D2.2 - Final Storage Scenarios and Use Cases

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Document History

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0.2	2018-05-02	EDYNA	First draft
0.3	2018-05-16	FRAUNHOFER	Adding use cases overview, adjusted HLUC-3 based on use case workshops with Eniig, major changes in HLUC-2
0.4	2018-05-25	FRAUNHOFER	Adding comments from ENIIG, EDYNA, UNINOVA, Adding ESG Workshop results as appendix
0.5	2018-05-27	UPB	Revised and major changes in the HLUC-1 subcases
0.5	2018-06-08	EDYNA	Small corrections
0.6	2018-06-08	FRAUNHOFER	Major changes to HLUC-3 together with Gitte, removed UML diagrams, added information in Chapter 2; added Scope and Related Documents table
0.7	2018-06-22	FRAUNHOFER	Major changes in HLUC-3 all PUCs as output of telco with Eniig, Libal, and UNINOVA
0.8	2018-07-02	EDYNA	Executive summary
0.9	2018-07-03	FRAUNHOFER	Comments and updates on HLUC-3 to be checked by ENIIG and LIBAL
0.91	2018-07-04	LIBAL	LIBAL comments on HLUC-3
0.92	2018-07-04	ENIIG	ENIIG comments on HLUC-3
0.92	2018-07-05	UPB	Added references to business cases into HLUC-1 tables
0.93	2018-07-05	FRAUNHOFER	Added business cases for HLUC-2-PUC-1, -PUC-2, cleaning up
0.94	2018-07-06	FRAUNHOFER	Clean-up of HLUC-3-PUC-2 and PUC-3 after telco with Libal, UPB, and UNINOVA. Added statement about HLUC-3-PUC-2 and PUC-3 having a pre-condition: Inverter allows dynamic voltage control mode
0.95	2018-07-08	EDYNA	Conclusion and final tables (acronyms, list of figures, list of tables)
0.96	2018-07-30	LiBal	Updated HLUC-3-PUC-3 table and HLUC-3 actor table
0.97	2018-07-31	FRAUNHOFER	Included Regulatory Analysis, adapted executive summary wrt. Document review
1.0	2018-07-31	FRAUNHOFER, ISMB	Final Version to be submitted

Internal Review History

Review Date	Reviewer	Summary of Comments
2018-06-26 (v0.96)	UPB (Marta Sturzeanu)	Approved: • General corrections
2018-07-30 (v0.96)	Vasco Delgado-Gomes (UNINOVA)	Approved: • Minor corrections and typos • Clarification is necessary in HLUC-3

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Executive Summary

This deliverable presents the final scenarios and use cases which were analysed and documented during the first half of the Storage4Grid project (M1 – M18). It updates the initial storage scenarios and use cases described in D2.1 (V1.1) with a focus on technical use cases and scenarios. Additionally, it bridges the technical with the business use cases collected in T2.2 and documented in the deliverable D2.3 Initial S4G Business Models. The main objective is to define the main reference scenarios and use cases for the S4G project. This was done by involving end-users as well as external stakeholders as well as the input of all project partners. D2.2 is part of T2.1 Storage Scenarios and Use Case Definition and lays the foundation of the technical solutions developed by the work packages WP3, WP4, and WP5. The works to realize these use cases are described in D6.2 Phase 2 Test Site Plans and D6.3 Phase 3 Test Site Plans.

The three main use cases HLUC-1 - Advanced Cooperative Storage System, HLUC-2 - Cooperation EV Charging and HLUC-3- Storage Coordination are described in both tabular as well as a story-like form to allow for a better understanding of the objectives, triggers and goals for each use case. The written scenarios are described from a user perspective following a user-centered design approach to emphasize the importance of end-users in future smart-grid solutions as well as the motivation of the S4G project originated from the European Commission's Winter package and further detailed in D2.1.
The tabular form gives a more detailed overview over single steps, involved actors (humans and systems), preconditions, success criteria etc.
To allow for a better readability, the use cases have been structured according to the three test-sites:

- Lower TRL solutions will be experimented and evaluated in a lab-scale test site by using MicroDERLab facilities in Bucharest, Romania (part of European DERLAB network)
- Higher TRL developments will be evaluated in two different real-life distribution grid infrastructures and energy use patterns:
  - in southern Europe (Bolzano, Italy), interacting with professional and end-users leveraging small-scale real-life test sites
  - in northern Europe (Island of Fur, Denmark) interacting with end-users.

The use cases are more detailed in the Sections 3, 4 and 5.

Additionally, in Chapter 2, the scenarios and use cases are grouped with respect to the topics addressed, such as storage solutions from a residential and a commercial point of view and technical approaches. Those approaches focus on control, optimal control, monitoring and simulation for the professional use cases, and control as well as optimal control for the residential use cases.

Attached to this document, there is a summary of the first ESG meeting in Bonn in 2017, as well as the regulatory anlysis conducted for Portugal, Romania, and Italy.

1 Introduction

The purpose of this deliverable is to present the final Storage Scenarios and Use Cases by updating what has been described in D2.1 "Initial Storage Scenarios and Use cases", based on the advancements in detailing and redefining different aspects of the project. This deliverable is part of Task 2.1. Storage Scenario and Use Case definition.

An overview on visions and key facts about the three Storage4Grid scenarios has been given in D2.1, as well as a description of the methodology used for the definition of the adopted use cases.

1.1 Scope

D2.2 establishes a connection between the initial business models and cases documented in D2.3 and its update in D2.4 (M30). It is important to note that D2.2 focuses on the technical use cases that bear innovative approaches and actions for the future smart grid development and therefore does not describe potentially necessary additional and state-of-the-art steps relevant for the business cases, such as baseline calculation. Those steps will be further described in D2.4 (M30). However, the developed business cases and models are based on the use cases described by D2.2; this is why this document also references the corresponding business models and cases in the relevant use case tables in Section 3, 4 and 5.

1.2 Related documents

ID	Title	Reference	Version	Date
D2.1	Initial Storage Scenarios and Use Cases		1.1	2017-02-28
D2.3	Initial S4G Business Models		1.0	2018-03-20
D2.6	Initial Lessons Learned and Requirements Report		1.0	2017-02-28
D2.7	Updated Lessons Learned and Requirements Report		1.0	2018-06-07

2 Summary of the existing use cases

During the first half of the project (M1-M18), the use cases collected for D2.1 Initial Storage Scenarios and Use Cases were refined and slightly restructured based on end-user and stakeholder workshops. For a better overview, the use cases are presented in two different ways of structuring:

1. Structured according to test site, where the division is based on the three demonstrators presented in Bucharest (UPB), Bolzano (Edyna/Alperia), and Fur (ENIIG), as depicted in Figure 1, and
2. Structured according to theme to better show the relation between the distinct demonstrators by emphasizing differences and similarities in components, problems and approaches used in the test sites, as depicted in Figure 2.

The test sites in Fur and Bolzano both involve use cases depicting planning, monitoring, and operating actions. However, in order not to repeat information, the use cases are only documented once as HLUC-2 (control and planning) - with a special focus on EVs as well as the control of storage systems - and HLUC-3 - highlighting the simulation and grid planning actions performed by strategic grid planners in addition to monitoring actions performed by grid operators.

In fact, both test sites will be able to demonstrate the planning and monitoring of (future) grid situations (presented in HLUC-3) as well as the operation of such systems (presented in HLUC-2). It is important to note that only the test site in Bolzano will involve EVs.

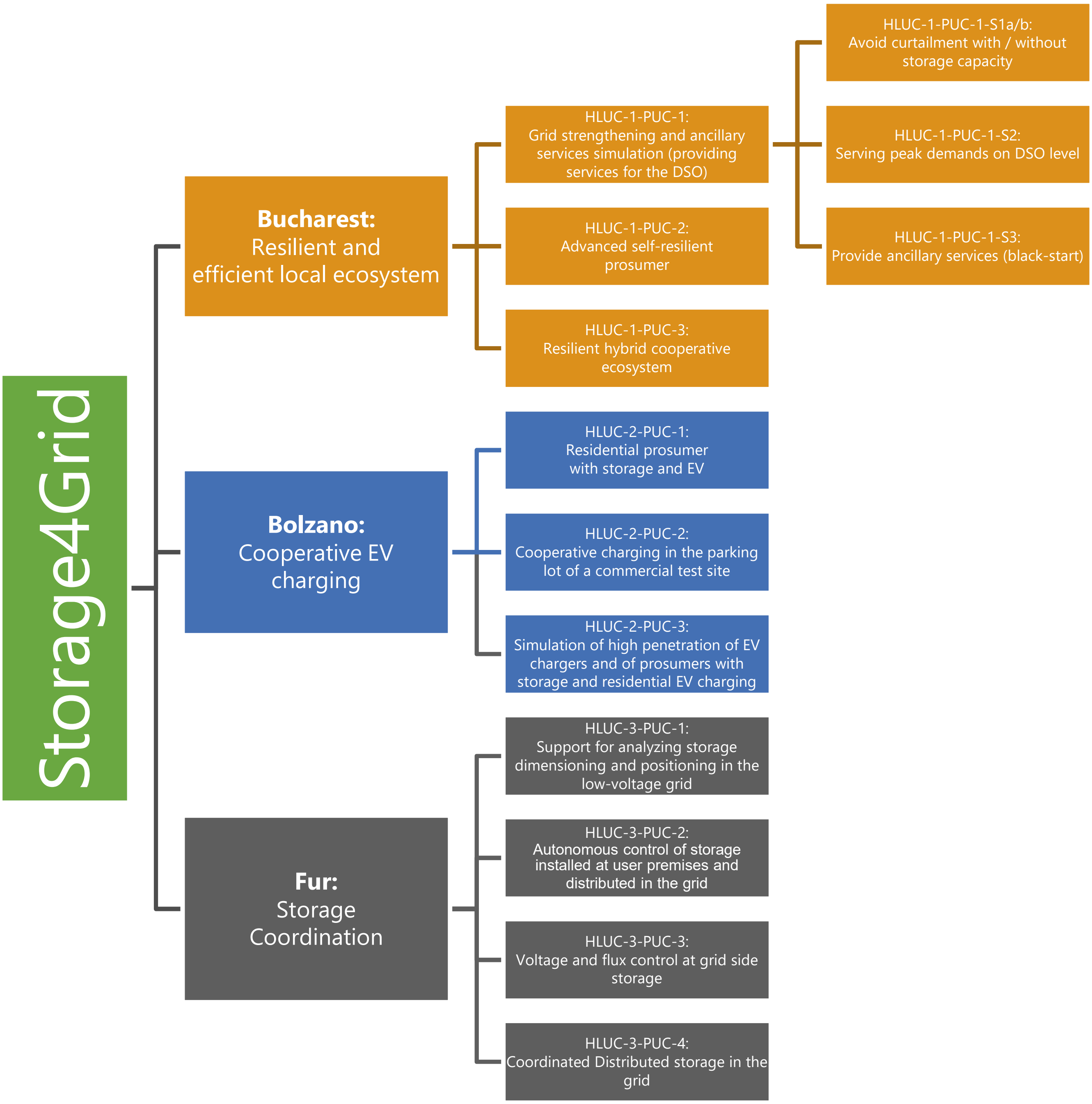

Figure 1 – Use cases presented in S4G structured by test site

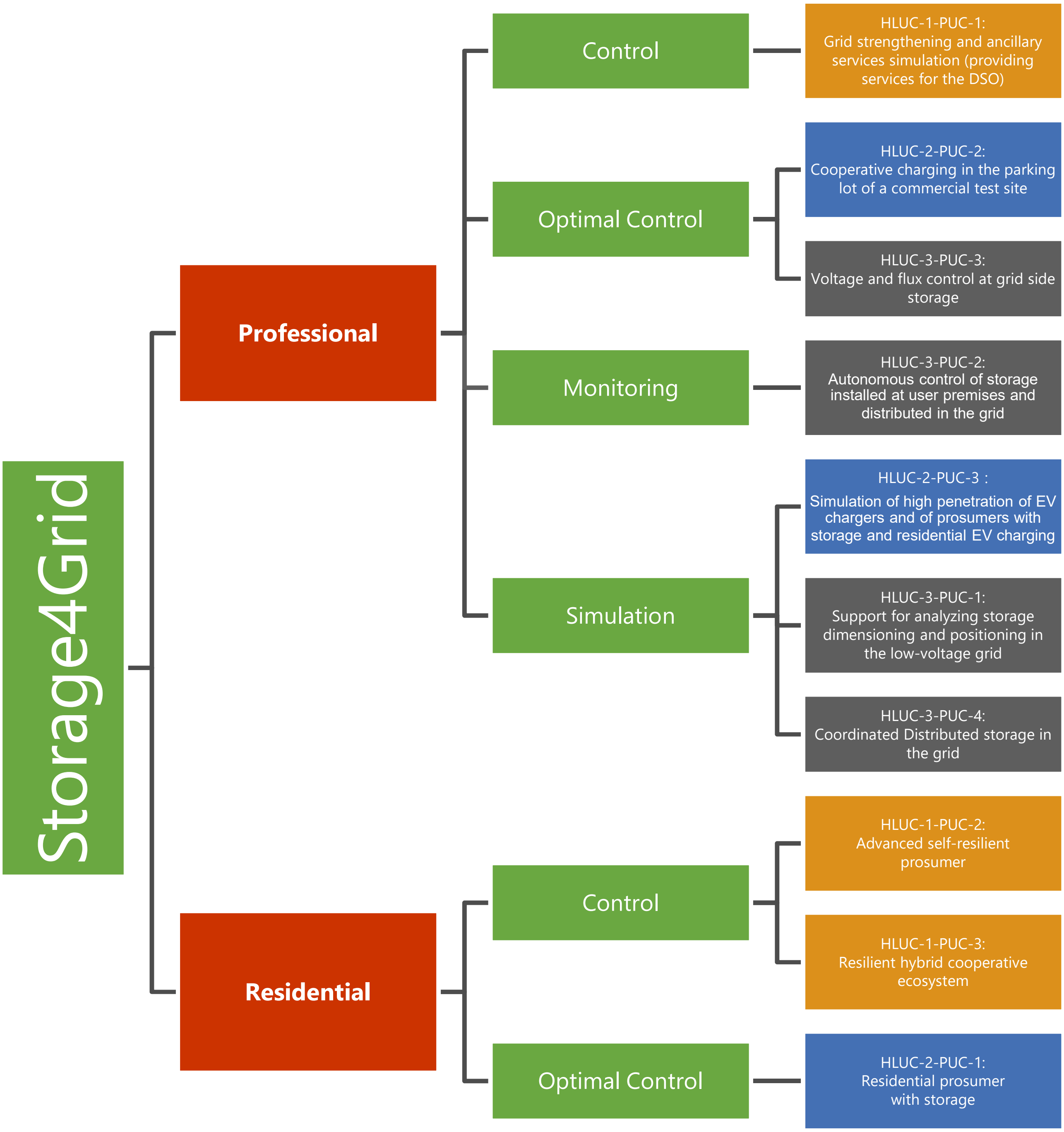

Figure 2 – Use cases structured according to the addressed topics

3 Advanced Cooperative Storage System

3.1 Actor description

Relevant actors for the Bucharest test site's use cases are listed in Table 1.

