It is important to agree on a single process or mindset for both, requirements and software development	Volere requirements and SCRUM-like approaches are difficult to be matched which produces organizational overhead and inconsistencies in the documentation chain	
PRO	FIT	Technology-driven research projects	User-centered approaches for	It is important that the necessity of involving	

		should adopt the user-centric methodology as good as possible - at least on a high level of user needs and system features	technology improvement and research are a modern way of ensuring the applicability and usability of developed hard- and software systems	users as one of the main drivers of system features is explained to and understood by all project partners - users are not a limiting factor for evolving ideas and advancing technology, but a very important source for motivation and requirements for future systems	
PRO	FIT	Agile software development is only beneficial if every partner is able to adopt and apply the necessary mindset and actively participating in the project and regular meetings	It is easy to restrain agile software development in interdisciplinary, international (EU research) projects	The development process can be blocked if partners are feeling uncomfortable with agile methods, are not willing to participate in regular meetings and are in general not keen in working in a fast and agile way	
PRO	FIT	The waterfall process and waterfall-ish methods like Volere Requirements are not flexible enough to adapt to unforeseen changes (law, technical limitations)	The chosen process needs to be able to support changes due to technical limitations or other reasons discovered later in the project.	Available infrastructure and hardware kept changing during the project; requirements could be adapted to reflect the new circumstances in the project goals because a mixed approach of Volere and SCRUM was used; however, this was not optimal.	
PRO	FIT	The user needs research in the beginning of the project needs more time than originally reserved for this task and needs to be kept alive over the project run time	The time needed for user research was underestimated.	Several requirements kept being reworked throughout the project because there was no clear user need / reasoning for the feature described by the Volere Requirement. It was not possible to properly research	
PRO	FIT	High fluctuation in team members causes trouble because undocumented	A plan to tackle team member fluctuation needs to be established; knowledge needs to be	High fluctuation in team members causes knowledge loss. This is especially painful if requirements have been formulated and the	

		knowledge and targets get lost	documented in a format that sits all project members	person taking the requirement over has no option to contact the original author to ask about his/her intentions	

3.4.3 WP 3 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
Year 1					
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 of 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.	
Year 2					
PRO	UPB	Common information model was (is) an important topic of discussion and in order to match all the needs and initial proposals, some standards and protocols have been in depth analyzed and debated.	The decisions involving further development of components and communication needs to be rationally and commonly taken in a reasonable time.	In this way the continuous progress of the project is achieved.	
ARC	ISMB	Including a common information model	Technical objectives have to be considered	A common information	all

		generates significant modifications to the overall architecture.	since the beginning on every design face.	model was not considered during architecture design and it added extra components in the architecture.	
PRO	ISMB	Easy interoperability between 3rd party systems was not accomplished since a common information model was not considered.	A common information model have to be considered to enable separate developments of grid-connected storage systems.	Grid storage systems interoperability was not considered.	all
			Year 3		
ARC	UPB	New microgrid architectures have been discovered and understood, which can complement the project initial advanced prosumer architecture.	In TRL 4 to 6 projects it is needed to have an open mind on new solutions.	Microgrids by design were possible to be considered with added Solid State transformers, to allow high RES deployment and resilience. Theoretical analysis and simulation have been made and reported in papers.	
ARC	LINKS	An accurate definition of a system architecture and components specification depends on a clear identification of the provided services	It is important to provide more detail about vague/general concepts to provide accurate component specifications	Few components specification were not matching the real scenario	

3.4.4 WP 4 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
			Year 1		
RTD	UPB	It is not clear yet well how the Grid-side ESS control can take advantage of both grid-ESS and local ESS	A clear setup of the typical ESS usage is needed: grid-ESS points and capacity, local ESS, network topology and	Investigate situations how the grid-side ESS is useful for high penetration of	S4G-31, S4G-33

		and what data is needed from DSF	constraints, scaling method to simulate high RES penetration and corresponding high ESS	RES production and avoidance of network reinforcement. Provide KPIs.	
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 and implementation problems can be successfully treated and optimal solutions can be found	Expansion of communication ways such as teleconferences, personal meetings, common documentation tools (e.g Confluence), etc.	
Year 2					
PRO	ISMB	Retrieved data from EV charging stations contain errors.	Data pre-processing is needed for stochastic modelling and predictions	Data quality insurance processes shall be included in the preprocessing phase	
PRO	ISMB	Essential (behavioral dependent) parameters for Cooperative Charging are not stationary	Analysis over existing data (commercial stations) proves the non-stationary cooperative charging parameters	Data might be different from what was expected	
RTD	FIT	Sample data from local nodes is important for developing optimization strategies	Sample data from application scenarios is needed for optimization models	Sample data should be taken as soon as possible in the project, so effective algorithms are developed.	

