D2.5 – Initial Lessons Learned and Requirements Report

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0.1	2017-03-08	FRAUNHOFER	First draft of TOC
0.2	2017-05-05	FRAUNHOFER	Initial content
0.3	2017-05-12	FRAUNHOFER	Updated content, some preliminary internal comments handled, current requirements included
0.4	2017-05-15	FRAUNHOFER	Inclusion of Lessons Learned from the GreenCom project
0.5	2017-05-19	FRAUNHOFER	Inclusion executive summary, introduction, and scope; reworked references list, minor corrections
0.6	2017-05-20	FRAUNHOFER	Updated requirement listing from JIRA, table with non-functional requirements
0.7	2017-05-28	UPB	Updates and review
0.8	2017-05-29	FRAUNHOFER	Integration of reviewer comments (UPB, ENIIG)
1.0	20017-05-30	FRAUNHOFER	Final version to be submitted to the EC

Internal Review History

Review Date	Reviewer	Summary of Comments
2017-05-25	Mihaela Albu (UPB)	Approved: • Editorial changes (definitons, acronyms, typos) proposed; • Suggestions for including detailed list of stakeholders
2017-05-29	Gitte Wad Thybo (ENIIG)	Approved

Table of Contents

Executive Summary

This deliverable presents the initial set of requirements and lessons learned based on the storage scenarios depicted in D2.1 Initial Storage Scenarios and Use Cases. It also lays the foundation for the innovations expected to materialise 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.

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**. The Storage4Grid methodology encompasses storage at user premises and storage at substation level, Electrical Vehicles, 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 neighbourhood 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 [1] project on the Island of Fur, Denmark featuring five houses equipped with RES and storage.

1.1 Scope

This deliverable presents S4G's initial set of requirements as well as initial lessons learned. The initial 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 builts upon the use case descriptions documented in D2.1 Initial Storage Scenarios and Use Cases, as well as upon the findings in several S4G internal workshops. They are to be further maintained and specified, closely following the development cycle of S4G. Corresponding to that, *lessons learned* will be refined and added in later phases of S4G. The results of the iterative maintenance process will be documented in **D2.6 Updated Lessons Learned and Requirements Report** in M18 and D2.7 Final Lessons Learned and Requirements Report in M30.

1.2 Related documents

ID	Title	Reference	Version	Date
D2.1	Initial Storage Scenarios and Use Cases		1.0	2017-02-28

2 Requirements

In S4G, a user-centered design (UCD) [2] 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.