Table 1 - Actors identified for the use cases in the laboratory test site in Bucharest

Name	Description	Type
AP	Advanced prosumer; owns a storage system as well as a renewable energy source and an energy router with high flexibility for providing various energy services to the AC grid;	Person
ASRP	Advanced self-resilient prosumer; owns a storage system as well as a renewable energy source and an energy router with additional features compared with AP: DC bus for local supply of critical loads;	Person
DC bus for local resilience	Component of ER which enables a local DC bus to supply resilient loads which allows DC supply. This bus is specific to ASRP	System
DC bus for neighbour energy exchange	Component in cooperative DC micro grids; used for energy exchange between neighbouring systems. This is specific to UniRCon	System
DSO	Distribution System Operator	Person
ER	Energy router; communicates with the USM	System
EV	Electric vehicle	System
GESSCon	Grid ESS controller	System
LESSAg Software	Autonomous local ESS agent software; tries to maximize the use of locally produced energy or to answer the requirements of another objective function, depending on the scenario; ensures a dynamic minimal level of energy being stored in the local battery systems; calculations are based on estimations of consumption and production for the next few hours; acts as an autonomous intelligence which does not need information from higher level, AC grid related applications	System
Neighbour	Neighbour of the end-user who can be either consumer, prosumer, AP, ASRP or UniRCon	Person
RES	Renewable energy source; the RES-based generator owned by Prosumers / AP / ASRPs / UniRCon; for example, PVs (other RES types are also possible)	System
UniRCon	Uni-directional resilient consumer; owns a RES and storage but does not back-generate into the grid; appears to act as a	Person

	consumer for the DSO point-of-view and can have a second DC bus which enables local power balancing with neighbours having a similar architecture. It is an evolution of an ASRP	
USM	Unbundled smart meter; Smart meter used for communication with the DSO and the ER, which orchestrates the energy ecosystem by including also different software modules such as EMS, external actors' communication and local interface.	System

3.2 Resilient and efficient local ecosystem - HLUC-1

The usage of renewable energy sources increased over the past decades, causing new challenges for the grid infrastructure as well as to the (AC) grid operators. The electricity production of renewable energy sources (RES) highly depends on the weather and is therefore intermittent and not controllable, which ask for additional balancing resources and can cause voltage fluctuations in the grid, beyond the acceptable values (EN 50160). This effect might be inflated in small and weak network sections (micro grids), or in grids with asymmetrically distributed loads and generators in the three-phase system. Additionally, in the existing paradigm, the decentralized distribution of energy sources and storage requires communication and remote controllable solutions. This can be avoided by increasing the resilience of local energy systems and level of intelligence through advanced local EMS.

As energy efficiency is asked as a first measure or pillar to be considered in the new vision of the Winter package [3], the solution proposed in this high-level use case is considering an architecture which increases the efficiency of energy produced, stored and used locally while, in addition, enabling self-resilience and empowerment of citizen and its local community (as end-users of the energy services). Such empowered ecosystems can also serve the grid by providing distribution-related services (ancillary services for distribution) and can better make use of the European energy market.

This target is served by using the functionality provided by the Advanced Prosumer (AP) and by the advanced self-resilient prosumer (ASRP). Difference in the today architecture of prosumers connected to the grid with hybrid inverters, and the one proposed in this project the Advanced Prosumers with an energy router (ER) is presented in Figure 3.

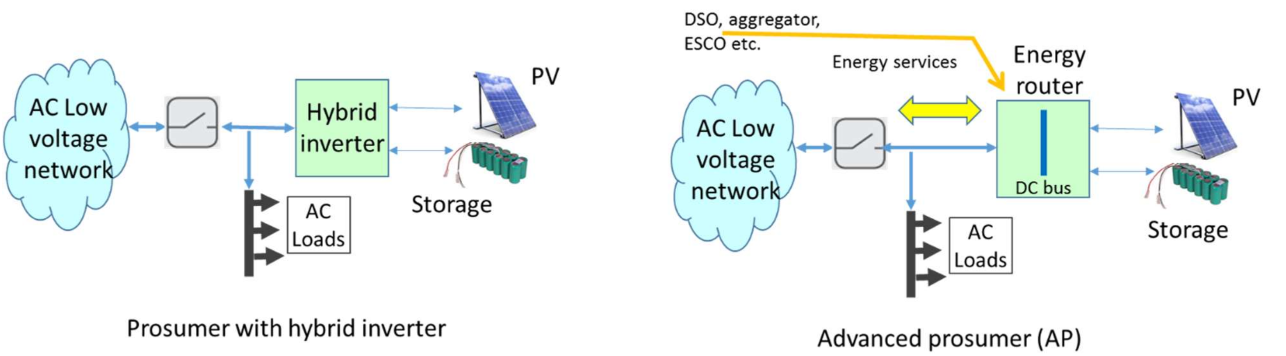

Figure 3 - Prosumer with hybrid inverter and advanced prosumer (AP), having an energy router

The main difference lies in the fact that due to a highly flexible solution, the advanced prosumer is also able to provide energy services requested by DSO, ESCO or aggregator. The advanced prosumer is able then to ensure grid strengthening and to provide on request different ancillary services and will be subject of S4G primary use case1 (PUC-1)

The resilience of the prosumer with hybrid inverter as well as of the advanced prosumer is ensured only after the breaker disconnects the prosumer from the AC network.

A more resilient prosumer is the one which uses the ER internal bus to directly supply resilient DC loads at the prosumer local premises, as per Figure 4a. These loads make the prosumer even more resilient – in fact it becomes immune to grid disturbances, and for the resilient local loads it is not needed to have the network connector open.

Figure 4b gives an advanced variant comparing with ASRP, when the ER has only consumption behaviour on DSO side and which is able to balance prosumer internal energy through an additional DC bus to connect to neighbours (i.e. customers of same utility able to exchange electricity outside the legacy contracts).

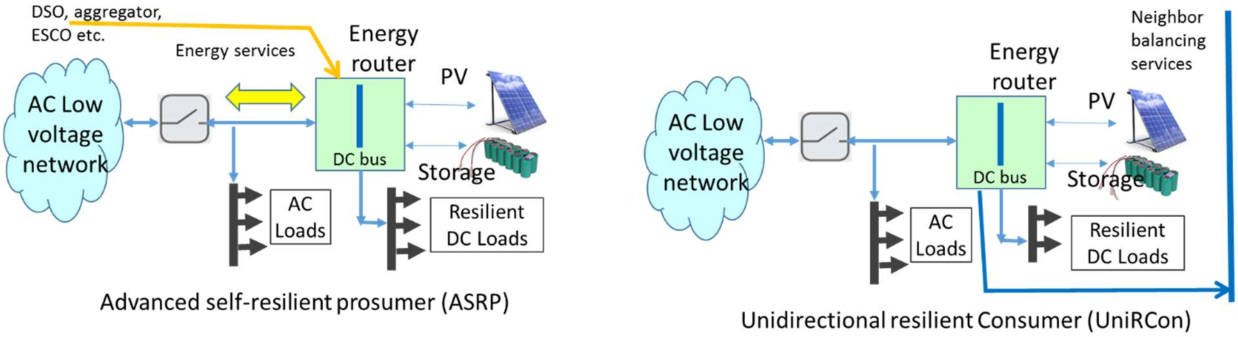

Figure 4 - a) Advanced self-resilient prosumer (ASRP); b) Unidirectional resilient consumer (UniRCon)

3.3 Grid strengthening and ancillary services simulation (providing services for the DSO) – HLUC-1-PUC-1 (Advanced Prosumer – AP)

Lately, as one possible business model, the local DSO is considering to install new technology composed of Unbundled Smart Meters (USM), ERs, batteries for storage and the cloud applications GESSCon and Decision Support Framework (DSF) software. Energy routers and USMs allow for sophisticated remote-control capabilities and offer additional services to the local DSOs, such as Storage-as-a-service, which allows for the seamless integration of energy from prosumers into the grid. USMs communicate with the local DSO and with the grid ESS controller (GESSCon) and forward demands and storage requests to the ER. The ER regulates the electricity flow inside the prosumer's micro (DC) grids and provides ancillary services to the DSO's grid, if needed. The setup corresponds to an AP functionality (Figure 3b), while ASRP can provide as well services to the grid, as per Figure 4a.

3.3.1 Handle over-generation of renewable energy sources on DSO-level (avoid curtailment) – HLUC-1-PUC-1-S1

Consider that today is a sunny day, therefore the PV energy sources produce an energy surplus. Since the current energy demand is not high enough to consume the produced overhead, it needs to be sent back in the network or to be curtailed (classic approach) or to be stored locally in the grid where the energy is produced, in order to increase local [auto]-consumption and to avoid undesired energy flows. Locally, the energy storage is controlled automatically by the USM and the ER.

Paul, a local DSO's grid operator is monitoring the current situation on the grid. He is using the S4G Grid ESS Control (GESSCon) which allows him to check on the currently produced amount of (renewably) energy and/or the net-metered energy, as well as to predict the expected demand of the overall electricity for the next hours.

Because of the sunny weather, the various prosumers' PV systems produce a vast surplus of energy. In order to ensure that this energy is not lost through curtailment due to grid limitations and in order to keep the grid voltage in the acceptable band, the surplus energy needs to be stored locally or somewhere in the storage systems distributed all over the low-voltage grid. Therefore, the S4G GESSCon automatically detects storage resources at different grid levels with available free capacity for cooperative use. This does not only include storage owned by the DSO, but also batteries on the micro grid level owned by the various clients (prosumers). By communicating with the corresponding USMs, a redirection of energy into the local battery storage system at another prosumer level or sent to the cooperative storage is possible using different ER modes. The process is automatic, based on the settings programmed by the prosumer and on the signals sent by GESSCon.

From logical point of view, this use case has always a peer of two AP or ASRPs, one which sends surplus energy in the AC network, to be stored somewhere at the grid level, and another which is able to absorb energy from the same network level, thus allowing a cooperative storage by using the AC local network. In order to be free of DSO network constraints and to allow flexible lab-testing, the DSO network is simulated, especially in the case of energy injection to the grid.

The two use cases presented next correspond to the peer of two AP/ASRPs, in case S1a being analysed the energy injection in the grid, while in case S1b being analysed the energy absorption for storing it locally.
The HLUC-1-PUC-1-S1a and b are to be simulated in the Bucharest laboratory. Even if the DC bus for resilience is not relevant for these tests (specific to ASRP), ASRP will be addressed further, as being also AP. Moreover, even if the DER can be solar, wind or other type (biomass etc.), the tests are performed only with PV production, as microDerLab has this facility.

Use case Table for HLUC-1-PUC-1-S1a – Handle over-generation of renewable energy sources on DSO-level (avoid curtailment), when surplus energy cannot be completely stored locally, thus being sent to the network

This use case analyses the situation of excess energy which cannot be stored locally, thus needing to be sent in the AC grid, in order to be stored at another(s) AP/ASRP(s) at the same LV grid level. In the descriptive Table 2 it is used as an entity which controls the storage available in the grid the DSO, which is represented by the Grid ESS Controller (GESSCon), considering that the DSO operates GESSCon, even if some other business model may also apply.

Table 2 HLUC-1-PUC-1-S1a - Handle over-generation of renewable energy sources on DSO-level (avoid curtailment), when surplus energy cannot be completely stored locally

ID	HLUC-1-PUC-1-S1a
Name	Handle over-generation of renewable energy sources on DSO-level (avoid curtailment)
Related Business Cases	HLUC-1-PUC-1-BM-1: Handle over-generation from RES into the grid (avoid curtailment orders from DSO)
Actors	• DSO (Person) • Advanced Prosumer AS/ASRP (Traian) • Grid (System)

<table>
<tr><td></td><td colspan="2">ER (System)
USM (System)</td></tr>
<tr><td>Actors Goals</td><td colspan="2">Advanced Prosumer AS/ASRP (Traian):
Use as much as possible the PV production (maximize harvesting of DER production, tested in the particular case of PV)
Avoid curtailment orders received from the DSO
DSO:
Prevent grid congestion</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">AP/ASRP has
ER
Production (PV as lab-tested case)
Storage resources
USM acting as energy control and gateway equipment
High PV production (sunny day)</td></tr>
<tr><td>Trigger</td><td colspan="2">Expected overproduction and exceeding local storage capacity, which may ask for curtailment</td></tr>
<tr><td>Post conditions success</td><td colspan="2">Energy produced by ASRP is not curtailed due to storage coordination on AP-side, based on orders received from GESSCon.
The network storage and GESSCon commands are simulated
Local ER acts according to received set-points
Simulation can be executed successfully</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">Storage resources are not enough to store all surplus energy produced by DER (PV as lab-tested case)
Local capacity is computed incorrectly / not forwarded to DSO / GESSCon
Set-points are not forwarded to USM and / or ER
Power is not routed into the grid
Too little power is routed into the grid
Simulation cannot be executed due to missing data or system failure</td></tr>
<tr><td rowspan="7">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>USM sends to GESSCon the RES production amount and the storage available resources (usable SoC), in the condition of low free capacity in local storage (ESS is nearly or completely charged)</td></tr>
<tr><td>2</td><td>DSO sends signal of possible curtailment in next period to USM, in case that no storage solution will be found.</td></tr>
<tr><td>3</td><td>GESSCon gives to USM a recommendation for storing surplus energy in the network (either on grid side or at another AP). The recommendation is in fact a set-point for sending an amount of energy in the grid, which is considered to be correlated by GESSCon with the other part, having available storage means.</td></tr>
<tr><td>4</td><td>USM forwards new set-point settings to ER</td></tr>
<tr><td>5</td><td>ER changes set-points</td></tr>
<tr><td>6</td><td>ER routes surplus active energy into grid</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>4a</td><td>The prosumer refuses the DSO action due to certain local situation; this may bring a curtailment order from DSO, or can be accepted if this refusal is not</td></tr>
</table>

		frequently used (depends on the contract with DSO, which may allow some flexibility in performing services)

Use case Table for HLUC-1-PUC-1-S1b – Handle over-generation of renewable energy sources on DSO-level (avoid curtailment of other prosumers RES production), when the local storage can absorb surplus energy from the grid (Storage as a Service – SaaS)

This use case analyses the situation of excess local storage, thus the AP/ASRP is able to receive active energy from the AC grid, in order to be stored locally. From this point of view, even if it is about a similar entity as the one at S1b, the service is different, meaning that it is a Storage-as-a-Service (SaaS), which is needed to complement the first use case. For the reason of needing a pair of "entity with excess energy" and of an "entity which provides storage service", and for showing that they are complementing, the two use cases are labelled S1a and S1b.