PRO	FIT	Technical partners need to know how to enter and obtain information to/from a framework like PROFESS	A defined API facilitates and explains the use of a framework for local optimal control like PROFESS	An API defines and explains by itself the use of a framework for local optimal control	
PRO	FIT	Installation process can be hard and tedious, bringing too much problems to the developers.	The framework for optimal control must be easily deployed	The framework will work on a container architecture which facilitates the deployment on the nodes	
			Year 3		
INT	LiBal	REST API connector endpoints should have a standard to follow.	It is important to define and agree on a standard for the API endpoint format.	During integration, different API endpoint format increases the complexity of the work.	

3.4.5 WP 5 Lessons Learned

Cat	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
			Year 1		
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, S4G-44
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

SEC	ISMB	There should be a definition of personal data, in order to analyze the potential private issues with a baseline.	Directive 95/46/EC (General Data Protection Regulation) defines the concept of personal data, S4G 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.	Once private data is identified and collected, it is important to keep track of its source, e.g. by adding some meta-data which clearly specify the owner and the privacy sensitivity of data.	S4G-15, S4G-37
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 anonymized during the collection process, and treated as anonymous data by the majority of the consortium, the link between anonymized 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 details, preferences and measurement and infrastructure-related data. The first two use unstructured data format while the third	S4G-39, S4G-41, S4G-42

				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 anonymized 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 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	S4G-38

				about their preference and expectation, instead of being passively monitored.	
SEC	ISMB	When it involves tracking or observation of participants, ethics issues arise If further processing of previously collected personal data is needed, ethics issues may 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 anonymized and access to all sensitive information must be secured. 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.	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 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. 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	S4G-38, S4G-40

				case, all data will be published in aggregated and anonymized 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 – 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 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.	
Year 2					
PRO	UPB	In the monitoring of the data acquisition from the meters in the test sites, existed unnoticeable stops.	DSF needs to monitor (through IT channels) the arriving of the messages and signalization of the moments when the messages are not received. In addition some recovery functionality will be implemented as well in the SMX.	In this way the moments when issues appear will be immediately known.	
PRO	ISMB	Predictive models need sample data for modelling.	Sample data could be provided from the beginning of development phases.	Open source data can be used to start with the data modelling	

INT	ISMB	EB#SMX interface confuses about the adapter implementation.	An adapter cannot be developed between a component and the MQTT broker.	Adapter cannot be developed if data flows are not well defined.	S4G-1
PRO	ISMB	DSF-SE needs to be verified for cloud deployment.	External load-flow solver may impose deployment limits, based on its native OS.	DSF-SE should be tested on Virtual machine.	all
PRO	ISMB	DSF-SE must have modular architecture to support all defined scenarios.	Hybrid simulation support requires specific functionality by DSF-SE.	Architecture needs to be as flexible as possible	
PRO	ISMB	Wrong input data might cause load-flow solver not to converge.	DSF-SE should handle a set of errors.	Data errors need to be tested and taken into account during the software development process	
ARC	FIT	Not knowing exactly how the scenario is going to work, expands the conception of the architecture making it difficult to be defined	Application scenario must always be present while developing an Architecture (DSF-SE)	The scenarios must always be present while defining an architecture	
PRO	FIT	Without a data model for global services is difficult and to implement the whole architecture	The communication between global and local services must have a standard data model	A standard data model should be the starting point for implementing the communication between modules	
SWD	FIT	OpenDSS was developed for Windows and it states problems for deployment on the server.	Simulator software for DSF-SE should run on Linux for easy deployment on the server	The best option for the deployment on the server is the selection of open source tools running on Linux or that can be adapted to Linux	
PRO	FIT	Without a defined API the use of any service is not feasible. However it requires a hard work between partners to accomplish a good-defined and useful API	API definition requires hard work together between partners	API definition should be made from the starting point while defining a service architecture. It requires many sessions between partners to accomplish a common understanding	
Year 3					
RTD	LINKS	The performance of the predictive models highly	It is important to define the requirements about data availability, quality, etc. with respect to the deployment	Few predictive models have not been evaluated using the data collected with the	

