D2.3 - Initial S4G Business Models

Deliverable ID	**D2.3**
Deliverable Title	**Initial S4G Business Models**
Work Package	**WP2**

Dissemination Level	**PUBLIC**

Version	**1.0**
Date	**20/03/2018**
Status	**Final**
Type	**Report**

Lead Editor	**Eniig (Gitte Wad Thybo)**
Main Contributors	**Edyna (Karen Stocker) , Alperia (Giovanni Paolucci), Alperia Smart Mobility (Massimo.Minighini),UPB (Marta Sturzeanu, Michaela Albu), Libal (Rasmus Rode Mosbæk)**

Published by the Storage4Grid Consortium

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731155.

Document History

Version	Date	Author(s)	Description
0.1	2017-06-08	ENIIG	TOC
0.2	2017-08-18	ENIIG	Revised TOC
0.3	2017-11-02	ENIIG	Preliminary business models Chapter 6
0.31	2017-11-07	ENIIG	Preliminary business models Chapter 6
0.4	2017-12-21	ALPERIA/ASM	Contribution by Alperia/Edyna/ASM
0.5	2017-12-22	UPB	Contribution by UPB; edits throughout entire document
0.6	2018-01-05	Eniig	Edits by UPB accepted and minor contributions
0.7	2018-01-11	UPB	Final contributions
0.8	2018-01-24	Libal	Contributions to chapter 2
0.9	2018-01-25	Eniig	Ready for review
0.95	2018-03-15	Eniig	Ready for final review
1.0	2018-03-20	Eniig	Final version, ready for submission to the EC

Internal Review History

Review Date	Reviewer	Summary of Comments
2018-02-07 (v0.9)	ISMB	Not Approved: • Minor language corrections • Suggestions for the homogenisation of methodology application across sections • Suggestions on how to increase the formal robustness of the analyses conducted
2018-02-14 (v0.92)	Anabela Pronto and Vasco Delgado-Gomes (UNINOVA)	Not Approved: • The deliverable needs to be unified, it is clear when the contribution of each partners starts. For instance: the same table in several HLUCs, PUCs and BMs should have the same name. Moreover, the sections should have the same subsections in the 3 pilots' sites. • A lot of comments need to be addressed from different partners. • An English revision is a plus
2018-03-16 (v0.95)	Vasco Delgado-Gomes (UNINOVA)	Approved
2018-03-16 (0.96)	Ferro Enrico (ISMB)	Approved with minor modifications

Table of Contents

Document History ... 2
Internal Review History ... 2
Table of Contents ... 4
Executive Summary ... 6
1 Introduction ... 7
1.1 Scope ... 7
1.2 Related documents ... 7
2 The Storage Market ... 8
2.1 Storage market in Europe ... 8
2.2 Technology Readiness Level / Technology versus Price versus Efficiency ... 9
2.3 Stakeholders ... 11
2.4 Policy framework ... 12
3 Business modelling framework in S4G ... 18
3.1 PESTLE analysis ... 18
3.2 Stakeholder analysis ... 19
3.3 SWOT analysis ... 20
3.4 Risk analysis ... 20
3.5 Business Model Generation ... 21
4 Initial Business models in Bucharest High Level Use Case-1 (HLUC-1) ... 24
4.1 Background and expected impact ... 25
4.2 Overview of use cases and related business cases for the Bucharest test site (year 1) ... 26
4.3 Related use case: Advanced Prosumer, HLUC-1-PUC-1 ... 27
4.4 Related use case: Advanced self-resilient prosumer, HLUC-1-PUC-2 ... 30
4.5 Related use case: Resilient hybrid cooperative ecosystem, HLUC-1-PUC-3 ... 35
4.6 Conclusion business models in Bucharest HLUC-1 ... 40
5 Initial Business models in Bolzano HLUC-2 ... 41
5.1 Background and expected impact ... 41
5.2 Overview of use cases and related business cases for the Bolzano test site (year 1) ... 43
5.3 Related use case: Residential prosumer with storage, HLUC-2- PUC-1 ... 44
5.4 Related use case: Cooperative charging in the parking lot of a commercial test site, HLUC-2- PUC-2 50
5.5 Related use case: Simulation of high penetration of EV chargers and of prosumers with storage and residential EV charging, HLUC-2-PUC-3 ... 54
5.6 Conclusion business models in Bolzano HLUC-2 ... 54
6 Initial Business models in Fur HLUC-3 ... 55
6.1 Background and expected impact ... 55
6.2 Overview of use cases and related business cases for the Fur test site (year 1): ... 58
6.3 Related use case: Traditional grid strengthening simulation, HLUC-3-PUC-1 ... 59
6.4 Related use case: Simulation of private households investing in residential storage, HLUC-3- PUC-2 61