Table 3 - HLUC-1-PUC-1-S1b - Handle over-generation of renewable energy sources on DSO-level (avoid curtailment), when the local storage can absorb surplus energy from the grid

ID	HLUC-1-PUC-1-S1b
Name	Handle over-generation of renewable energy sources on DSO-level (avoid curtailment)
Related Business Cases	HLUC-1-PUC-1-BM-1: Handle over-generation from RES into the grid (avoid curtailment orders from DSO)
Actors	• DSO (Person) • Advanced self-resilient Prosumer AP/ASRP (Traian) • Grid (System) • ER (System) • USM (System)
Actors Goals	Advanced self-resilient Prosumer AP/ASRP (Traian) • Use as much as possible the PV production and energy storage capacity • Avoid losing harvested energy due to curtailment orders received from the DSO DSO • Prevent grid congestion • Prevent energy curtailment due to high RES production, by pairing prosumer with excess energy with storage owners capable to provide SaaS

Pre-conditions	• AP/ASRP has
	  ○ ER
	  ○ Production
	  ○ Storage resources
	  ○ USM acting as energy control and gateway equipment
	• High PV production (sunny day) and surplus storage capacity

Trigger	Expected overproduction which may ask for curtailment
Post conditions success	• Energy produced by ASRP is not curtailed due to storage coordination in the network • The excess energy of the AP needing to store energy is simulated • Local ER acts according to set-points • (Enough) power is absorbed from the grid, to simulate the energy released by the other AP (described in HLUC-1-PUC-1-S1a) • Simulation can be executed successfully

Post conditions fail	• Storage resources are not enough to store all surplus energy • Local capacity is computed incorrectly / not forwarded to DSO • Set-points are not forwarded to USM and / or ER • Power is not absorbed from the grid • Too little power is absorbed from the grid • Simulation cannot be executed due to missing data or system failure	
Description	**Step**	**Action**
	1	USM sends the DER production power and the storage available resources to DSO / GESSCon: it is reported that there is free capacity in local battery of this ASRP, to be used for external needs, as SaaS.
	2	DSO sends asset-point for asking to store surplus energy from the network (usually from an ASRP in the situation studied in S1a) to USM
	3	USM forwards new set-point settings to ER
	4	ER changes set-points
	5	ER absorbs the requested active power from the grid
	6	ER routes absorbed active energy into local storage
Extensions	**Step**	**Branching Action**
	/	/
Sub variations	**Step**	**Branching Action**
	/	/

3.3.2 Serving peak demands on DSO-level – HLUC-1-PUC-1-S2

It is close to noon. Unfortunately, the sunny weather is about to change. The weather forecasting ability of the GESSCon triggers an update for the overall demand and production of the grid. GESSCon then notifies Paul that it is foreseen to reach the expected peak (with respect to weather changes, expected energy generation, storage load levels and historical data in a way which may brake network constraints (DSO-related problem). It suggests to activate at a certain hour in the evening the discharge mode of the local storage systems from low-voltage grids, which were previously charged with spare energy from private PVs in the sunny period of time. This discharge set-points are sent in such a way that the AP/ASRP can reduce evening peak demand in the network by increasing energy release from the batteries (use them for increasing local generation with energy released from storage). This use case translates into modifying the loading conditions at the prosumer level by using the available storage (on-site). It can be triggered by price or – in this case – by GESSCon external control signal.

GESSCon automatically takes the energy demand settings from the local prosumers into account made and calculates the overall possible energy to be discharged from the local storage systems on DSO and prosumer levels. The DSO system now regulates the cooperative storage resources of the low-voltage grid by communicating with the local USMs. The energy flow is regulated by the local energy routers, which directly receive set-points from the USMs. The ERs can release energy from storage systems as well as from the generating sources, if they still are able to produce. By applying the coordinated storage control to various advanced prosumers, the peak period is shaved and some of the grid constraints are avoided.

Use case Table for HLUC-1-PUC-1-S2 – Serving peak demands on DSO-level (HLUC-1-PUC-1-S2):

The HLUC-1-PUC-1-S2 is to be simulated in the laboratory setting.

Table 4 - HLUC-1-PUC-1-S2: Serving peak demands on DSO-level

<table>
<tr><td>ID</td><td colspan="2">HLUC-1-PUC-1-S2</td></tr>
<tr><td>Name</td><td colspan="2">Serving peak demands on DSO-level</td></tr>
<tr><td>Related Business Cases</td><td colspan="2">/</td></tr>
<tr><td>Actors</td><td colspan="2">• DSO (Person)
• Advanced self-resilient Prosumer AP/ASRP (Traian) (Person)
• ER (System)
• USM (System)
• Grid (System)
• GESSCon</td></tr>
<tr><td>Actors Goals</td><td colspan="2">DSO:
• avoid network congestion during the evening
• solve congestion problem by using storage resources from the prosumer</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">• AP/ASPR has
  ○ ER
  ○ Production
  ○ Storage resources
  ○ USM acting as energy control and gateway equipment</td></tr>
<tr><td>Trigger</td><td colspan="2">High consumption expectation (possible peak network conditions: low voltage level, high-power flow, higher losses for the DSO</td></tr>
<tr><td>Post conditions success</td><td colspan="2">• Peak demand is shaved, based on injection of energy from storage resources at prosumers sites; the grid is simulated, considering that it has been reduced the power on critical section, e.g. on the MV/LV transformer.
• Local ER acts according to set-points
• (Enough) power is routed into the grid</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">• Storage resources are not enough in order to inject all surplus energy, even in a cooperative solution
• Set-points are not forwarded to USM and / or ER
• ER neglects new set-points
• Power is not routed into the grid
• Too little power is routed into the grid
• Simulation cannot be executed due to missing data or system failure</td></tr>
<tr><td rowspan="4">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>USM sends the available storage resources to DSO/GESSCon: certain energy stored by local battery, partly available for the grid services; this is a real-time functionality, which is needed to be considered for the following steps</td></tr>
<tr><td>2</td><td>DSO sends signal of possible peak situation in next period</td></tr>
<tr><td>3</td><td>DSO gives a recommendation (set-point) for injecting energy from the local storage at certain time periods, in order to reduce consumption from the grid and to perform load peak shaving at the grid level
Based on the set-point from DSO/GESSCon, the order to produce power from the storage resource can bring two situations:
a) The power produced by the battery is lower than the current consumption of ASRP, thus ASRP is still a consumer, but with lower</td></tr>
</table>

		energy absorption from the grid. This helps the peak shaving as seen e.g. at the MV/LV transformer level, as the consumer is consuming less; b) The power produced by the battery is higher than the current consumption of ASRP, thus the difference is sent to the grid. This also helps the peak shaving, because acts as a production in the network, which reduces the overall grid consumption, as seen e.g. at the MV/LV transformer level.
	4	USM forwards set-points to ER
	5	ER changes behaviour according to the set-points
	6	ER routes available power from storage into the local consumption and/or to the grid
Extensions	**Step**	**Branching Action**
	/	/
Sub variations	**Step**	**Branching Action**
	3a	The prosumer refuses the DSO action due to certain local situation; this refusal can be part of a contract which may allow a certain number of such situations

3.3.3 Provide ancillary services (black-start) on DSO-level – HLUC-1-PUC-1-S3

This is a study on required future regulations allowing black-start capabilities in a defined DSO area (e.g. low-voltage micro grid).

This ancillary service can be requested by the DSO in order to be able to energize a local micro grid and require additional energy supply from the local prosumers. The black-start service requires specific power converter design without grid signal for synchronization, thus being able to impose the micro grid frequency (grid former). The power needed to be injected in the grid cannot be higher than the nominal power of the ER.

Use case Table for HLUC-1-PUC-1-S3 – Provide ancillary services (black start) at DSO-level:

Table 5 HLUC-1-PUC-1-S3 – Provide ancillary services (black start) at DSO-level

ID	HLUC-1-PUC-1-S3
Name	Provide ancillary services (black start) at DSO-level
Related Business Cases	/
Actors	• DSO • Advanced self-resilient Prosumer ASRP (Traian) • ER (System) • USM (System) • Micro grid (System)
Actors Goals	DSO: • perform black-start for the micro grid where the prosumer is connected using storage resources from the prosumer

Pre-conditions	• ASRP has
	  o ER
	  o Production
	  o Storage resources

	 ◦ USM acting as energy control and gateway equipment • A blackout appeared in the micro grid and the DSO disconnected the micro grid from the main grid: needs to have a black-start energy service for this micro grid; due to regulatory constraints, the DSO micro grid will be simulated as a load with a load asking for a lower power than the maximum ER power which can be injected in the grid.	
Trigger	Black-start and micro grid separation from the main grid	
Post conditions success	Micro grid is supplied in a sequence which initially needed the black-start service	
Post conditions fail	• The black-start is not successful (due to high load in the micro grid / micro grid is not disconnected from the main grid) • Set-points are not forwarded to USM and / or ER • DSO does not send the black-start signal • Power is not routed to micro grid separated from main DSO network • Too little power is routed to micro grid separated from main DSO network • Simulation cannot be executed due to missing data or system failure	
Description	**Step**	**Action**
	1	Micro grid is disconnected from main grid by DSO
	2	DSO sends signal of a micro grid black-start need to USM
	3	USM forwards set-point to ER
	4	ER changes its status according to the received set-points
	5	ER routes necessary power to the micro grid, up to its maximum available power, respecting the current local demand in the micro grid
Extensions	**Step**	**Branching Action**
	/	/
Sub variations	**Step**	**Branching Action**
	/	/

3.4 Advanced self-resilient prosumer – HLUC-1-PUC-2

The advanced self-resilient prosumer (ASRP) has an ER with a resilient DC bus available for connecting resilient DC loads. This modular ER is the core interface designed for optimal usage of advanced prosumer energy resources (PV, storage). ASRP is an extension of AS which has in addition the local DC bus which can be used by the consumer.

Traian is an ASRP, having an S4G Energy Router based local energy architecture. Traian wants to be sure that he can consume as much as possible his RES energy production (increase self-consumption). Additionally, he wants his activities to remain resilient to possible main grid outages. Therefore, he is using the local intelligence of the EMS (as an autonomous local ESS agent a LESSAg) to control energy production, storage and consumption such that he always has some spare energy in the batteries in case that there is a short interruption on the AC network or in case it is a complete blackout.

To do that, the a LESSAg software is continuously trying to maximize the use of locally produced energy and keeps a dynamic level of minimal stored energy, which is based on the estimated consumption in the next hours, such that the consumption is resilient for the consumption connected to the DC bus of the ER.

In the case that the connection of the ER to the DSO grid is designed or programmed to be unidirectional, the advanced self-resilient prosumer becomes an UniRCon (Uni-directional Resilient Consumer), meaning that he is adapting the internal strategies in order to be consumer-only when seen from the DSO side. This is transforming the prosumer in a pure consumer on DSO side, which simplifies the responsibilities and requirements of connection and allows a complete control of internal resources.

<u>Use case Table for HLUC-1-PUC-2 – Advanced self-resilient prosumer:</u>

Table 6 - HLUC-1-PUC-2 – Advanced self-resilient prosumer

<table>
<tr><td>ID</td><td colspan="2">HLUC-1-PUC-2</td></tr>
<tr><td>Name</td><td colspan="2">Advanced self-resilient prosumer</td></tr>
<tr><td>Related Business Cases</td><td colspan="2">HLUC-1-PUC-3-BM-1: Prosumer will act always as a consumer from the grid side</td></tr>
<tr><td>Actors</td><td colspan="2">• Advanced self-resilient Prosumer ASRP (Traian) (Person)
• DSO (Person)
• USM (System)
• ER (System)</td></tr>
<tr><td>Actors Goals</td><td colspan="2">ASRP:
• Increase self-consumption as much as possible
• Always keep a certain resilience behaviour (a certain time to be able to supply his critical loads)</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">• ASRP has
  o Energy router with the DC bus extension
  o Production
  o Storage resources
  o USM acting as energy control and gateway equipment
• ASRP keeps storage, production and consumption in such a way that self-consumption is maximised, and a certain resilience is available, based on estimated consumption, production and storage in the next hours</td></tr>
<tr><td>Trigger</td><td colspan="2">A blackout appeared in the DSO grid</td></tr>
<tr><td>Post conditions success</td><td colspan="2">The ASRP
• can keep a certain resilience period of time
• is able to supply his critical loads</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">ASRP is not able to be resilient in terms of needed time</td></tr>
<tr><td rowspan="5">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>ASRP turns his ER strategy to supply in resilient mode the critical loads using the USM</td></tr>
<tr><td>2</td><td>ER / USM gives continuous information about the resilience time and about measures which may increase this key performance indicator (KPI)</td></tr>
<tr><td>3</td><td>If storage runs out of energy, USM (SMX) inform ASRP</td></tr>
<tr><td>4</td><td>ASRP safely disconnects critical loads</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>5</td><td>If the supply from DSO comes back, the ASRP enters in a strategy which covers back the resilience expectancy.</td></tr>
<tr><td>Sub variations</td><td>Step</td><td>Branching Action</td></tr>
</table>

	1a	Additionally, to increasing self-consumption and resilience, the ASRP is acting as a UniRCon, meaning a unidirectional flow of energy (no back-generation in the DSO network) during normal operation; the resilience is kept as before, while self-consumption target is 100%.