		depends on the available data	in order to select the best strategy for data analysis	S4G project because data requirements were too high with respect to the deployment plans	
RTD	LINKS	External software could have hidden restrictions	The API of the load-flow solver software selected for Hybrid Simulation Plug-in, is still under development and doesn't cover all needed functionalities, while in windowing mode offers those one	For missing APIs, suitable and efficient implementation has been possible thanks to COM interface and representative model definitions.	
RTD	LINKS	Choice of appropriate predictive models depends on the final destination of forecasts	Changes in forecasts' features, even though slightly, may require to change machine learning models completely.	Sticking to standard features helps to converge different actors and entities with various tasks.	
RTD	LINKS	Quality of predictions cannot be guaranteed relying only on project dataset	Particular predictive methods especially those applied to sequence models require far richer datasets, for wider time span, otherwise hardly reaches the minimum acceptable precision	Combination of available public or private dataset helps to improve performance of predictions.	
PRO	EDYNA	The SCADA system does not always provide the desired measurements	The SCADA system provides only MV measures, but the test site is located in LV grid. Furthermore these measures are inaccurate, because they come from a protection system and not from a measurement system	An existing system not always provides the desired data. For specific purpose is better to a have a dedicated system.	

3.4.6 WP 6 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
Year 1					
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	S4G-46

				integrated with SMX in each site.	
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 L&G 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	This setup is not suited for installations at test sites in private homes, as it's	Use a modular connector to USB adapter in the future and then use a prefabricated	

		these, UPB send 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)	delicate and could break	Ethernet path cable in the correct length.	
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 were 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 simpler 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	Supporting software needs to be taught to partners to gain a shared knowledge	

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 experimentation. Therefore it may happen that EDYNA's technicians and engineers have to spend much more time in the house as originally planned.	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.	
PRO	EDYNA	Very difficult to buy the recommended L&G 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	Cleary distinguish between user-driven and technology-driven features and focus on the user-driven ones	

			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 purpose 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 extent 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 subtile 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 subtile 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 extent 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.	
Year 2					
PRO	ENIIG	It is important to use high quality hardware, such as cables to ensure proper connections between devices.	In private settings, cables must be professional and secured properly	Cable-Connections should be kept simple and need to consist of high quality hardware plugs to prevent the connections from unplugging themselves.	
PRO	ENIIG	Reinstalling the SMX and cable was repeatedly necessary due to connection loss caused by unknown reasons.	Installation instructions have to be clearly defined and well written: a. plug USB into SMM, b. then turn on the SMX. An additional error-log on the SMX might help searching for appropriate solutions.	Hardware and installation instructions should be excessively tested in the lab mimicking a real setup before being installed in private houses.	
PRO	UPB	Meter mapping addresses verification is required in order to have a compatibility in SMX and thus the desired measures retrieved from the meter in SMX. It is a necessary task because the data maps are different for different types of meters.	Meter mapping addresses verification is required in order to have a compatibility with SMX acquisition and thus the desired measures can be retrieved from the meter in SMX.	For automating the process a user guide was produced and successfully used.	
RTD	UPB	A continuous operation of data acquisition is needed, and for the research and upgrading needed in different	Continuous operation does not mean the need for a high industrial availability, but operation without	In the smart metering context, in order to overpass uncertainty, we should	

		acquisition points, proving period of at least one week with continuous records will be considered as data useful for validating the concepts.	hops, in order to test our project scopes.	introduce more metering systems rather than postpone the deployment process.	
PRO	EDYNA	During the test in the private house we lost the communication with the SMX and between SMX and meter	All the components should be checked properly in terms of robustness and reliability	Should be tested in lab before installing in private houses	
PRO	EDYNA	The internet connection in the private house was not stable, causing problems in the communication. At the beginning we used the internet connection of the house owner	To use a dedicated internet connection	Involve the IT department since the beginning of the project to establish a proper dedicated internet connection	
Year 3					
INT	UPB	It should be a close communication between the partners that use the same devices for different purposes.	Mention the intentions and the needs before acting.	Putting different software on the same device can cause problems, if the situation is not closely monitored and controlled. For example, SMXs created some internal files that in very short time occupied almost the entire memory of the SD card, making impossible to store the recorded data.	
NET	UPB/EDYNA/ ALPERIA	When you are working with real time data collection, you have to test before the internet	A simple internet router/ internet connection/ internet provider can be very	Because the accessibility to the residential test site was limited, some	