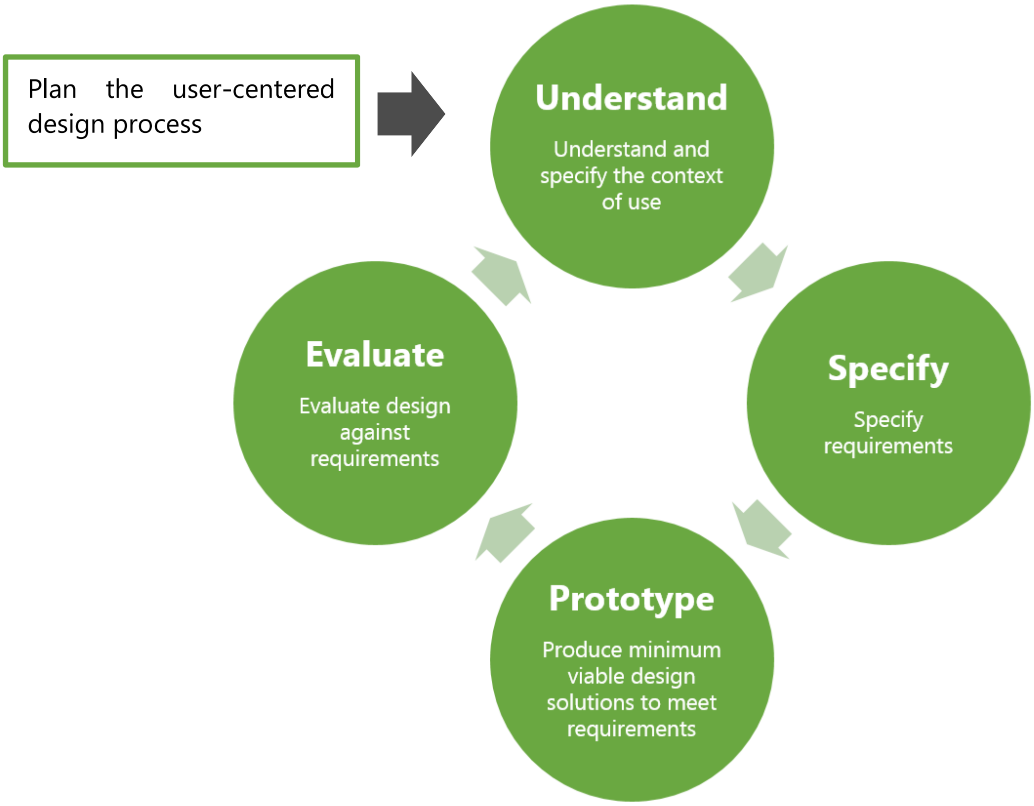


Figure 1 The UCD process adapted from the standard ISO 9241-210:2010 [5]

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 [3], [4], [5], [6]).
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 [7] 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, we have conducted several online workshops with the partners involved in all pilot sites.

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 [7].

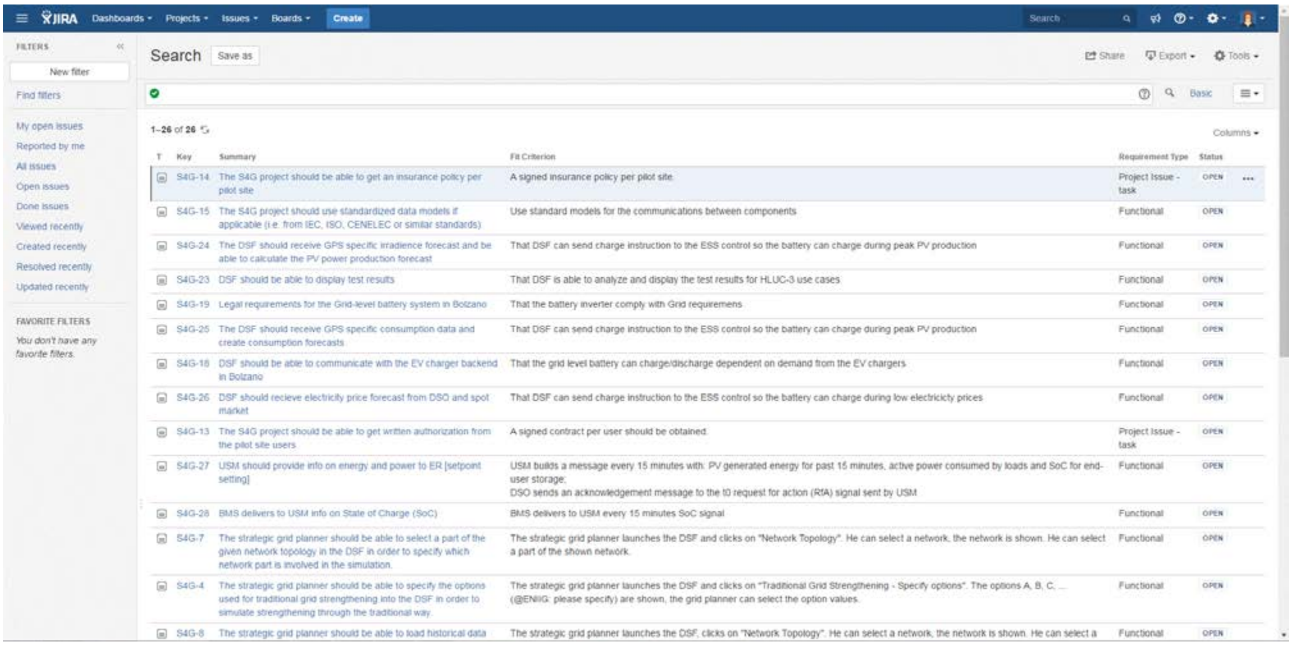
Functional requirements give the specification of the product's functionality, derived from the fundamental purpose of the product, whereas non-functional requirements are the properties of the product, the qualities and characteristics that make the product attractive, usable, fast or reliable. Non-functional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