3.5 Resilient hybrid cooperative ecosystem – HLUC-1-PUC-3

UniRCon offers energy services (based on new technology) to connected neighbourhood prosumers and consumers.

The UniRCon has a Modular ER with resilient DC bus and with a DC connection for exchanging energy with neighbours. It is an evolutionary extension of ASRP.

The most complex solution is presented in Figure 5.

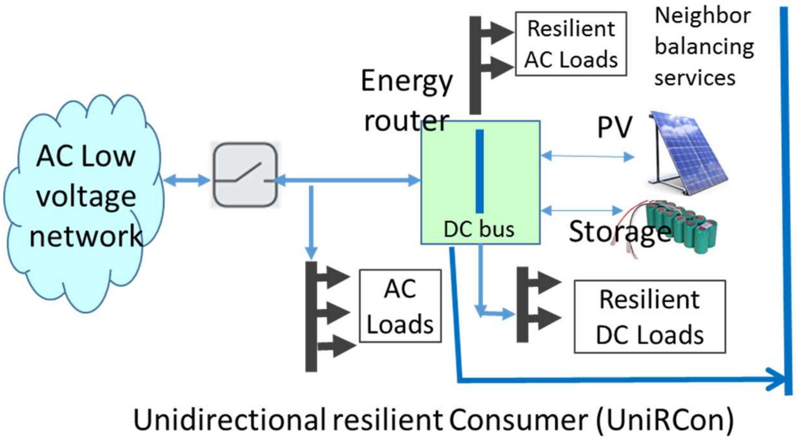

Figure 5 Complete UniRCon architecture

The solution can have in its most complex situation local AC and DC busses, to supply resilient consumers, as well as neighbour DC link, to balance energy within neighbours. However, resilient local AC bus is not studied in the use case.

Decebal is a UniRCon, having a Modular ER which is equipped also with a DC connection to neighbours. Decebal wants to consume his entire RES energy production inside his premises and/or together with his neighbours, by using a cooperative energy control. Moreover, the cooperation is intended to behave as a resilient cluster against different types of grid outages, thus to be used the local intelligence of the autonomous LESSAg to control energy production, storage and consumption for its local needs as well as to provide energy services to its neighbour consumers and prosumers.

Use case Table for HLUC-1-PUC-3 – Resilient hybrid cooperative ecosystem:

Table 7 - HLUC-1-PUC-3 – Resilient hybrid cooperative ecosystem

ID	HLUC-1-PUC-3
Name	Resilient hybrid cooperative ecosystem
Related Business Cases	HLUC-1-PUC-3-BM-1: Enabling energy services to connected neighbourhood prosumers and consumers

<table>
<tr><td>Actors</td><td colspan="2">Advanced self-resilient Prosumer ASRP (Person)
Neighbour of ASRP (Person)
DC bus for neighbour connection (System)</td></tr>
<tr><td>Actors Goals</td><td colspan="2">ASRP
Increase as much as possible self-consumption
Keep always a certain resilience behaviour
Balancing his resources with neighbours using a local DC network
Neighbour
Keep a certain resilience period from DSO outages</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">ASRP has
ER with neighbour energy exchange extension
Production
Storage resources
USM acting as energy control equipment
Neighbour has
Resilient internal network (DC)
Neighbour energy exchange extension equipment (DC bus)
ASRP
Keeps storage, production and consumption in such a way that self-consumption is maximised, and a certain resilience is available
Has excess energy to be shared with the neighbour</td></tr>
<tr><td>Trigger</td><td colspan="2">Due to a blackout, neighbour needs energy to remain resilient and asks for energy to be delivered by the ASRP (it is triggered the energy exchange request).</td></tr>
<tr><td>Post conditions success</td><td colspan="2">The critical loads of the neighbour are supplied by the ASRP through the common DC connection</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">ASRP is not able to provide energy to the neighbour, due to lack of excess energy</td></tr>
<tr><td rowspan="5">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>Neighbour asks ASRP for energy through his resilient DC bus</td></tr>
<tr><td>2</td><td>ER coordinates energy flow of DC buses</td></tr>
<tr><td>3</td><td>ASRP offers energy through the DC bus for neighbourhood energy exchange</td></tr>
<tr><td>4</td><td>Neighbour receives information about the availability of energy from the main ASRP and absorbs excess energy from UniRCon through the neighbour DC bus.</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
</table>

4 Cooperation EV Charging

4.1 Actor description

EDYNA's use cases involve the actors listed in Table 8.

Table 8 – Actors identified for the Bolzano test site

Name	Description	Type
DSF-DWH	DSF-Data warehouse; a storage system for time-series data	System
DSF-GRIDDB	Database at the DSO's premises;	System
DSF-SE	DSF Simulation Engine running power flow simulations in a defined grid	System
DSO (EDYNA)	Distribution System Operator	Company
Energy Storage System	ESS whose charging and discharging is being controlled by the PROFEV	System
EV	Electric vehicle	System
Garage Owner	The owner of the Garage wanting to give the service for charging EVs	Person
GESSCon	Grid ESS controller	System
Professional GUI	DSF tool enabling the professional user to interact with the DSF-SE in a graphical form	System
PROFEV	Framework delivering optimal control of ESS and charging of EVs	System
Prosumer	A prosumer with production and storage behind the meter (BTM)[1]	Person
Residential GUI	Graphical User Interface; allows to observe the current production of the private RES and the consumption of the house; allows for preference settings	System
USM	Unbundled Smart Meter	System

4.2 Cooperative EV charging – HLUC-2

The energy grid in the city of Bolzano is characterized by growing shares of intermittent power generation from Renewable Energy Sources (RES) while facing with increasing diffusion of Electrical Vehicles (EVs). Such scenario is creating new challenges for efficient management and grid stability. Michele, a manager of the local DSO, Edyna, has found a valuable solution to such challenges by using Energy Storage Systems (ESS) with the S4G application system.

[1] Widely known in the photovoltaic industry with the term "**Behind The Meter**" (BTM), a BTM system is a renewable energy generating facility (in this case, a solar PV system) that produces power intended for on-site use in a home, office building, or other commercial facility. [Wikipedia]

4.3 Residential prosumer with storage and EV - HLUC-2-PUC-1

Gigi and Raffaella live in a little village close to Bolzano: they have a PV plant on the roof of their house and one EV, which needs to be charged during the night in order to be ready the day after. To better exploit the energy produced by their PV plant that generates an overhead of energy during the day, while they need more energy during the night for charging the EV, they decided to install an ESS.
The system is integrated with an Unbundled Smart Meter (USM) and a Graphical User Interface (residential GUI). The system automatically collects data about the production of the residential PV, the state of the ESS, the electrical consumption of the household, the voltage levels, and currents, etc. Gigi reads all the data of the system on the display of the residential GUI and can monitor in real time what happens, recognizing that the delivered power at the Point of Delivery (POD) never exceeds the previous maximum allowed value, and in this way the economical return of investment of the system is optimized. PROFEV manages automatically the power flow in the house and starts the EV charging in order to complete the charge within the next morning.
Gigi and Raffaella can do all the home activities: washing, cooking, ironing and other energy consuming tasks in the evening using the energy that was produced by their own roof PV during the day and was stored in their residential ESS.

<u>Use case Table for HLUC-2-PUC-1 – Residential prosumer with storage and EV:</u>

Table 9 - HLUC-2-PUC-1 – Residential prosumer with PV production and storage behind the meter

ID	HLUC-2-PUC-1
Name	Residential prosumer with PV production and storage behind the meter
Related Business Cases	Business model HLUC-2-PUC-1-BM-1: prosumer with ESS “stand alone” Business model HLUC-2-PUC-1-BM-2: Prosumer with grid integration
Actors	• Prosumer (Person) • Energy Storage System (Only controllable system) • PROFEV (System) • DSF-DWH (System) • Residential GUI (System) • GESSCon • EV
Actors Goals	Prosumer: • Accommodate the charging of his EV following optimal control strategies • Contractual conditions regarding maximal consumed and produced power are preserved DSO (as a stakeholder): • The grid is not stressed (maintenance of voltage level and load)
Pre-conditions	Prosumer has: • Roof PV (selected RES in the Bolzano site) • Access to the residential GUI for his/her house • Energy Storage System • Plugs for classic charging (16A) of the EV • Unbundled Smart Meter (USM) o is installed and collects real-time power information of the different system actors o sends collected information in real-time to the DSF-DWH o has south-bound ESS connector o has south-bound EV connector • PROFEV

<table>
<tr><td></td><td colspan="2">• GESSCon sends a schedule for charging/discharging of ESS for the next day</td></tr>
<tr><td>Trigger</td><td colspan="2">• Charging the EV at night and in addition to the existing loads of the house
• Montage of local storage, USM and PROFEV</td></tr>
<tr><td>Post conditions success</td><td colspan="2">The coordination of EV charging with the PV production and the consumption is coordinated in such a way that the maximal power at POD is within the contractual limit, not needing an upgrade or needing a smaller upgrade than without storage and coordination</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">The maximal power at POD contractual limit is exceeded</td></tr>
<tr><td rowspan="5">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>Prosumer plugs the EV at the residential charging station without specifying a charging priority</td></tr>
<tr><td>2</td><td>PROFEV registers the existence of a new load (EV)</td></tr>
<tr><td>3</td><td>PROVEV reacts by adapting the charging/discharging as well as the charging of the EV following an optimal control strategy while analysing the schedules sent by the GESSCON</td></tr>
<tr><td>4</td><td>The residential GUI updates the power flow information accordingly</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>1a</td><td>Prosumer changes the priority of charging the EV from the standard setting to a higher priority using the residential GUI</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
</table>

4.4 Cooperative charging in the parking lot of a commercial test site - HLUC-2-PUC-2

In Bolzano, a commercial test site with a rooftop PV installation plans to acquire a fleet of EVs. The owner aims to equip the parking lot with several EV charging stations which will use the energy produced by the PV installation. Filippo, the owner of the company, aims to provide the parking lot with several Charging Units (CU) for the EV fleet of the company. In addition to that, he'd like to use the energy produced by his PV plant for giving green energy to the EVs of the company. The delivered system is equipped with software for optimal control. This software respects Filippo's settings and distributes the produced and stored energy automatically in a way that all the demands can be satisfied as optimal as possible.

Use case Table for HLUC-2-PUC-2 – Cooperative charging in the parking lot of a commercial test site:

Table 10 - HLUC-2-PUC-2 – Cooperative charging in the parking lot of a commercial test site with PV and EV charging stations

ID	HLUC-2-PUC-2
Name	Cooperative charging in the parking lot of a commercial test site with PV and EV charging stations
Related Business Cases	HLUC-2-PUC-2-BM-1: Cooperative Charging at Commercial or Fleet level
Actors	• Garage owner (Person) • DSO (Person) • PROFEV (System) • USM (System)

<table>
<tr><td></td><td colspan="2">DSF-DWH
GESSCon</td></tr>
<tr><td>Actors Goals</td><td colspan="2">Garage owner:
Optimal coordination of several charging stations for EVs together with PV and ESS, in a way which is compatible with the contract with the DSO
Avoid a contractual increase in maximum power at the point of delivery
DSO:
The grid is not stressed (maintenance of voltage level and load)</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">Garage has installed behind the meter:
Energy Storage System (ESS)
PV
EV
5 charging stations (2x22 kW + 3x7,4 kW)
Unbundled Smart Meters (USM)
PROFEV
GESSCon sends a schedule for charging/discharging of ESS for the next day</td></tr>
<tr><td>Trigger</td><td colspan="2">Charging requests from EVs parked in the garage (up to simultaneous charging requests from all charging stations)</td></tr>
<tr><td>Post conditions success</td><td colspan="2">Grid is not stressed in terms of voltage band violation (basic power quality is kept) due to storage and EV charging coordination</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">The grid constraint limits are violated (high power flow, thus congestion, voltage exceeding the limits allowed)</td></tr>
<tr><td rowspan="4">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>USM collects real-time power information of the different system actors</td></tr>
<tr><td>2</td><td>PROFEV coordinates the charging/discharging of the ESS and the charging of the EV (if possible) following an optimal control strategy while analysing the schedules sent by the GESSCON</td></tr>
<tr><td>3</td><td>Information collected from the USM is sent in real-time to the DSF-DWH</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
</table>

4.5 Simulation of high penetration of EV chargers and of prosumers with storage and residential EV charging - HLUC-2-PUC-3

Michele, a grid planner of the local DSO, wants to investigate on the maximum numbers of public and private EV charging stations that can be supported by the existing grid topology. The software he is using is able to simulate the behaviour of storage installed in the network as well as cooperative charging behaviour. He is highly interested in situations in which the grid is not able to serve all needs and problems regarding the voltage level occur. For Michele, this is a sign that grid enforcement measures, such as installing additional storage or installing thicker cables, have to be taken.
By using his software, Michele is able to simulate the installation of new charging points as well as modelling higher penetration levels of existing storage by entering their penetration level as a percentage; this will inform him about the grid behaviour in potential future scenarios, in which the number of EVs and/or their energy demand rises. After Michele starts the simulation, calculations are being executed and the results are presented

on the grid topology by emphasizing occurring problems. Michele is also able to download the results for further analysis in other software programs such as Microsoft Excel.