		connection for such kind of applications.	important for the project deployment.	project tools cannot be tested in time (PROFES) and data collection became difficult. A partial mitigation is based on local daily records on the SMX SD card, which can be used for tests with real data.	
PRO	UPB	In a research project it cannot be guaranteed full time acquisition, as the equipment is a flexible solution for research, upgrades and restart are frequently needed, remote communication problems are usual and unforeseen is also a disturbing factor	We should be willing to find & implement tolerant, thus also robust solutions which allow to run applications in a partial acquisition environment.	For example, UPB needed to create MEDAS & PROSIT software in order to fill the gaps in data collection (missed by various reasons) with predicted values, based on similarities with acquired daily records.	
TST	UPB	Following the ER deployment in UPB test site we realized that more useful measures can be needed from ER device.	It is recommended to look for all the outcomes of a deployment and not only for the planned ones in order to deliver better results.	Uninova made available for SMX some internally read by Arduino measures. Then the partner tested the update remote, assisted by UPB.	
SWD	LINKS	Temporary solution must be avoided or replaced during initial project phases	It is important to adopt a solution that does not depend on temporary developments	Few solutions were approached assuming the highest risk	
PRO	LINKS	An efficient pilot management depends on a precise deployment plan	It is important to consider a draft analysis of the software behavior	Few software were requiring too many resources with respect to the	

			with respect to available hardware	available hardware	
NET	EDYNA	Before activating an internet connection it is necessary to evaluate the data traffic that will be necessary	It is not nice to activate an internet connection and discover that this is a data traffic of over 25 GB per month, much higher than contractually expected	The correct evaluation of the resources necessary for a project or a new work is a necessary requirement for the success of the same	
NET	EDYNA	In the real world the internet connection is not always stable, especially in rural areas and with bad weather	Sometimes in the residential test site, located in a rural area, internet access is not available, especially in bad weather	The stability of the internet connection cannot be a requirement for the success of the project. A stand-alone operation must be provided for situations where the data connection is not available	
PRO	EDYNA	When installing equipment, it is necessary to have all the necessary tools and ask first if there is what is necessary at the place of installation	The works may be delayed due to setbacks that could have been foreseen (for example, lack of internet connection)	Better work planning can avoid annoying setbacks	
IWU / PRO / VAL	FIT	Software and hardware evaluation based solely on the requirements as well as technical functionality is not sufficient for a product involving end-users	Software and hardware components should always be tested in collaboration with actual end-users if applicable results are expected	Functional tests or software driven tests do not replace user-based testing and evaluation of the overall system. If a system does work from the technical point of view but is difficult to use and understand for end-users, it	

				will not be used at all.	
IWU	Eniig	Getting data from the main (billing) meter is not possible with direct access.	We were not allowed to interact with the billing meter, because it would give us access to setting up / changing the meter	We decided instead to install another meter in series with the billing meter	
IWU	Eniig	Installing another meter in series with the billing meter	This solution raised other problems. a) There was not room in the board. b) we needed to interrupt the entire building, which was not allowed due to main servers for fiber broad band customers. c) the billing meter is a transformer meter, which was very expensive to install, due to the above to issues.	The solution was to install a meter in the sub-board where the ER is installed and receiving set-points from this board, which will not be very different from the main board.	

3.4.7 WP 7 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
			Year 1		
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).	
Year 2					
DIS	UNINOVA	The project video and flyer should be released during year 1 (even if updates are provided nearly the end of the project)	The dissemination process should start in an earlier phase of the project	Starting in an earlier phase, it will allow the early engagement of the project stakeholders, creating a set of early followers that can help to disseminate the project.	
Year 3					
EXPL	LINKS	Several exploitable outputs with different TRLs and time-to-markets strategies have been developed	Outputs can be exploitable after the end of the project	Dataset, DSF, Energy Router, GESSCon, Professional User	
DIS	LINKS	Open source licenses of some assets	A further deep evaluation of these licenses should be	The assets generated will be released mostly through open	

			done in the next upcoming months	source licenses in order to maximize the reuse potential and to reflect the role that public funding played in their development	
DIS	LINKS	Development of a DSF-EE (economic engine)	Decision maker support system for long term investment analysis	The DSF-EE (economic engine) asset has been developed and it should be considered by Partners for the final exploitation strategy as a strategic asset useful for decision makers economic analysis	
DIS	LINKS	Industrial interest of S4G assets	S4G addresses an industry and an international context undergoing profound changes	Such change represents a great opportunity that Venture Capitalists and incumbents alike are trying to seize through conspicuous innovation investments	
DIS	LINKS	Expected future growth for storage systems	Exploit the future trend of storage systems is advisable for economic opportunities	Two-digit long-term growth trend is forecasted coupled with promising cost structure dynamics that may positively influence the future profitability of business operations	
DIS	LINKS	Future trend of storage pricing	Decreasing of future storage prices represents a necessary condition for higher profitability and investment opportunity	It can generate a great opportunity for stakeholders with interest in investing in storage system that today are not so profitable.	