T	Key	Summary	Fit Criterion	Requirement Type	Status
	S4G-14	The S4G project should be able to get an insurance policy per pilot site	A signed insurance policy per pilot site	Project Issue - task	OPEN
	S4G-15	The S4G project should use standardized data models if applicable (i.e. from IEC, ISO, CENELEC or similar standards)	Use standard models for the communications between components	Functional	OPEN
	S4G-24	The DSF should receive GPS specific irradience forecast and be able to calculate the PV power production forecast	That DSF can send charge instruction to the ESS control so the battery can charge during peak PV production	Functional	OPEN
	S4G-23	DSF should be able to display test results	That DSF is able to analyze and display the test results for HLUC-3 use cases	Functional	OPEN
	S4G-19	Legal requrements for the Grid-level battery system in Bolzano	That the battery inverter comply with Grid requiremens	Functional	OPEN
	S4G-25	The DSF should receive GPS specific consumption data and create consumption forecasts	That DSF can send charge instruction to the ESS control so the battery can charge during peak PV production	Functional	OPEN
	S4G-18	DSF should be able to communicate with the EV charger backend in Bolzano	That the grid level battery can charge/discharge dependent on demand from the EV chargers	Functional	OPEN
	S4G-26	DSF should recieve electricity price forecast from DSO and spot market	That DSF can send charge instruction to the ESS control so the battery can charge during low electricicty prices	Functional	OPEN
	S4G-13	The S4G project should be able to get written authorization from the pilot site users	A signed contract per user should be obtained.	Project Issue - task	OPEN
	S4G-27	USM should provide info on energy and power to ER [setpoint setting]	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	Functional	OPEN
	S4G-28	BMS delivers to USM info on State of Charge (SoC)	BMS delivers to USM every 15 minutes SoC signal	Functional	OPEN
	S4G-7	The strategic grid planner should be able to select a part of the given network topology in the DSF in order to specify which network part is involved in the simulation.	The strategic grid planner launches the DSF and clicks on "Network Topology". He can select a network, the network is shown. He can select a part of the shown network.	Functional	OPEN
	S4G-4	The strategic grid planner should be able to specify the options used for traditional grid strengthening into the DSF in order to simulate strengthening through the traditional way.	The strategic grid planner launches the DSF and clicks on "Traditional Grid Strengthening - Specify options". The options A, B, C, ... (@ENIIG: please specify) are shown, the grid planner can select the option values.	Functional	OPEN
	S4G-8	The strategic grid planner should be able to load historical data	The strategic grid planner launches the DSF, clicks on "Network Topology". He can select a network, the network is shown. He can select a	Functional	OPEN

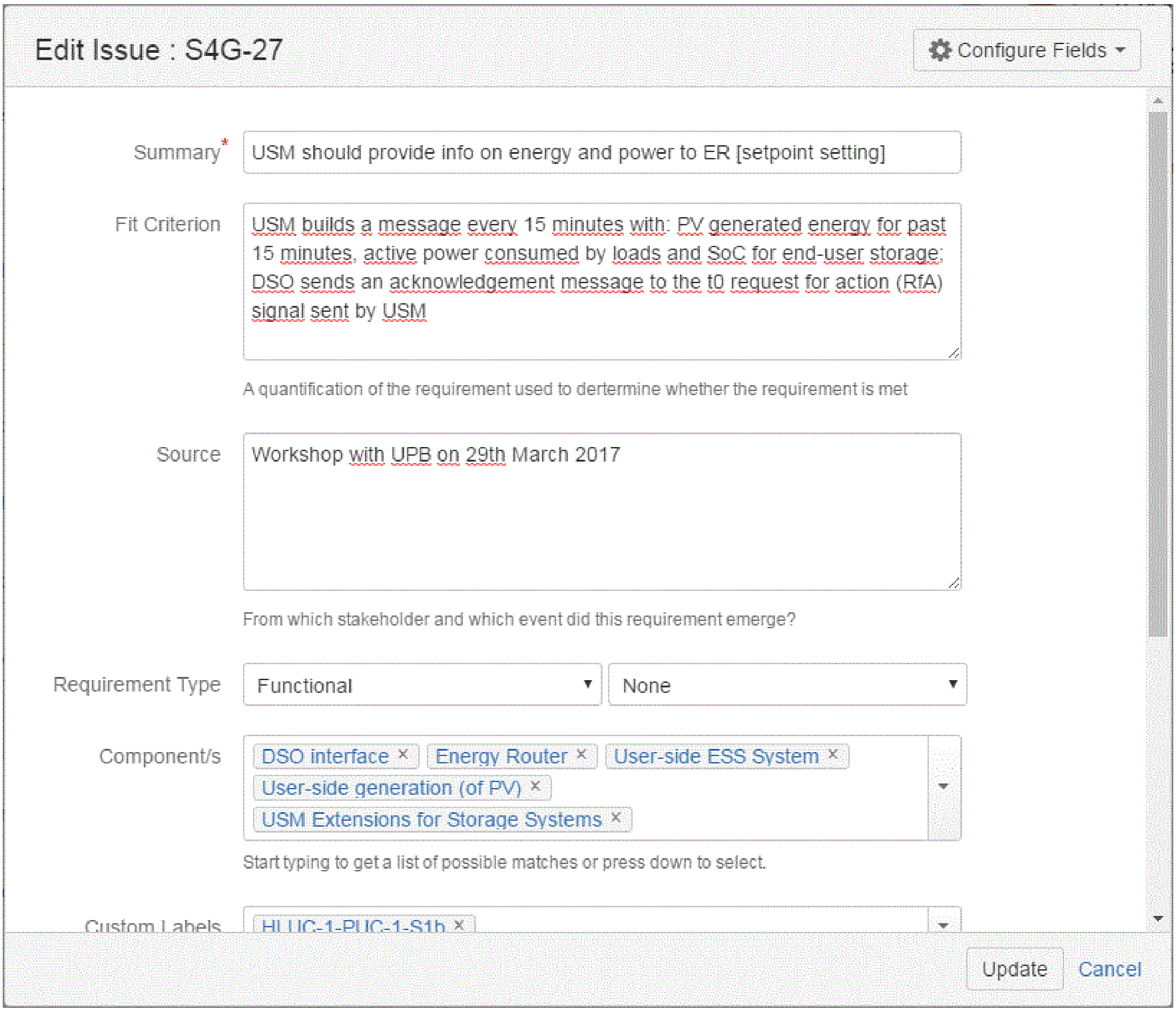
Figure 2 Screenshot of JIRA with a list of S4G requirements