Use case for HLUC-2-PUC-3 – Simulation of high penetration of EV chargers and of prosumers with storage and residential EV charging:

Table 11 - HLUC-2-PUC-3 – Simulating EV charging and storage behaviour, considering both public and residential charging stations

ID	HLUC-2-PUC-3	
Name	Simulating EV charging and storage behaviour, considering both public and residential charging stations	
Related Business Cases	/	
Actors	• Professional GUI (System) • DSF-SE (System) • DSF-GRIDDB (System) • PROFEV (System) • Grid Planner (Person)	
Actors Goals	Grid planner: • Determine the maximum number of charging stations to be supported by the grid, with the help of ESS placed in the grid	
Pre-conditions	• Grid topology for the analysed grid must be present in the DSF-GRIDDB	
Trigger	• DSO needs to investigate on the grid stability based on the current grid topology or a future grid scenario	
Post conditions success	• The maximum number of public and private charging stations can be deducted by the Grid planner from the simulation results	
Post conditions fail	• The simulation could not run	
Description	**Step**	**Action**
	1	DSO selects one or multiple radials in the grid in which he wants to run the simulation using the professional GUI
	2	DSO specifies the penetration level of EVs in the selected grid areas using the professional GUI
	3	DSF-SE runs the simulation with optimal control of ESS in each POD delivered by PROFEV
	4	Professional GUI displays the results delivered by the DSF-SE
Extensions	**Step**	**Branching Action**
	/	/
Sub variations	**Step**	**Branching Action**
	3a	New optimal control algorithms of the ESS and EVs at the scaled situation might enable an increased penetration of EV chargers in the existing network

5 Storage Coordination (HLUC 3)

5.1 Actor descriptions

For the use cases of ENIIG, the actors described in Table 12 were identified.

Table 12 - Actors identified for use cases on the Fur and Skive test site

Name	Description	Type
DSO (N1)	Local Distributed System Operator	Company
DSF-SE	DSF Simulation Engine running power flow simulations in a defined grid	System
DSF-GRIDDB	A database owned by the DSO; it contains the grid topology	System
ESS	Energy storage systems installed in the grid	System
Grid Planner	Strategic grid planner working for the DSO	Person
Grid Operator	Grid operator working for the DSO	Person
PROFESS	Framework delivering optimal control of ESS	System
Professional GUI	DSF user interface enabling the professional user to interact with the DSF-SE in a graphical form	System
USM	Unbundled Smart Meter	System
LiBal Site Controller	Control unit for calculating and sending reactive power set point to ESS inverter	System

5.2 Grid simulation and monitoring – HLUC-3

As society is focusing on becoming more environmentally friendly and zero CO_2 emitting, the DSOs will experience an increasing pressure to take action considering both high- and low-voltage grid. Basically, the two main topics of interest for the DSOs in the future are the following: More DER production from renewable energy sources installed and increasing consumption of electric energy as heating and transport are shifted from fossil fuels towards electricity.

Decentralized production in the low-voltage grid in the form of photovoltaic and small wind generators gives a new energy flow. Earlier, the energy flow was always top-down as the energy was generated in big power plants in the high-voltage grid and then distributed through the grid to the consumers at the low-voltage grid. This was easier to analyse and plan. With the decentralized production the energy flow is now shifting according to the production from DER and the consumption. With high production and low consumption, the energy will flow from the low-voltage grid towards the higher voltage levels which causes grid loss, besides the necessary transformation from DC produced by the RES to AC used in the high-voltage grid, which also causes grid loss. The increasing use of RES also contributes to problems caused by unstable voltage levels in the grid. In grid planning, the transformers and the tap changers are usually designed according to the voltage drops in the cables related to the consumption, but with decentralized production the grid now experiences two situations.

1) During high production and low consumption, the voltage rises
2) During high consumption and low production, the voltage drops

This leads to the necessity to trim the transformers in different settings during different situations. In low-voltage areas there is no monitoring and no remote control, trimming is a manual task as one has to go to the transformer in person.

The increasing consumption of electric energy will naturally give an added stress on the grid as this is planned according to the historical electricity consumption. With the added focus on electric vehicles as well as electric heating, the amount of consumed energy will experience a sudden rise for which the grid is not designed. This will ultimately amount to lower voltage in the grid, less reliable supply of electricity and more grid loss.
A similar situation will be present when DER are producing more than the consumption is in the local grid. As a consequence, a rise in voltage occurs which leads to grid loss and low-quality electricity for the consumer, besides lower prices on selling former stored energy.
The standard way of coping with the above two problems from the DSO side is grid strengthening, i.e. to install more and bigger cables and transformers. However, installing some kind of remote controllable storage in the grid might help avoiding these situations and thereby avoiding the grid strengthening necessity.

5.3 Support for analysing storage dimensioning and positioning in the low-voltage grid - HLUC-3-PUC-1

Kasper, a grid planning manager of Eniig, is in charge of voltage issues in the existing grid topology and of investigating potential solutions for future grid setups. He is using the DSF to find out which is the best solution for a specific situation and a given grid topology. Based on different data sources, e.g. real data stored from the end user premises or standard consumption and generation profiles, he can also simulate the impact of remote controllable energy storage systems installed on different grid levels.
To determine the best solution for grid stabilization, he needs to simulate a variety of options with different variables focusing on the voltage level.
In order to determine the current grid situation by analysing the voltage levels, Kasper runs the power flow simulation without installing additional storage in the current grid topology. After the results in form of voltage level in each line are presented, the problems are visually highlighted in the grid. By placing new storage systems of different sizes and models, he starts to solve the issues locating additional storage in the grid topology and repeatedly simulating their impact on the grid behaviour. As soon as the simulation results do not depict errors anymore, he knows which storage configuration can solve the current problems. In order to be able to compare his results to classical grid enforcement techniques, he has to perform a baseline calculation[2].

However, Kasper is also interested in potential future scenarios. By changing variables such as penetration levels of energy storage systems, he can gain more knowledge about the future behaviour of the grid.

Use case Table for HLUC-3-PUC-1: Support for analysing storage dimensioning and positioning in the low-voltage grid

Table 13 - Support for analysing storage dimensioning and positioning in the low-voltage grid

ID	**HLUC-3-PUC-1**
Name	**Support for analysing** storage dimensioning and positioning in the low-voltage grid
Related Business Cases	HLUC-3-PUC-1-BM-1: Baseline
Actors	• DSO Strategic Grid Planner (Person) • DSF-SE (System)

[2] The baseline calculation is relevant for the business models and cases and delivers a cost value. By determining the price of classical grid enforcement, the grid planner is able to determine which solution is better suited for the DSO. However, this baseline calculation is state of the art and already performed by the DSOs. Therefore, it is not further described in D2.2, but relevant for D2.3 and D2.4, which are describing the S4G business models and business cases.

	• Professional GUI (System) • DSF-GRIDDB (System) • PROFESS (System)	
Actors Goals	• Analyse the control of ESS elements in a grid topology	
Pre-conditions	• Grid topology is stored at the DSF-GRIDDB	
Trigger	DSO Strategic Grid Planner needs to analyse the positioning of new ESS elements in the grid	
Post conditions success	DSO Strategic Grid Planner can manually determine the best ESS positioning and dimensioning based on the of the simulation (voltage level)	
Post conditions fail	Analysis could not be executed due to missing / false data	
Description	**Step**	**Action**
	1	Grid planner selects one or multiple radials in the grid in which he wants to run the simulation using the professional GUI
	2	Grid planner analyses the current grid situation by running the simulation on the existing grid topology using the professional GUI
	3	Professional GUI visualizes the results delivered by the DSF-SE
	4	Grid planner specifies the location of the new ESS elements in the selected grid areas using the professional GUI
	5	Grid planner specifies the storage type and additional data needed (e.g. capacity)
	6	DSF-SE runs the simulation with optimal control of ESS in each end-user house delivered by PROFESS
	7	Professional GUI visualizes the results delivered by the DSF-SE
Extensions	**Step**	**Branching Action**
	/	/
Sub variations	**Step**	**Branching Action**
	4a	Grid planner specifies it manually
	4b	Grid planner specifies the penetration level in the GUI

5.4 Autonomous control of storage installed at user premises and distributed in the grid- HLUC-3-PUC-2

Erik, a grid operator of Eniig, is in charge of voltage issues in the existing grid topology and wants to setup voltage levels for the real-time power flow control at user premises. Erik thinks that limiting the superior and inferior voltage level at the end user premises will keep the voltage level in the grid within the set boundaries.

Use case Table for HLUC-3-PUC-2 – Autonomous control of storage installed at user premises and distributed in the grid:

Please notice that HLUC-3-PUC-2 is only implementable if two pre-conditions are satisfied:

- ESS inverter allows reactive power control (for accomplishing voltage control)
- ESS allows charging/discharging control.

Concerning the test site, these two pre-conditions are still to be verified within the project.

Table 14 - Autonomous control of storage installed at user premises and distributed in the grid

ID	**HLUC-3-PUC-2**	
Name	Autonomous control of storage installed at user premises and distributed in the grid	
Related Business Cases	HLUC-3-PUC-4-BM-1: Autonomous voltage control at household battery	
Actors	• DSO (Person) • PROFESS (System) • SMX including South-bound Connector (System) • ESS (System) • PV (System)	
Actors Goals	• Maintain the voltage at the end user premises within defined limits	
Pre-conditions	• PROFESS is running • SMX is running • DSO has set the voltage limits • Power limits are set to enable curtailment • ESS inverter allows reactive power control (for accomplishing voltage control) • ESS allows charging/discharging control	
Trigger	ESS has to be controlled	
Post conditions success	Voltage levels at the user premises remain at the limits established by the DSO	
Post conditions fail	Voltage levels exceed limits established by the DSO	
Description	**Step**	**Action**
	1	SMX receives energy measurements from ESS, PV and connection point to the grid
	2	PROFESS reads the information from SMX and calculates the optimal control for the ESS based on load and generation predictions
	3	SMX sends the control information to the ESS
Extensions	**Step**	**Branching Action**
	/	/
Sub-variations	**Step**	**Branching Action**
	/	/

5.5 Voltage and flux control at grid side storage- HLUC-3-PUC-3

Erik, a grid operator of Eniig, is in charge of voltage issues in the existing grid topology and wants to control the voltage via an ESS placed at the grid level. Erik thinks that using optimal control of the reactive power of the ESS's inverter, it can help stabilizing the voltage of the grid within a range set by the DSO. He wants to analyse the voltage control at the moment when a surplus of PV energy is present.

Use case Table for HLUC-3-PUC-3 – Voltage and flux control at grid side storage

Please notice that HLUC-3-PUC-3 is only implementable if the ESS inverter allows reactive power control (for accomplishing voltage control). Concerning the test site, this is still to be verified within the project.

Table 15 - Voltage and flux control at grid side storage

<table>
<tr><td>ID</td><td colspan="2">HLUC-3-PUC-3</td></tr>
<tr><td>Name</td><td colspan="2">Voltage and flux control at grid side storage</td></tr>
<tr><td>Related Business Cases</td><td colspan="2">HLUC-3-PUC-3-BM-1: Voltage control at grid side battery</td></tr>
<tr><td>Actors</td><td colspan="2">DSO (Person)
LiBal Site Controller (System)
USM (System)
ESS (System)
PV (System)
South-bound Connector (System)</td></tr>
<tr><td>Actors Goals</td><td colspan="2">To make sure that voltage is within acceptable range</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">USM is running
South-bound Connector for controlling ESS is running
DSO has set the voltage limits (upper and lower boundary)
ESS inverter allows reactive power control (for accomplishing voltage control)
LIBAL</td></tr>
<tr><td>Trigger</td><td colspan="2">PV production is sufficient for providing services</td></tr>
<tr><td>Post conditions success</td><td colspan="2">Voltage levels at transformer secondary side remain at the limits established by the DSO</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">Voltage levels exceed limits (upper and lower boundary) established by the DSO</td></tr>
<tr><td rowspan="4">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>USM receives energy measurements from ESS, PV and connection point to the grid</td></tr>
<tr><td>2</td><td>LiBal Site Controller reads the information from USM</td></tr>
<tr><td>3</td><td>LiBal Site Controller will calculate dynamic set points
and send to inverter to adjust reactive power output</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
<tr><td rowspan="2">Sub-variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
</table>

5.6 Coordinated Distributed storage in the grid – HLUC-3-PUC-4

Kasper, a grid planning manager of N1, is in charge of voltage issues in the existing grid topology and of investigating potential solutions for future grid setups. He is using the DSF to find out in which extent voltage problems can be tackled by charging/discharging the storage of residential users in a given grid topology and a given radial using the global control perspective of the DSO.

Kasper runs the power flow simulation in the current grid topology in order to determine the current grid situation in terms of voltage levels. The GUI shows voltage problems marked in red. Kasper selects the simulation option for global control and starts the simulation again. In this simulation the power flow control at user premises as well as the global control of ESS (representing the perspective of the DSO) are used. The results of the simulation are visualized in the GUI (highlighted red/green) and Kasper can observe if the problem was solved through a charging/discharging control of the ESSs taking into consideration the whole behaviour of the grid. With this information, he knows if a global control of ESS for the grid can solve the problem.

Use case Table for HLUC-3-PUC-4 – Coordinated Distributed storage in the grid

Table 16 - Coordinated Distributed storage in the grid

<table>
<tr><td>ID</td><td colspan="2">HLUC-3-PUC-4</td></tr>
<tr><td>Name</td><td colspan="2">Coordinated Distributed storage in the grid</td></tr>
<tr><td>Business Models</td><td colspan="2">• HLUC-3-PUC-4-BM-2; Voltage control at both household and grid side battery and Energy Flux control at grid side battery
• HLUC-3-PUC-4-BM-3; Flux control and loads shaving at households with PV and battery
• HLUC-3-PUC-4-BM-4; Flux control at household battery by introducing network-controlled demand side management
• HLUC3-PUC-4-BM-5; Privately owned virtual storage plant</td></tr>
<tr><td>Actors</td><td colspan="2">• Professional GUI
• DSF-SE (System)
• GESSCon (System)
• PROFESS (System)</td></tr>
<tr><td>Actors Goals</td><td colspan="2">• Simulation of a global coordination of the end user premises
• Relieve the congestion in the grid</td></tr>
<tr><td>Pre-conditions</td><td colspan="2">• PROFESS is running
• GESSCon is running
• Professional GUI is available
• DSF-SE is running</td></tr>
<tr><td>Trigger</td><td colspan="2">DSO wants to analyse a coordinated distributed storage in the grid</td></tr>
<tr><td>Post conditions success</td><td colspan="2">• Congestion in the grid was relieved
• Indirectly is the system compliant in voltage levels</td></tr>
<tr><td>Post conditions fail</td><td colspan="2">• Congestion in the grid still exists</td></tr>
<tr><td rowspan="8">Description</td><td>Step</td><td>Action</td></tr>
<tr><td>1</td><td>Grid planner selects one or multiple radials in the grid in which he wants to run the simulation using the professional GUI</td></tr>
<tr><td>2</td><td>Grid planner analyses the current grid situation by running the simulation on the existing grid topology using the professional GUI</td></tr>
<tr><td>3</td><td>Professional GUI visualizes the results delivered by the DSF-SE</td></tr>
<tr><td>4</td><td>Grid planner selects the global control option</td></tr>
<tr><td>5</td><td>GESSCon sends schedules for the next 24h for ESSs of each end user premises</td></tr>
<tr><td>6</td><td>Simulation runs with local instantiations of PROFESS and GESSCon input</td></tr>
<tr><td>7</td><td>Professional GUI visualizes the results delivered by the DSF-SE</td></tr>
<tr><td rowspan="2">Extensions</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
<tr><td rowspan="2">Sub variations</td><td>Step</td><td>Branching Action</td></tr>
<tr><td>/</td><td>/</td></tr>
</table>

6 Conclusions

This deliverable presents the latest and final state of the use cases and storage scenarios documented by S4G and finalizes the work of T2.1 Storage Scenarios and Use Cases Definition. As a basis of the development and realization work executed in the work packages WP3, WP4, WP5, and WP6, the results of T2.1 hold very important role.