				The Danish and the Italian markets show a short-term situation of limited economic sustainability mainly due to current regulatory incentives and constraints coupled with significant costs of storage equipment	
REG	LINKS	Regulatory open issues	Changing in regulatory environments is needed	In some EU countries the regulation does not permit for DSO to invest in storage system	
REG	LINKS	Increasing added value of the distributed storage	Increasing role of the distributed storage system is crucial for developing a sustainable long term strategy of storage deployment in the grid	The role of distributed storage appears to be pivotal in solving some of the key challenges that the transition to a new energy paradigm is going to pose due to the diffusion of renewable sources of energy generation as well as self-consumption patterns	

4 Outcomes

In this document, we present the main outcomes of T2.3. The collection of lessons learned is to be treated as valuable input for projects which are similar to or overlapping with S4G regarding the application field, project management tasks and SCRUM implementation. This is also indicated by the fact that the majority of reported lessons learned addresses procedural issues and tips for tackling them. This is also related to the interdisciplinarity and internationality of the distributed teams.

Whereas lessons learned handling software development and hardware related issues might be difficult to directly apply in projects other than S4G, they might provide helpful ideas and concepts of addressing similar problems. Especially the requirements process evolved during the 3 phases of S4G and established a common knowledge about implementation issues and challenges the consortium was facing. Regular requirements workshops kept this knowledge alive and updated, which proved very useful during the implementation phases and triggered the direct communication of partners. This lead to a more efficient way of solving obstacles and reduced the number of blocking issues. While the written SCRUM and requirement process in S4G was laden with documentation tasks – also due to the fact that Volere requirements and SCRUM are originated from different working concepts that do not really match by their nature – the practical part was quite simple and fast, supporting the consortium to establish quick and efficient means of communication.

Safety and security related issues documented in S4G’s lessons learned might not be very relevant in future projects since this field is expected to be dynamic – therefore, lessons learned and requirements addressing this area are to be checked for up-to-dateness before they are applied.

Requirements reported in this document are specifically created for this project and might not hold in other contexts with different software architectures and hardware set-ups. However, they might give a better insight on the particular topics addressed by S4G and hint to established concepts.

5 Conclusions

This deliverable presents the latest state of the iteratively collected, maintained and updated results of Task T2.3 Requirements Specification and Refinement of WP2 Business Models and Requirements Engineering. As a basis for the technical and economic implementation of S4G, this task ensures the conformance of developed results with the DOA as well as results developed by other work packages of S4G, especially end-user needs, technical specifications, standards, data safety and security, and ethics.

The ongoing collection of lessons learned supports this activity by documenting detected issues and their solutions throughout the implementation of S4G.

This activity ends in M33. The final results will be documented in D6.12 Phase 3 Evaluation report.

Acronyms

Acronym	Explanation
AAA	Authentication, Authorization, and Accounting
API	Application Programming Interface
ARC	Architecture oriented
CP	Charging Point
DER	Distributed Energy Resource
DoA	Description of Action
DIS	Dissemination and Exploitation
DOD	Definition of Done
DSF	Decision Support Framework
DSO	Distribution System Operator
Dx.y	Deliverable x.y
EB	Event Broker
ER	Energy Router
ESG	External Stakeholder Group
ESS	Energy Storage System
EV	Electric Vehicle
GUI	Graphical User Interface
HLUC	High-Level-Use-Case
INT	Integration experience
IWU	Interaction with (end) user
LL	Lesson Learned
L&G	Landys and Gyr
LV	Low voltage
MQTT	Message Queuing Telemetry Transport
MV	Medium voltage
Mx	Month x
NET	Network oriented
NMCF	Network Monitor and Control Framework

OCPP	Open Charge Point Protocol
PO	Product Owner
PRO	Process oriented
PV	Photo Voltaic
QC	Quality Check
REG	Regulatory
RES	Renewable Energy Source
RTD	Research and Technological Development
SEC	Security oriented
SM	Scrum Master / Smart Meter
SMX	Smart Meter Extension
S4G	Storage4Grid
SoC	State of Charge
SWD	Software development experience
TRL	Technology Readiness Level
TST	Testing result
TX.y	Task x.y
UCD	User-centered Design
USM	Unbundled Smart Meter
VAL	Validation experience
VPN	Virtual Private Network
WPx	Work Package x

List of figures

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