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 requirements.

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



Edit Issue : S4G-27

Summary*: USM should provide info on energy and power to ER [setpoint setting]

Fit Criterion: 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

A quantification of the requirement used to dertermine whether the requirement is met

Source: Workshop with UPB on 29th March 2017

From which stakeholder and which event did this requirement emerge?

Requirement Type: Functional | None

Component/s: DSO interface ×, Energy Router ×, User-side ESS System ×, User-side generation (of PV) ×, USM Extensions for Storage Systems ×

Start typing to get a list of possible matches or press down to select.

Custom Labels: HLUC-1-PUC-1-S1b ×

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.

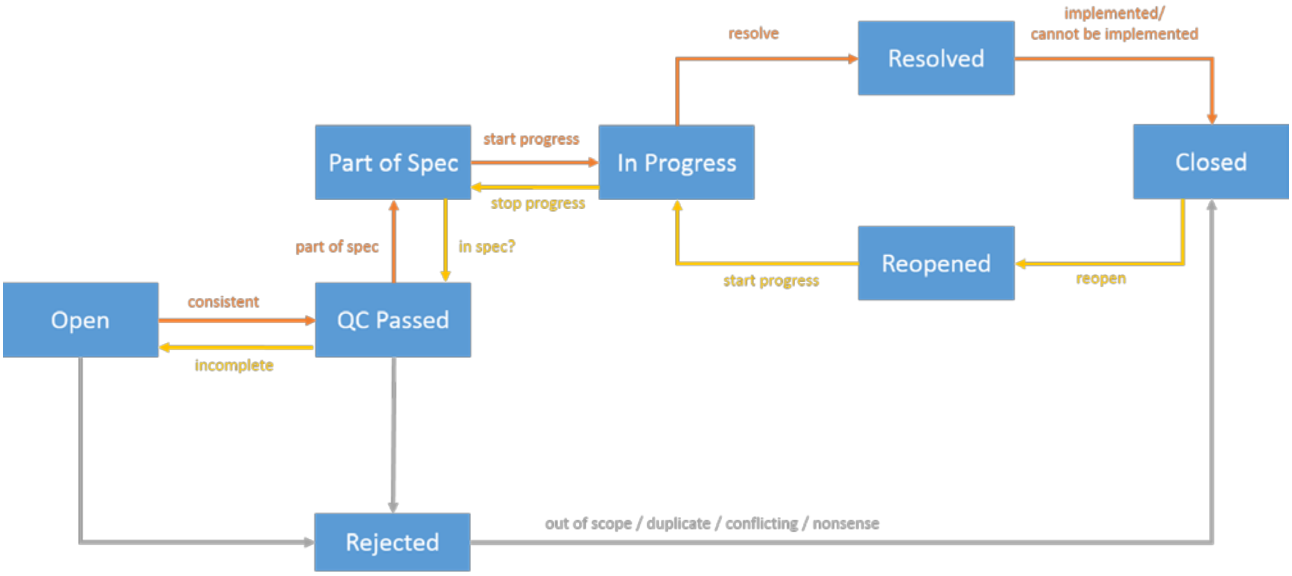


Figure 4 Structure of the Requirements Workflow

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.