The previous work on use cases and scenarios documented in D2.1 had to be updated with the input of several technical discussions as well as opinions from external experts (ESG) as well as potential and actual end-users involved in the tests sites. Doing this ensures the applicability and technical feasibility of proposed and developed solutions; additionally, the continuous involvement of end-users and experts ensures the relation to a potential future reality with respect to user acceptance as well as innovativeness measured with already existing solutions.

The results presented in D2.2 summarize the work of the first 18 months of the S4G project and will influence the success of the S4G project.

Acronyms

Acronym	Explanation
AP	Advanced Prosumer
ASRP	Advanced self-resilient prosumer
BMS	Battery Management System
BTM	Behind The Meter
CU	Charging Unit
DER	Distributed Energy Resource
DSF	Decision Support Framework
DSF-DWH	Decision Support Framework Data Warehouse
DSF-GRIDDB	Database at the DSO's premises
DSF-SE	Decision Support Framework Simulation Engine
DSO	Distribution System Operator
EMS	Energy Management System
ER	Energy Router
ESCO	Energy Service Company
ESG	External Stakeholder Group
ESS	Energy Storage System
EV	Electric Vehicle
GESSCon	Grid ESS Controller
GUI	Graphical User Interface
G2V	Grid to Vehicle
HLUC	High Level Use Case
KPI	Key Performance Indicator
LESSAg	Local ESS Agent
LV	Low Voltage
MV	Medium Voltage
POD	Point of Delivery

PROFEV	Framework delivering optimal control of ESS and charging of EVs
PUC	Primary Use Case
PV	Photovoltaic
RES	Renewable Energy Source
S	Scenario
SMX	Smart Meter Extension
SUC	Secondary Use Case
TSO	Transmission System Operator
UCD	User-Centred Design
UniRCon	Uni-directional resilient consumer
USM	Unbundled Smart Meter
V2G	Vehicle to Grid

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Appendix A – Report of the ESG Workshop on Scenarios, Use Cases and Requirements

A. Background and goals of the meeting

The Storage4Grid External Stakeholder Group[3] (ESG) is a group of external, independent experts of recognized knowledge in different kind of background and area of expertise including market, technological trends and standards. The ESG has been constructed through an open call for participation on the Storage4Grid website[4], properly representing all domains and market roles relevant for the S4G goals, including above all representatives of industries providing storage solutions, but also experts in metering, utilities, international standardization.

The first ESG Workshop on Scenarios, Use Cases and Requirements is one of the two physical meetings planned during the course of the project. It aims at collecting ESG recommendations and advices about the key use cases and requirements identified by the project, so to positively affect further development activities.

While the on-line collaboration with the ESG will continue throughout the project, a second physical meeting is planned when the project approaches its final phases, in order to collect feedback about proposed concepts and generated results.

The meeting took place in conjunction with one of the Storage4Grid plenary meetings on August 3th 2017, in Sankt Augustin (Germany), at the premises of partner FRAUNHOFER. It followed the agenda described below:

Time	Subject, topics to be covered	Duration	Lead
8:30	**Welcome and Coffee**	30 min.	
9:00	**The Storage4Grid project** • Quick recap of project Goals, Concept, Partners, Scenarios • The role of the ESG	20 min.	**ISMB**
9:20	**ESG Introduction** • Overall ESG members' presentation • Main value brought **to** the project • Main expectations **from** the project	25 min (6/7 min each).	**EPS** **GES** **DANSK ENERGI** **EGRID**
9:45	**Storage Coordination Scenario (Fur): Use Cases and Architecture** • Overview of the key High-Level Use Cases (HLUC) and Primary Use Cases (PUCs) in this scenario • Instantiation of the Architecture deployed in this test site • Feedback from ESG and open discussion	45 min	**ENIIG**
10:30	**Storage Coordination Scenario (Fur): Business Models** • Discussion on associated Business Models • Feedback from ESG and open discussion	45 min	**ENIIG**
11:15	**Coffee Break**	15 min	
11:30	**Cooperative EV Charging Scenario (Bolzano): Use Cases and Architecture** • Overview of the key High-Level Use Cases (HLUC) and Primary Use Cases (PUCs) in this scenario • Instantiation of the Architecture deployed in this test site • Feedback from ESG and open discussion	45 min	**ALPERIA**
12:15	**Cooperative EV Charging Scenario (Bolzano): Business Models**	45 min	**ALPERIA**

[3] http://www.storage4grid.eu/pages/esg.html

[4] http://www.storage4grid.eu/pages/esg-opencall.html

	• Discussion on associated Business Models • Feedback from ESG and open discussion		
13:00	**Lunch Break**	75 min	
14:15	**Storage4Grid: low-TRL features** • Overview of the most innovative/disruptive Storage4Grid features, validated by Storage4Grid in the Bucharest Lab test sites • Feedback from ESG and open discussion	45 min	**UPB + S4G Partners** **ESG**
15:00	**Round-table panel with ESG members** Discussion-starters: • What is the Storage4Grid outcome that could be more valuable to your company? • What are the specific needs of your business that you think Storage4Grid may contribute solving?	90 min	*Panel discussion with ESG Members:* **EPS** **GES** **DANSK ENERGI** **EGRID** *moderators: FRAUNHOFER (WP2 leader) + ENIIG (Innovation Manager)*
16:30	**Conclusions** • Additional suggestions and recommendation • Wrap-up and Conclusions	30 min	**ESG members**
17:00 (strict)	**Close of the Day**		

A.1.1 ESG Attendees

The following ESG members have attended this ESG physical meeting.

- **Ilaria Rosso**: *Chief Innovation Officer, Electro Power Systems Group, Co-founder of Electro Power Systems, Ilaria leads Innovation activities of Electro Power Systems Group, specialized in hybrid-storage solutions and micro grids that enable intermittent renewable sources to be transformed into a stable power source. She holds a PhD in Chemistry with 10 years researcher at University and Politecnico di Torino. Since 2002 Ilaria has published more than 50 scientific papers at industry conferences and within international journals focusing on the chemical processes involved in hydrogen technologies. Since 2014 she has been member of the Coordination Group of Hydrogen Europe, and has cooperated with the European Commission and the Research Grouping N.ERGHY in supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe, in the frame of the FCH-JU program.*
- **Luigi Crema**: *Delegated CTO, Green Energy Storage s.r.l., Involved in Green Energy Storage with delegated role as CTO. Responsible for the development programme of the company and management of all technical activities. Head of ARES - Applied Research on Energy Systems, Fondazione Bruno Kessler, Responsible of research on Energy in Fondazione Bruno Kessler, Trento. Active roles in Europe on energy themes such as Redox Flow Batteries, Concentrated Solar Power, Hydrogen and Fuel Cells. Vice chair Energy Pillar, N.ERGHY research grouping, Fuel Cells and Hydrogen Joint Undertaking Member of EERA, European Energy Research Alliance. Member of the extended Italian board at support of H2020 programme. Involved at European and National levels on Energy policies and programmes,*

including the preparation of the National Strategic plan on Hydrogen mobility. Coordinator of several EU funded projects (e.g. DIGESPO, EDEN and running CH2P), involved in big EU initiatives such as FET Flagship Graphene, KIC Raw Materials, KIC ICT, STAGE STE IRP and INSHIP ECRIA. Invited expert by European Commission in several initiatives.

- **Zaid Al-Jassim**, *Development Engineer, Dansk Energi (Danish energy association). Zaid Al-Jassim holds an MSc degree in electrical engineering, specialized in electrical energy systems. Currently, he is working as a development engineer at the Danish energy association (Dansk Energi). His main focus is the development of future energy systems and smart grids. The Danish Energy Association is a non-commercial lobby organization for Danish energy companies. It is managed and financed by its member companies, mainly the electricity companies, and works to secure for them the freest and most favourable conditions for competition and development to ensure development, growth and well-being in Denmark. Zaid have been involved in a number of R&D projects such as IDE4L, Smart City Kalundborg (SCK) and NetVind.*
- **Dr. Gernot Graefe,** *Managing Director, egrid applications & consulting GmbH. Gernot Graefe holds a PhD in Strategic Marketing. Being with Siemens he held various roles in Business Development, Innovation Management and Technical Sales in the last 15 years. Since 2017 Gernot is Managing Director at egrid. egrid develops intelligent solutions for the decentralized integration of renewable energies in distribution grids. In particular Gernot Graefe is interested in new business models that are enabled by innovative technologies. Considering user requirements is equally important to make innovation successful. Gernot is not only interested in innovative technologies. He aims to review business models that are enabled making use of technologies under development as well as the consideration of user requirements.*

A.1.2 Storage4Grid findings and plans discussed with ESG members

The Storage4Grid consortium has presented to ESG members the preliminary version of results documented in the following deliverables.

Result	Relevant Storage4Grid Document
Use cases for Storage Coordination scenario and Cooperative EV Charging Scenario	D2.1 - Initial Storage Scenarios and Use Cases
High-level Architecture for Bolzano and Fur test sites	D2.1 - Initial Storage Scenarios and Use Cases Early highlights from D3.1 - Initial S4G Components, Interfaces WP3 and Architecture Specification
Low-TRL features in Bucharest Lab test site	D2.1 - Initial Storage Scenarios and Use Cases Early highlights from D3.1 - Initial S4G Components, Interfaces WP3 and Architecture Specification
Initial Business models identified for the Bolzano and Fur scenarios	D2.3 Initial S4G Business Models

A.2 Minutes of the workshop

A.2.1 Session A – The Storage4Grid project

The Storage4Grid consortium presents the main S4G Project objectives, vision and targeted outcomes.

A.2.2 Session B – ESG Introduction

Electro Power Systems Group (EPS) presents its storage solutions and some of its relevant projects (on-gird, smart micro-grids and off-grid). EPS shows a number of projects demonstrating micro gird functionalities, such as peak shaving, black start supporting, etc. EPS looks with interest at results of project such as Storage4Grid, because they may bring innovations that can be applied directly in EPS business.

Green Energy Storage s.r.l. (GES) presents its business and development plans. GES is mostly working on a multi-year product development plan starting from flow battery technologies licensed by Harvard University. Some relevant projects developed by GES are also mentioned. GES are willing to bring competences and capacities to support use cases and technical development, to standardization approach for S4G. Additionally, GES hopes to have an open collaboration platform, test its batteries in S4G and build new potential collaborated research activities with S4G.

Egrid applications & consulting GmbH (EGRID) introduces its background and core research directions, also mentioning a number of relevant projects such as ELSA. For this project, interesting points for EGRID in Storage4Grid include block-chain and second-life battery reuse, and simulation done for planning energy supply.

DANSK ENERGI presents its background and shows its point of view, focusing on grid analysis on distributed and transmission level. Due to its role of mediating and aggregating the interest of the main Danish Energy companies, DANSK energy looks with interest at potential results generated by Storage4Grid that can find applications across Denmark.

A.2.3 Session C – Cooperative EV Charging Scenario (Bolzano): Use Cases and Architecture

The S4G consortium presents the Cooperative EV Charging Scenario in Bolzano.

ESG members are curious about the role of the local Residential GUI, and point out that many solutions for showing data in the residential domain are already available – and the project should not re-invent the wheel. The S4G consortium clarifies that the consortium does not plan to develop a dedicated GUI – but mostly to extend existing prototypes (e.g. from the GreenCom project) and extend it with new functionality to allow the test site users to interact with the S4G features specific to ESS and EV scheduling.

ESG members look with interest at the Unbundled Smart Meter (USM) and the Energy Router (ER). The S4G consortium explains that the both USM and ER have been developed in previous projects such as NobelGrid[5]. S4G will focus on extend the USM and ER to use them in installations where ESS and EV are available.

Some ESG members are interested in understanding how S4G will dimension the battery used in the commercial part of this scenario. The S4G consortium clarifies that the methodologies to choose the battery size and characteristics is within the scope the S4G project. Since the ESS in the commercial case is planned for the second phase of the project, this problem will be used as a case study to develop the first S4G simulation featuring early version of the DSF (Decision Support Framework) components. The S4G consortium looks with interest at case studies and problems (eventually also proposed by ESG members) where DSF components can play a role.

ESG members want to know if V2G (Vehicle to Grid) features are considered in the project, since these features may entail complex configurations and requirements on the vehicle. The S4G consortium confirms that V2G is

[5] http://nobelgrid.eu/

not within the scope of the project. S4G looks with interest only at situations where EV charging processes are coordinated with ESS (cooperative EV charging) – but at the moment the project is not considering to use EVs as "mobile batteries" – buy only as "flexible loads".
ESG members are interested in the business models that will back the technical features described in this session. The S4G consortium clarifies that the development of business settings has just started, but the current ideas will be presented in the dedicated session D.
The ESG suggests that the project should also focus on how the ESS deployed in this scenario could serve other purposes while participating in cooperative EV charging features, trying to gather insight on which are the limits and the constraints for this to happen effectively. Examples of interesting features to be considered are e.g. providing ancillary services for DSO, "renting" unused storage quotas as an aggregator, etc.