2.2 Initial Requirements

The initial requirements are to be used as a reference for the development of the first iteration of the S4G software applications. The list of requirements will be continuously updated during project's lifetime, whenever a need for new or modified features is identified. We will apply various methods to improve our understanding of the user needs and to improve the user-perceived qualities of the prototypes. In particular, we will review the user requirements during the evaluation of the first application prototypes in order to get the second, improved set of user requirements, like it is shown in Figure 1.

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 initial functional requirements.

Key	Summary	Fit Criterion	Rationale
S4G-1	The USM should be able to interpret signals coming from the DSO	Information exchange signals are sent in real time (< 10 seconds from decision moment)	To allow for data and set-point communication between the ER and the DSO
S4G-3	The USM shall be able to forward signals to the Energy Router	Signals are forwarded in real time (< 10 seconds)	To allow for data and set-point communication between the ER (Energy Router) and the DSO
S4G-4	The strategic grid planner should be able to evaluate cost of traditional grid strengthening	The strategic grid planner can access the Professional User Interface and use it to implement the HLUC-3-PUC-1 workflow. The DSF Simulation Engine provides the API necessary to perform the computation required by this scenario.	The strategic grid planner (main actor of HLUC3-PUC-1) needs to know the baseline cost of traditional grid strengthening, so that he/she can use it as baseline benchmark against ESS-related cases. This is normally done through custom tools in use by DSOs such as ENIIG.
S4G-5	The DSF shall be able to simulate scenarios where EV Charging Stations are cooperatively coordinated	It is possible to model and simulate features specified in S4G-35	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
S4G-6	The user-side ESS control shall consider the preferred EV charging policies specified by the residential user	The residential user is able to set constraints and preferences concerning the EV charging policy. The User-side ESS tries to respond to such preferences while maximizing the use of cheap, self-produced energy from the storage system.	During night, EV could be charged aggressively (e.g. to achieve full charge quickly and have the EV available earlier) or slowly (e.g. at reduced power or scheduled to charge later). User needs may impact optimal decision.
S4G-7	The strategic grid planner shall be able to model or select the distribution grid topology of interest for the simulation at hand	The DSF Simulation Engine is able to import the grid topology of interest from the strategic planner. This can be either imported from existing modelling tools and/or modified/verified using the professional user interface.	From a given grid topology, the grid planner needs to select which part of the grid is going to be involved in the simulation.
S4G-8	The strategic grid planner shall be able to import and select historical data of interest (consumption, production, storage)	The strategic grid planner launches the DSF, clicks on "Grid Topology". He can select a grid, the grid is shown. He can select a part of the shown grid. Now he clicks on "Load historical data" and can select a time interval and a substation from the grid topology. Energy consumption and production are shown for that specific substation and time interval in the past.	The simulation of storage placement is based on historical data: consumption, production, storage. This data is loaded into the DSF before a simulation can be carried out. Possibly selecting sub-sets of data may be useful.
S4G-10	The DSF shall be able to generate synthetic data in real time to USM to emulate hypothetical scenarios	A real USM deployed in the Bucharest test site receives fake data generated from a DSF simulation.	Many lab scenarios require testing components under development using hypotetical scenario
S4G-12	The DSF shall be able to integrate and coordinate inputs from different specialized simulators	Architecture design of DSF component include a standard pattern for federation of existing simulators.	Different evaluation (technical, economical) require coordinated use of different existing tools to avoid re-implementing existing tools.
S4G-14	The S4G project should be able to get an insurance policy per pilot site	A signed insurance policy per pilot site.	To protect the people and goods involved in the pilot site.

S4G-15	The S4G project should use standardized data models if applicable (i.e. from IEC, ISO, CENELEC or similar standards)	Use standard models for the communication between components	To allow a standardized approach
S4G-16	The S4G components/systems and its interactions should be based on open standards (as much as possible)	All S4G components/systems implement open protocol/standards that allow third parties to interact with the S4G systems.	Open standards enable a broader acceptance of the products developed within the S4G project.
S4G-17	A Local ESS control agent shall be available to coordinate energy flows between ESS, EV, ER and grid	The Local ESS control agent is able to monitor and send commands to local ESS, EV charging points, ER via the USM interfaces	A local entity must be available to control the ESS set points, EV charging points, ER.
S4G-18	A DSF Adapter shall be available to enable monitoring and control EV charging points	All information made available by the CP can be collected by any authorized (local or remote) third party system e.g. the grid-side ESS control agent	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.
S4G-19	Legal requirements for the Grid-level battery system in Bolzano	That the battery inverter complies with grid requirements	Legal grid requirements are necessary
S4G-20	The user-side ESS control shall consider the preferred ESS charging policies specified by the residential user	User-side ESS control applies ESS charging policies given by the residential user	While in general the ESS is self-controlling, its performances may be helped by collecting user inputs (e.g. about next-day expected loads).
S4G-21	A model shall be available to statistically predict the battery capacity and the SoC of EVs based on history of charges	SoC and battery capacity are available.	Battery capacity and SoC values may not be available. They should be modelled statistically or can possibly be

			manually provided by the user.
S4G-22	Energy Manager actors shall be able to import load profiles in the DSF	A dedicated work-flow is available to import load, generation profiles (time-series).	Load (and generation) profile information are needed to perform several evaluations in HLUC-2 and HLUC-3. Several types of data may be needed (e.g. meter data, transformer data).
S4G-23	Professional users shall be able to display and export test results	That DSF is able to analyze and display the test results for HLUC-2 and HLUC-3 use cases	DSF needs to display the result and export them in open format to allow future re-use.
S4G-24	The Grid side ESS control should receive irradiance forecast and be able to calculate the PV power production forecast	That the grid side ESS control send charge instruction to the Local BESS agent to charge battery during peak PV production	Avoid grid congestion in a grid feeder line
S4G-25	The Grid side ESS control shall receive consumption data and create consumption forecasts	That grid side ESS control can send charge instruction to the user side ESS control so the battery can charge during peak PV production	Avoid grid congestion in a grid feeder line
S4G-26	Grid side ESS control should receive electricity price forecast from DSO or spot market	That Grid side ESS control can send charge instruction to the user side ESS control so the battery can charge during low electricity prices	Improve economy of battery systems
S4G-27	USM should provide energy and power information to Energy Router [setpoint setting]	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	Depending on the DSO data and energy transfer planning, we need to derive the setpoint[s] for ER as a function of local generation for the past 15 minutes, the SoC of the storage and other constraints (for example curtailment avoiding scenario)
S4G-28	BMS delivers to USM info on State of Charge (SoC)	BMS delivers to USM every 15 minutes SoC signal	We need the information on SoC for establishing the set-point for ER
S4G-29	USM receives external message on maximal power to be transferred to the grid for the next 60 minutes (average)	USM process external info on power, update rate 15 minutes. If signal is not received, USM keeps the last value received	This info is needed for deriving the set point for ER

		(maximal power to be transferred to the grid)	
S4G-30	The DSF should help DSO to design the installation of new ESS		The simulation functionality of DSF should be able to help the Strategic Grid Planner of DSO to evaluate the best use of ESS at different grid levels. Examples of how the DSF can be useful include: collecting the load flows data in the selected grid; highlighting possible critical points of the grid; showing the positive effects of an ESS connected to the grid.
S4G-31	The DSF should be able to simulate the grid and to use scaling factors in the use cases of interest		To simulate high EV, heat pump or RES penetration in a future scenario, the DSF is able to use scaling factors.
S4G-32	The SMX interface should allow the user to select his/her operating mode	This interface information is translated in commands for the Energy Router (ER).	This information is needed on the SMX for the User-side ESS control. Initial Operating Modes: automatic (user is "controlled" by the grid-side ESS), semi-automatic (user allows changing to automatic mode, if needed), and manual. Manual mode allows the user to: provide energy to the grid, self-consumption, and battery charge.
S4G-33	User side ESS control and substation ESS control shall receive charge instructions from the grid side ESS control	That the user side or substation ESS control are able to receive charge/discharge instructions from the grid side ESS control and respond on the instructions.	Fx 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