A.2.4 Session D – Cooperative EV Charging Scenario (Bolzano): Business Models

The S4G consortium presents early ideas of business models developed for the Cooperative EV Charging Scenario in Bolzano.
ESG members ask for clarification about the business configuration of this scenario. The S4G consortium clarifies that this activity is on-going, but the focus at the moment is on studying what is allowed by the normative framework in Italy and what are the most suitable actors to fulfil the different roles of the framework. It is interesting to observe that there are already some constraints to be considered (e.g. according to the local regulations, the DSO is not allowed to operate ESS used for purposes other than continuity of the power supply). The introduction of ESS could also invalidate the advantageous contractual conditions that some (residential or commercial) customers have gained by installing EV systems in the past – therefore, even if technically the may gain advantages in deploying ESS, they are not motivated as their current conditions make more convenient to just sell energy to the grid at higher price.
ESG members suggest to document and raise awareness also about such "non-technical" barriers – because they are very interesting for both ESS operators, regulators and possibly also policy makers.
The ESG members discuss how the technical challenges described in the technical part may affect the business setting. The S4G consortium indicates that installation of all components and remote operation of all devices needs to be achieved at a sustainable cost (e.g. low maintenance needed), otherwise the business exploitability of the concept may be limited.

A.2.5 Session E – Storage Coordination Scenario (Fur): Use Cases and Architecture

S4G consortium presents four use cases for Storage Coordination Scenario (HLUC3) in Fur, as described in D2.1. The different Primary Use Cases of this scenario are then discussed.
Concerning HLUC3-PUC1, ESG members are curious about how grid-reinforcement investments are planned and decided for, according to "Business as Usual" process currently in use. The S4G consortium clarifies that this process is not standardized currently, and it may be driven in different ways also within the same DSO. In general, this process starts when grid issues are raised by customers. As the low-voltage grid is not automatically monitored, in such cases some monitoring equipment is deployed to verify and confirm the issue (to confirm that the problem is not on the user side). In case the issue is confirmed, the decision to reinforce the local grid is taken by a grid planner, which takes the decision based on current loads and the future plans of the DSO in this area. ESG members confirm that the same process is followed often also in their countries, especially for industry customers (e.g. complaining that their machines don't work properly). Also, in this case dedicated measurement equipment is also installed for 1 to 2 months.
Some ESG member doubts if the consumption profile is predictable with annual measurements. The S4G consortium confirms that specific feeder lines are selected and monitored at this purpose when such need arise.
Concerning HLUC3-PUC2, ESG members are interested in better understanding the objective of the scenario. The S4G consortium clarifies that the purpose is to increase the self-sufficiency and the self-consumption of the houses. This use case is representative of all cases where ESS is deployed and operated on behalf of the user.

HLUC3-PUC3 and HLUC3-PUC4 are discussed. ESG members look with interest at grid-side storage applications and share their experience in this area. There are several interesting aspects mentioned by the ESG members. For instance, some project uses incentives and some focuses on the TSO level.
The S4G consortium ask what the role of simulation tools is today, in the ESS installations operated by ESG members. Some ESG member clarifies that the Engineers have some rules and they simulate some scenarios (basically trial and error based on manually determined placement models). There is no single tool – but it's mostly a human-driven process.
The S4G consortium looks with interest at evaluating how fully centralized storage would perform against a more decentralized solution. ESG members suggest that decentralized storage may be more difficult to operate, but it would definitely be more effective in terms of ability to smoothen the transition from peaks into the medium voltage grid. The S4G consortium agrees that for many applications, placing ESS as close as possible to loads will give more flexibility in solving pea-shaving problems.
ESG member advices to consider also mobile batteries, at least by simulation – as they may be an interesting solution (e.g. in areas where grid reinforcements are planned but need to be deferred). The S4G consortium acknowledges that this is an interesting direction to be evaluated, and may fit some of the problems identified by the project (e.g. higher peak loads in areas with high density of holiday houses or other areas characterized by seasonal behaviour), which may worsened by the increasing EV penetration. ESG members also suggest to look at "island" grid applications i.e. cases where portions of the grid are disconnected to avoid maintaining transmission lines.
ESG member also suggest to look at cases where residential users can join a Virtual Power Plant (VPP) thanks to their own local ESS.

A.2.6 Session F – Storage Coordination Scenario (Fur): Business Models

The S4G consortium presents early ideas of about five potential business models identified for further development in the Storage Coordination Scenario.
ESG members ask for clarification about what is the value for the DSO in first business model ("Autonomous" Voltage control at household battery). The S4g consortium clarifies the DSO expectation for this business models, which are mostly in the possibility to avoid or defer grid reinforcement investments in areas where user-side ESS are available to be controlled. ESG members also observe that the focus of this business model is mostly on the DSO side, and suggest to clarify in details the pricing schema for stimulating users in joining the voltage control schema.
ESG members asks for clarifications about business Model 2 – "voltage control at household and grid-side battery and energy flux control at grid-side battery", more specifically related to how control is performed and at which time scale. The S4G clarifies that control can be performed in the scale of 10-60 seconds, depending on the specific use case. ESG members point out that the IT infrastructure may be an issue –since especially for rural areas available technologies e.g. GSM modems only support low data rate. The S4G consortium clarifies that this is not an issue in the Fur test site (users have fiber-broadband connections provided by ENIIG) – but indeed this is a barrier for replication in rural areas, and it must be tackled.
Some details of "business model 3: flux control at household battery, PV max control and load shaving" and "business Model 4 - flux control at household battery" are discussed. ESG members show interest in this business case, and advice to research and clarify a number of questions including: will the house owner be interested in buying a battery to join this business? Will he/she benefit from it? Will the DSO benefit from that? ESG members also indicate that the introduction of a dynamic tariff may help these business cases e.g. inviting users to sell their energy according to spot prices to gain the most.
Finally, "business Model 5 - Privately owned virtual power plant" is discussed. Some ESG member wonder why a consortium with two DSOs is investigating in a case that may cut DSOs out of the picture. The S4G consortium clarifies that this is done with an innovation perspective, because other players may still find this business case interesting and implement it before DSOs have a chance to react. At this purpose, S4G may also look into innovative, fully-distributed approaches e.g. based on block chain to support this kind of business.

A.2.7 Session G – Storage4Grid: low-TRL features

S4G consortium presents use cases and the technical scenario for low-TRL features as described in D2.1.
ESG members are interested to have more insight on how intelligence is distributed between the ER and the USM. S4G consortium clarifies that there are several valid possibilities to distribute intelligence in this case, but the chosen approach is to have fast control on-board the ER and high-level (slower) control within the USM, in a dedicated SMX extension which has visibility over all ESS-related devices in the test site.
ESG members are interested in better understanding why a SMM (Smart Metrology Meter) needs to be bundled within the USM. S4G consortium clarifies that this is a choice (made in previous projects developing the USM) to ensure fiscal validity of metering information – while allowing the possibility to have dedicated "extra" functionalities (extension) which can rely on fiscally-valid data, but running in a dedicated "user space".
The ESG advises that the USM concept becomes more valuable if a critical mass of controllable assets are integrated with it, both in the user and in the grid-side domain. For example, a large population of deployed USMs may be used by an aggregator to achieve e.g. generation or load curtailment potential.

A.2.8 Session H – Panel debate with ESG members

In the final part of the meeting, a final round-table discussion among ESG members and the S4G consortium takes place, drawing a number of conclusions and advices.
In first place, the ESG reminds that DSO industry is very conservative, and in general DSOs are not very keen to consider innovative technology. They therefore prefer to use technology they already know. Therefore, it would be a key success factor for S4G to adopt and connect to the legacy hardware platform already in use. The idea of the USM is very interesting – but also in this case is very important to deliver the concept bundled with existing commercial meters to maximize adoption.
In second place, the ESG points out that the communication with the policy makers is very important. According to ESG members' experience, DSO will be more interested in investing in ESS when there is a perspective that something will change. At this purpose, it is important to evaluate the benefits that S4G will be able to bring to different actors.
In third place, the ESG advises to keep the focus on the needs of DSOs. It is also important that project outcomes (e.g. the DSF) can be packaged and included in commercial products, so that DSOs can use them reliably also outside research initiatives. It will also be important to look beyond ESS and to present how the S4G infrastructure can support management of energy flexibility in smart grid applications. The USM, for instance, could be a nice tool for aggregators and other third-party players, to support business cases where flexibility is sold or traded. Presenting these feature in a more generic fashion will allow DSOs to understand the broader benefits of the S4G concept and how they can coordinate them with other assets. It is however important also to consider that presenting a complete new infrastructure, it is not attractive for DSOs, as the cost of the investment could be too high.
In fourth place, the ESG highlights the range of applications targeted by the project is impressive and is curious to see the results of real tests and business models. A special point of interest may be e.g. in proving the sustainability of business models in the residential side, which at the moment has not yet fully proven to be sustainable without incentives. The project can also play a role in convincing sceptical DSOs that also user-side storage can bring advantage to them; due to the conservativeness of the market, it is well known that this will be a difficult and slow process.
The S4G project can be of significant help for the sector, but strategically it needs to operate at policy level; if such a policy agreement is not present, achieving something is very hard with strongly-regulated DSOs. Regulations can also be obstacles for introducing innovations, but it is important to be able to gradually introduce innovations in a structured way.
The S4G consortium concludes by asking if there is a specific S4G outcome that could be more valuable for the ESG members' company.
ESG members believes that the S4G project will be successful if it will be able to clearly show the benefit of ESS for DSO, by demonstrating how energy storage could be utilized to be, to increased hosting capacity. The DSF could play a key role in this.

The ESG also suggests that ESS producers are surely interested in working together with the project to identify together what could be the best way for integrating ESS in the grid. DC-based buses considered in the Bucharest test site are also very interesting in the longer term, due to the future potential evolution of micro grids. Such market segment will be difficult and not very large in the beginning, but it may provide large value in the longer term. Some ESG members are also interested in understanding what will be the most valid technical architecture for ESS integration that will become standard and enter the market.
The S4G consortium demands which use cases are the most interesting according to ESG members in the longer term.
ESG members note that all cooperative storage use cases are very actual, and strongly related to several projects they are currently following and supporting. In the longer term, use cases involving innovative types of prosumers are very interesting because they match with the rise of local energy communities. Also, all use cases evaluating effects of high penetration level of RES and EVs are interesting – since this is a very actual problem. In general, all the Low TRL solutions being researched by the project are quite in line with future 2030 targets. In general, ESG members will be interested in knowing how such outcomes will behave in-lab and on the field, also gathering lessons learned and analysing data from the test sites.
Some ESG members concludes that many players are mostly focused on ESS at transmission level and have not approached the residential market until now, but if there is value, they will definitely look at the project with the innovation perspective to see if cooperative storage may benefit their business in the future.
Some technical matters are then discussed.
The S4G consortium asks if ESG members have on-going best practices on how to estimate battery lifetime and to evaluate the impact of ESS age/use on performance.
Some ESG members explain how they carry-on life-time tests i.e. mostly in lab-scale systems running "accelerated" conditions. It is well-known that this approach is not 100% reliable compared to a full-scale systems evaluation, but it's the only feasible solution to consolidate a product properly before upscaling is done. During such tests, a large number of parameters are monitored for thousands of cycles e.g. various efficiency metrics, degradation of the electrolytes, temperature in various parts of the systems, etc.
The S4G consortium asks if ESG members would be interested in solutions for monitoring storage systems remotely and prompting warnings for misuses of the customer or unusual conditions. The S4G suggest that this be a product for the future as a prognostic feature. ESG members mention that these kinds of features are very relevant – and having them is more and more important. A proof of this is that some project developing such features are already on-going.
Some ESG member predict that more and more intelligence will be required for future ESS systems incorporating. At this purpose, ESG members advice the project to invest in such advanced features such as: predictive controls, self-learning, integration with higher level architectures and scenarios in the local grid, multi-objective metrics to allow exploitation of ESS to maximize the stability of the grid or the benefit for the end-user, more adaptation to user profiles, use of ESS in fully distributed scenarios (e.g. using block-chain infrastructure), etc.

A.3 Key recommendations by the ESG

In the following, the key recommendations by ESG members elicited during the meeting are summarized.

ID	Recommendation	Rationale	Relevant stakeholder
#1	Invest in developing approaches to support optimal sizing and placing of ESS	Currently, several "manual" processes are followed to determine optimal size and placement of storage in the grid. Any tool supporting such process would be beneficial in fostering adoption	ESS adopters e.g. DSO, aggregators

#2	Consider modelling and planning for mobile battery storage systems	Mobile battery storage may be helpful in scenarios characterized by seasonal behaviour	ESS adopters e.g. DSO, aggregators
#3	Consider "islanding" scenarios	In some longer-term scenarios focused on remote areas, TSO/DSOs may be interested in offering incentives for users to acquire ESS, so that they can disconnect (completely or partially) the user and save on transmission costs.	DSO, TSO
#4	Don't invent new GUIs, but integrate with existing user engagement systems	Many GUIs for monitoring consumption and production are already available.	End-users
#5	Invest in defining the optimal architecture and set of standards to integrate ESS in various scenarios	Better understanding the value of the different configuration will facilitate adoption of ESS	DSO, ESS adopters
#6	Work with policy makers to remove barriers hampering adoption of ESS	Policies are critical since the market is strongly regulated. This includes identification of "old" (but still enforced) incentives that make adoption of ESS not convenient.	DSOs, policy makers
#7	Focus on IT solutions that are cost-effective, reliable and feasible throughout Europe	Cost of infrastructure is a critical aspect for business sustainability	DSOs, aggregators
#8	Explore methods to exploit ESS to provide ancillary services to DSOs	Storage deployed to back EV charging stations could be used at the same time for other services.	DSO, aggregators, EV mobility companies
#9	Focus the key feature of the DSF that can be turned into products	In order to facilitate adoption, it must be well clarified how the DSF connects to existing products and what is the added value	DSO, aggregators
#10	Integrate the USM with as many devices and system as possible (both on the grid and in the user side)	To maximise re-use of deployed assets for multiple use cases	DSOs, aggregator
#11	Clearly evaluate value of DSO players, considering their current business as usual	DSOs are interested in solutions which are related to investment optimization and services offering.	DSO
#12	Disseminate best practices and proposed architectures for Storage integration	The results could give battery companies knowledge about the best schema of integrating battery systems.	ESS providers, ESS adopters
#13	Invest in researching intelligent features such as predictive and self-learning algorithms	ESS will be required to work in scenarios which are more and more uncertain and complex	Battery Companies, DSOs, Aggregators

#14	Focus on defining pricing schemas stimulating users to concede control of their ESS to DSOs	End-users needs to be stimulated to invest in storage and allow DSOs to (partially) control it	ESS adopters, End-users
#15	Develop solutions which can be easily integrated with legacy DSO systems	DSOs will be sceptical towards any solution which is not able to easily inter-play with existing systems	ESS adopters, DSO

Appendix B – Regulatory Analysis

PORTUGAL

1. Portuguese and EU regulatory framework for energy storage systems

Portugal has transposed for its legal framework the EU Directive 2009/72/EC, *Common rules for the internal market in electricity*, through Decree-law n. 78/2011 of 20th June [1]. This directive does not mention anything concerning electricity storage, therefore the Portuguese legal framework does not have any references to it.