S4G-34	User-side ESS control shall charge/discharge the battery depending for optimal self-consumption based on local energy production and consumption	User-side ESS control shall charge discharge the battery depending on local energy production and consumption	To make real time charge/discharge prioritization of the user side ESS for optimal self-consumption
S4G-35	The Grid-side ESS control system shall be able to implement scenarios where EV Charging Stations are cooperatively coordinated with ESS	Number of charging services increases by at least 20%	To maximize the charging services with respect to PV production, local and grid storage status and network constraints
S4G-36	A statistical predictive model shall be available to estimate Battery Remaining Useful Life (RUL) and Battery State-of-Health (SoH)	A statistical predictive model is able to estimate Battery Remaining Useful Life (RUL) and Battery State-of-Health (SoH), jointly with the associated estimated reliability of the estimation	This is a business need of any storage provider and DSO
S4G-42	Access to all S4G components must be secured implementing to state-of-the-art AAA solutions	Data being handled by S4G components cannot be easily intercepted or altered. Access to all S4G components is only possible using strong security keys (i.e. VPN certificates, strong SSH keys). Username/password combinations are only accepted for accessing residential and/or professional user interfaces.	As the project handles personal data, it is subject to security risks
S4G-43	The DSF shall offer a dedicated open API so that analysis and optimization functions can be accessed programmatically	Control components can get results of pre-defined parametric simulations made by the DSF by calling open APIs.	On some (very) specific scenarios, ESS control features and control agents in general may need to re-calculate or evaluate "optimal" set points. This does not require the use of the full-fledged generic DSF-SE functionalities, but rather to quickly evaluate to specific, pre-defined scenarios.
S4G-44	The DSF shall allow to export "optimal" simulation results so that they can be transferred to control systems	It is possible to export optimal simulation results, and to run a script that automatically transfers such results to some concrete control system.	There are possible scenarios where the DSF is used to evaluate optimal configuration

		Whereas possible, this shall be done using open control standards.	parameters of some devices.
S4G-45	A DSF Data Warehouse component shall be available to store raw data	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.	A dedicated component is needed to store raw historical data needed to train predictive models and run simulations
S4G-46	SMX should be able to read U, I, P, Q from a commercial meter and make it available to different actors	SMX should be able to read U, I, P, Q from a commercial meter with available drivers. The period of complete readouts should be maximum 10 seconds (1-2 seconds is advised). Reporting to different actors should be with a rate of 1 minute or better	SMX data (U, I, P, Q) on the border with the network is needed as support for various algorithms

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 initial non-functional requirements is described.

Key	Summary	Fit Criterion	Rationale
S4G-13	Pilot site users with smart metering, storage and/or EV charging solutions installed should provide written authorizations regarding monitored data management.	A signed contract per user should be obtained, meeting the requirements specified in S4G deliverable D8.1	Any operator willing to implement S4G use cases will be required to collect users' private data and monitored information. As this impact Data Protection Directive 95/46/EC, a proper process must be in place so that users can be informed properly and provide the necessary authorization. In the S4G project this is done following the processes specified in D8.1, but a process must be devised to use S4G outcomes as product.
S4G-37	The S4G information view and data models should cover privacy aspects	Dedicated descriptors (meta-data) must be available to annotate collected data when this is possibly associated with	Once data is collected in any cloud-based or local system, it is important to keep track about ownership and privacy

		privacy constraints. The S4G information views reflect the D8.1 constraints for each use cases as described in section 2 of D8.1.	constraints associated with it.
S4G-38	Data shall be kept as close as possible to the user site and secured	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.	In order to be cautious, data that is not needed should be in general not be transferred to cloud systems but kept on the user site, unless transfer is really needed.
S4G-39	Procedures are available for data storage, protection, preservation transfer and destructions	Procedures described in D8.1 are implemented by the project.	Data handling (as documented in D8.1) must comply with privacy regulations. This is also a requirement for any business model resulting from the project.
S4G-40	Upon any data import operation, the DSF user shall be aware about privacy constraints associated with secondary re-use of data.	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.	The DSF user may not be aware of privacy constraints associated with data that he/she is using
S4G-41	Access to data shall be protected	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.	Data handled by the S4G components is potentially privacy-sensitive or personal

3 Lessons Learned

This section presents S4G's definition of a lesson learned, 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.

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 organisational 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, we need first to define what we understand by the term "lesson". We use the following characterisation 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 this wiki page.
4. **Dissemination**: all project workers are encouraged to continuously consult the LL repository, not only with the purpose of reporting, but also to continuously follow LL reported by other project partners. LL will also be documented in D2.5, D2.6, and D2.7.
5. **Reuse**: the WP leaders have a responsibility to consult the LL repository regularly and at least before any major decision affecting the scientific work and the project outcomes is to be made.
6. **Identification of improvement opportunity**: from the lessons learned, relevant new and/or updated requirements will be extracted. The concerning Work Package Leader will evaluate and describe the impact on the future development work arising from the re-engineered requirements and report this in the deliverable which follow the present one, namely D2.6 and D2.7 (Updated as well as Final Lessons Learned and Requirements Report).

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

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

3.3 The S4G Lessons Learned Criteria & Category

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

- 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 current 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 [1], which had a pilot site at the Island of Fur. In order to avoid the same problems, S4G will leverage on a set of relevant lessons learned of the GreenCom [1] 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 realise 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 analysed 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 analysed 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

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
PRO	ENIIG	The proces 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

3.4.3 WP 3 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
RTD	UPB	There are functionalities which need components at different levels: local control, DSF, ESS and cooperative charging	Clarify split of functionalities between local control, DSF, ESS and cooperative charging	Clear split is needed in the architecture phase	S4G-all
PRO,RTD	UPB	The way how to manage the power equilibrum of the local DC bus of Energy Router (ER) in HLUC1 not yet well clarified.	There are sevearl 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 interraction 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

3.4.4 WP 4 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
RTD	UPB	It is not clear yet well how the Grid-side ESS control can take advantage of both grid-ESS and local ESS and what data is needed from DSF	A clear setup of the typical ESS usage is needed: grid-ESS points and capacity, local ESS, network topology and constraints, scaling method to simulate high RES penetration and corresonding high ESS	Investigate situations how the grid-side ESS is useful for high penetration of RES production and avoidance of network reinforcement. Provide KPIs	S4G-31 S4G-33
RTD	UPB	It is not clear yet well how the cooperative charging can be applied for an EV charging station	A clear setup of the typical charging station is needed: charging points, availiable 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

3.4.5 WP 5 Lessons Learned

Cat	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
ARC	ISMB	While designing control-oriented use cases, it is difficult to distinguish what should be estimated by simulation and what can be directly implemented by control strategies.	In general, control strategies can benefit from receiving information from DSF tools e.g. "optimal" set-points. This can be done by specifying some pre-defined parametric simulations, which can be programmatically activated (e.g. via some open APIs) by remote components	The role of DSF components and ESS control systems must be clearly detailed to avoid confusion and make scenarios very complex. It is also important to be aware about the complexity of the chosen "pre-defined parametric simulation", because control systems normally do not expect delayed answers.	S4G-43, 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 analyse 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.	Most of the data is anonymised during the collection process, and treated as anonymous data by the majority of the consortium, the link between anonymised data and identities of associated user is maintained by a limited number of employees of two consortium members.	S4G-39, S4G-41, S4G-42
SEC	ISMB	When it involves tracking or observation of participants, ethics issues arise.	There is the possibility that the data we collect during the project could be used in the future for enabling methods that can be used for tracking or observing participants, even if we don't do it at the current stage. Because of this, all data must be anonymised and access to all sensitive information must be secured.	Users will not be monitored automatically, nor observed during their usage of the system. Technical information will be logged for performance enhancement purpose. Any type of evaluation will be performed by means of interviews and workshops – where users are directly asked about their preference and expectation, instead of being passively monitored.	S4G-38
SEC	ISMB	If further processing of previously collected personal data is needed, ethics issues may arise.	Confirm that data is openly and publicly accessible or that consent for secondary use has been obtained (and	All published data will be in aggregated and anonymised form – so that no sensitive data whatsoever is released.	S4G-40

			details of how this consent was obtained (automatic opt-in, etc.)). Confirm permissions by the owner/manager of the data sets.	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.	

3.4.6 WP 6 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
PRO	UPB	There is not proper metering on sites in order to implement USM concept.	It is needed a quick investigation for finding the appropriate commercial meter which is compatible with SMX	It is needed to be decided in early stage (M7-9) the solution for a project related commercial meter to be integrated with SMX in each site.	S4G-46
SEC	ENIIG, ISMB	We need to be very careful about fulfilling the future EU: "The general data protection regulation" which is being implemented in all memberstates May 25th 2018	Be in compliance and follow D8.1.	Further analyzes may be needed	S4G-13 S4G-37 S4G-38 S4G-39 S4G-40 S4G-41

3.4.7 WP 7 Lessons Learned

Category	Partner	Experience and Knowledge gained	Lesson Learned	Analysis	Req affected
DIS	UNINOVA	The project website has experienced low access rates	The dissemination process needs to be targeted since the beginning of the project	A strategy needs to be defined to increase the project's website dissemination, increasing its visibility	

Acronyms

Acronym	Explanation
AAA	Authentication, Authorization, and Accounting
DER	Distributed Energy Resource
DSF	Decision Support Framework
DSO	Distribution System Operator
ER	Energy Router
ESG	External Stakeholder Group
ESS	Energy Storage System
EV	Electric Vehicle
LL	Lesson Learned
PV	Photo Voltaic
QC	Quality Check
RES	Renewable Energy Source
RTD	Research and Technological Development
SMX	Smart Meter Extension
USM	Unbundled Smart Meter

List of figures

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