Nevertheless, in February 2017, the European Commission (EC) has published the Commission Staff Working Document called "Energy storage – the role of electricity" [2] presenting the state of the art of the available storage technologies and some remarks concerning regulatory framework and markets for energy storage.

Almost simultaneously, in 23rd February 2017, the EC also published a document titled *Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity* [3], presenting several changes that should be applied/introduced in the EU Directive 2009/72/EC.

This proposal introduces several references and/or articles in the Directive 2009/72/EC concerning electric energy storage. The following section presents the most important changes referred in the document.

A. Changes in recitals of Directive 2009/72/EC [3]

Recital 2, item 5 (new) - The Communication from the Commission of 15 July 2015 *Launching the public consultation process on a new energy market design* highlighted that the move away from generation in large central power plants towards decentralized production from renewable energy sources and decarbonized markets requires an adaptation of the current rules of electricity trading and changes to the existing market roles. It underlined needs to organize electricity markets in a more flexible manner and to fully integrate all market players – including renewable energy producers, new energy service providers, ***energy storage*** and flexible demand. (New item)

Recital 8, item 10 (new sentence in italic and bold) - In order to secure competition and the supply of electricity at the most competitive price, Member States and national regulatory authorities should facilitate cross-border access for new suppliers of electricity from different energy sources as well as for new providers of power generation (2009/72/EC), ***storage and demand response***.

Recital 53, item 42 (new) - Distribution system operators have to cost-efficiently integrate new electricity generation especially generating installations using renewable energy sources and new loads such as heat pumps and electric vehicles. For this purpose, distribution system operators should be enabled and incentivized to use services from distributed energy resources such as demand response and ***energy storage***, based on market procedures, in order to efficiently operate their networks and avoid costly network expansions. Member States should put in place appropriate measures such as national network codes and market rules and incentivize distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid. Member States should also introduce network development plans for distribution systems in order to support the integration of generating installations using renewable energy sources, ***facilitate the development of storage facilities*** and the electrification of the transport sector, and provide to system users adequate information regarding the foreseen expansions or upgrades of the network, as currently such procedure does not exist in the majority of Member States.

B. Changes in articles of Directive 2009/72/EC [3]

In Chapter 1, subject matter, scope and definitions, the following modifications are proposed in the document:

Article 1
Subject matter and scope

This Directive establishes common rules for the generation, transmission, distribution, ***storage*** and supply of electricity, together with consumer protection provisions…

Article 2
Definitions

47. **'*energy storage*'** means, in the electricity system, deferring an amount of the electricity that was generated to the moment of use, either as final energy or converted into another energy carrier. (new item)

In Chapter 2, general rules for the organization of the sector, the following modifications are proposed in the document:

Article 3 (*new*)
Competitive, consumer-centered, flexible and non-discriminatory electricity market

1. Member States shall ensure that their national legislation does not unduly hamper cross-border flows of electricity, consumer participation including through demand-side response, investments into flexible energy generation, ***energy storage***, the deployment of electro-mobility or new interconnectors, and that electricity prices reflect actual demand and supply.

In Chapter IV (a substitution of Chapter VI), distribution system operation, the document proposed several modifications and new items including the ownership of storage facilities which would not be allowed to Distribution System Operators (DSO), excepted in some specific situations.

Article 31 (substitution of 25)
Tasks of distribution system operator

5. …Unless justified by a cost-benefit analysis, the procurement of non-frequency ancillary services by a distribution system operator shall be transparent, non-discriminatory and market based ensuring effective participation of all market participants including renewable energy sources, demand response, ***energy storage*** facilities and aggregators, in particular by requiring regulatory authorities or distribution system operators in close cooperation with all market participants, to define technical modalities for participation in these markets on the basis of the technical requirements of these markets and the capabilities of all market participants (new sentence inside 5).

Article 32 (new)
Tasks of distribution system operators in the use of flexibility

1. Member States shall provide the necessary regulatory framework to allow and incentivize distribution system operators to procure services in order to improve efficiencies in the operation and development of the distribution system, including local congestion management. In particular, regulatory frameworks shall enable distribution system operators to procure services from resources such as distributed generation, demand response or ***storage*** and consider energy efficiency measures, which may supplant the need to upgrade or replace electricity capacity and which support the efficient and secure operation of the distribution system.

Distribution system operators shall procure these services according to transparent, non-discriminatory and market-based procedures.

2. The development of a distribution system shall be based on a transparent network development plan that distribution system operators shall submit every two years to the regulatory authority. The network development plan shall contain the planned investments for the next five to ten years, with particular emphasis on the main distribution infrastructure which is required in order to connect new generation capacity and new loads including re-charging points for electric vehicles. The network development plan shall also demonstrate the use of demand response, energy efficiency, ***energy storage facilities*** or other resources that distribution system operator is using as an alternative to system expansion.

Article 36 (new)
Ownership of storage facilities

1. Distribution system operators shall not be allowed to own, develop, manage or operate ***energy storage facilities.***

2. By way of derogation from paragraph 1, Member States may allow distribution system operators to own, develop, manage or operate ***storage facilities*** only if the following conditions are fulfilled:

(a) other parties, following an open and transparent tendering procedure, have not expressed their interest to own, develop, manage or operate storage facilities;

(b) such facilities are necessary for the distribution system operators to fulfil their obligations under this directive for the efficient, reliable and secure operation of the distribution system; and

(c) the regulatory authority has assessed the necessity of such derogation taking into account the conditions under points (a) and (b) and has granted its approval.

3. Articles 35 and 56 shall apply to distribution system operators engaged in ownership, development, operation or management of ***energy storage facilities***.

4. Regulatory authorities shall perform at regular intervals or at least every five years a public consultation in order to re-assess the potential interest of market parties to invest, develop, operate or manage ***energy storage facilities***. In case the public consultation indicates that third parties are able to own, develop, operate or manage such facilities, Member States shall ensure that distribution system operators' activities in this regard are phased-out.

In Chapter V (IV in directive 2009/72/EC), general rules applicable to the transmission system operator, several modifications to the former text are also proposed. For example, in article 54 is referred that transmission system operators (TSO) shall not be allowed to own, manage or operate energy storage facilities. The following paragraphs reproduce the main changes concerning TSOs and energy storage.

Article 40 (old 12)
Tasks of transmission system operators

1. Each transmission system operator shall be responsible for:
(...)
(d) managing electricity flows on the system, taking into account exchanges with other interconnected systems. To that end, the transmission system operator shall be responsible for ensuring a secure, reliable and efficient electricity system and, in that context, for ensuring the availability of all necessary ancillary services, including

those provided by demand response ***and energy storage***, insofar as such availability is independent from any other transmission system with which its system is interconnected; (new item)
(i) procuring ancillary services from market participants to ensure operational security.
4. In performing the task described in point (i) of paragraph 1, the transmission system operator shall ensure that the procurement of balancing services and, unless justified by a cost-benefit analysis, non-frequency ancillary services, is:
(a) transparent, non-discriminatory and market-based;
(b) ensures effective participation of all market participants including renewable energy sources, demand response, ***energy storage facilities*** and aggregators, in particular by requiring regulatory authorities or transmission system operators in close cooperation with all market participants, to define technical modalities for participation in these markets on the basis of the technical requirements of these markets and the capabilities of all market participants.

Article 42 (old 23)
Decision-making powers regarding the connection of new power plant to the transmission system

1. The transmission system operator shall establish and publish transparent and efficient procedures for non-discriminatory connection of new power plants ***and energy storage facilities*** to the transmission system. Those procedures shall be subject to the approval of national regulatory authorities.

2. The transmission system operator shall not be entitled to refuse the connection of a new power plant ***or energy storage facility*** on the grounds of possible future limitations to available network capacities, such as congestion in distant parts of the transmission system. The transmission system operator shall supply necessary information.

Article 51 (old 22)
Network development and powers to make investment decisions
(…)
3. When elaborating the ten-year network development plan, the transmission system operator shall make reasonable assumptions about the evolution of the generation, supply, ***energy storage***, consumption and exchanges with other countries, taking into account investment plans for regional and Union wide networks.

Article 54 (new)
Ownership of storage and provision of ancillary services by transmission system operators

1. Transmission system operators shall not be allowed to own, manage or operate ***energy storage facilities*** and shall not own directly or indirectly control assets that provide ancillary services.
2. By way of derogation from paragraph 1, Member States may allow transmission system operators to own, manage or operate ***storage facilities*** or assets providing non-frequency ancillary services if the following conditions are fulfilled:
(a) other parties, following an open and transparent tendering procedure, have not expressed their interest to own, control, manage or operate such facilities offering ***storage*** and/or non-frequency ancillary services to the transmission system operator;
4. The transmission system operator shall perform at regular intervals or at least every five years a public consultation for the required ***storage services*** in order to assess the potential interest of market parties to invest in such facilities and terminate its own ***storage activities*** in case third parties can provide the service in a cost-effective manner.

In Section 5, former Chapter VII, the proposal addresses the unbundling and transparency of accounts, where some modifications concerning energy storage are introduce.

Article 58 (old 36)
General objectives of the regulatory authority

In carrying out the regulatory tasks specified in this Directive, the regulatory authority shall take all reasonable measures in pursuit of the following objectives within the framework of their duties and powers as laid down in Article 5937, in close consultation with other relevant national authorities including competition authorities and authorities from neighbouring countries, including third countries as appropriate, and without prejudice to their competencies:
(...)
(e) facilitating access to the network for new generation capacity and ***energy storage facilities***, in particular removing barriers that could prevent access for new market entrants and of electricity from renewable energy sources; (introduction of bold words)

Article 59 (old 37)
Duties and powers of the regulatory authority

1. The regulatory authority shall have the following duties:
(...)
(u) monitoring investment in generation ***and storage*** capacities in relation to security of supply;

2. Conclusion

Nowadays, the Portuguese legal regulatory framework does not include any information concerning energy storage or energy storage facilities. This is according to EU Directive 2009/72/EC, which is transposed to the Portuguese legislation, where there is not references to storage. Nevertheless, and based on [3], it seems to be already designed a new legal framework for electric energy markets where energy storage aspects are integrated. The new legal framework seems to open the way for parties other than the distribution and the transmission system operators to own, manage, and operate storage facilities.

ROMANIA

Storage Control: Regulatory Analysis

1. Energy storage systems in Romania

Romania as member of EU applies the deregulation concept which means that DSOs are not allowed to own storage facilities.

2. Romania market:

In Romania, there are chances to have conditions for a market involving storage, because:

- The quality of distribution service has some low indicators (including power quality, harmonics and supply interruption) in several areas, especially on countryside where weather conditions prevent fault elimination and/or fast network reconfiguration;
- Romania has more than 70.000 households not yet grid-connected due to high costs of connections in remote areas.
- EVs penetration, although we are at the beginning (with a few hundreds cars in 2018), has a clear tendency of alignment with the European trend

Issues and comments:

- In Romania there is no specific regulation regarding storage and by consequence there is no existing demand response scheme or market design to specifically encourage storage investments.
- We do not have any tax incentives (feed in tariff) for feeding power in the grid or for increasing self-consumption and there are no dynamic electricity tariff for households.
- In addition, the user of the grid could install a storage capacity on his premises, but he would not receive any incentives. In this context he would be the only beneficiary of the storage system.
- The request for distributed storage is mainly related to power availability (on short term, up to tens of seconds and of high values) and not about energy availability (the traditional approach).
- The local use of storage in grids with high RES-based distributed generation will enhance their contribution to a sustainable economy but, in the same time, the high variability of the renewables (PV, wind) asks for other sources availability. In this condition, and with the requirement of avoiding curtailment, the energy problem translates in to power equilibrium.
- In Romania, most of the households have district heating i.e. do not use electricity; for cooking it is used gas and the air conditioning (using electricity) is not an option in most of rural areas.

3. Romanian market opportunity

- Today it is in place a small feed-in tariff for small roof PVs (range of 1kW), which is around 5 cents, much lower than the average price of purchased energy, which is around 12 cents. It is an opportunity to have local storage which increases the self-consumption, in order to fully use the PV produced energy instead of selling it at 5 cents.
- A barrier is the fact that the price gap of 12 – 5 = 7 cents might not cover the storage investment (in other countries where the end-price is 25 cents, the gap is higher and today storage price may be easier paid by this difference)
- Romania will improve the attractivity for local storage if the end price will grow and/or if the storage price will decrease. Both situations are expected to occur in next 3-10 years.

4. Regulatory Asset Base

Romanian utilities are still applying the network operation and relation with customers in a Business as usual (distribute and take the tax) framework. The utilities have no plans to act among the first storage services providers. The situation may change if they will start losing revenues or if ESCOs will take the initiative.

ITALY

- In Italy the DSO cannot own or manage production plants (Decreto legislativo 79/99 [4])
- The ESS are assimilated to production systems (Delibera ARERA 574/2014/R/eel) [5]) --> the DSO cannot own or manage ESSs
- For the connection of the ESSs on the grid the compliance with the technical rules is necessary (CEI 0-16 [6]+ CEI 0-16/V1 [7] for MV and CEI 0-21 for LV)

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Acronyms

Acronym	Explanation
DSO	Distribution System Operator
EC	European Commission
EU	European Union
PHS	Pumped Hydro Storage
TSO	Transmission System Operator