6.5 Related use case: DSO investing in larger systems at substation level, HLUC-3-PUC-3 62
6.6 Related use case: Deploying and enforcing distributed controllable storage at various levels, HLUC-3-PUC-4 65
6.7 Conclusion business models in FUR HLUC-3 75
7 Conclusions 76
Acronyms 77
List of figures 78
List of tables 79
References 80

Executive Summary

This deliverable summarizes the Initial Business Modelling work in all the three S4G test sites. It uses the S4G vision from D2.1 – "Initial Storage Scenarios and Use Cases" [D2.1] and D6.1 – "Phase 1 test site plans" [D6.1]. This deliverable gives an overview of the storage market, TRL-level, stakeholders and policy framework in general, followed by a description of each test site and the associated business models. Every business model takes as input the described use cases from D2.1. For each test site is analysed the business environment, the business rationale and actors. A number of business models is analysed for each Use Case. Relevant analyses were made in each business models, such as stakeholder analysis, SWOT analysis from the DSO perspective, and risk analysis, A deeper and more qualitative analysis of a subset of the business models will be presented in the next release of this deliverable (D2.4.)

Looking at the outputs of this initial study on possible business models, it is clear that to be economically attractive from the point of view of the grid, commercial and residential sites, a multiple use of batteries is required.

These analyses are the first view and exemplification for the initial implementation to be adapted and refined during next phases, based also on the outcomes of the D2.2 – "Final Storage Scenarios and Use Cases", to be issued in M18.

1 Introduction

S4G will develop a viable and sustainable business framework for controllable storage solutions that align with global business conditions, and, in particular, developing realistic business models and Use Cases for deploying the S4G outcomes. While a number of technical capabilities and features of S4G control solutions can be operated by single business entities (e.g. private prosumers), the real value of such solutions lies in the use of S4G solutions as an enabler of complex business and market configurations where services of different stakeholders and partnerships are dynamically involved and integrated with the energy market.

An initial analysis of deployment and operation of storage systems are performed. Such initial activity includes references to current market configurations and regulations in Europe.

After this initial analysis, the core of the work is performed by tackling the Business Modelling problem from a multi-partner, eco-system perspective, projecting technical and market condition in the target period 2020-2030. This activity includes the exploration of new business models to stimulate discovery of new opportunities introduced by S4G outcomes. A SWOT analysis centred on the emergence of new business ecosystems and on configurations helping stakeholders in deploying the S4G outcomes in their business activities is also performed. New regulations and / or standardization will not be addressed at this moment. This makes the business models proposal an iterative process, as the evolving regulatory environment will dramatically influence the Cost Benefit Analysis (CBA) results for each of the stakeholders.

The developed business cases will build on knowledge gathered in D2.1 – "Initial Storage Scenarios and Use cases", which describe different actors or stakeholders in the different use cases. The stakeholders' business cases are being explored in business conditions, investments and cost, market perspective and regulation issues.

The focus in business modelling is business framework and cases definition. Focus in the target groups are on residential customers, a commercial fleet and grid site placement of storage. The business model view is in most cases analysed from the DSO perspective, the assumption is to avoid or postpone grid reinforcement and being able to control storages.

1.1 Scope

This deliverable presents the results generated by Work Package 2 "Business Models and Requirements Engineering", and more specifically by task T2.2. "Business Models and Eco-systems". It describes the methodology and the initial business models for each use case at the end of Year 1 (M12). One future version is expected to update and/or replace the developed business models documented in this deliverable, namely D2.4 - "Final S4G Business Modelling" (due in M30).

1.2 Related documents

ID	Title	Reference	Version	Date
[D2.1]	Initial Storage Scenarios and Use Cases	D2.1	1.1	2017-06-10
[D6.1]	Phase 1 test site plans	D6.1	1.0	2017-09-18

2 The Storage Market

2.1 Storage market in Europe

In the previous years, pumped hydro energy storage systems dominated utility scale market as they were practically the only one affordable utility scale (except Compressed Air Energy Storage (CAES) storage systems installed in the European market (business model based on the electricity price difference between night and day).

However, currently, with increased grid penetration of volatile and dispersed renewable generation sources, battery storage systems (and grid penetration) are gaining their momentum and this trend is expected to continue as it is presented in Figure 1 (for battery energy storage). The main drivers behind the development in the upcoming years are expected to be:

- **Technical**: transition towards dispersed generation systems, backup security, grid reliability with high RE penetration.
- **Environmental** (gradual elimination of fossil fuels, e.g. in transportation.
- **Economical:** demand management, benefits from using different tariffs, network reinforcement deferral.
- **Regulatory:** state incentives, regulatory framework and roadmap[i].

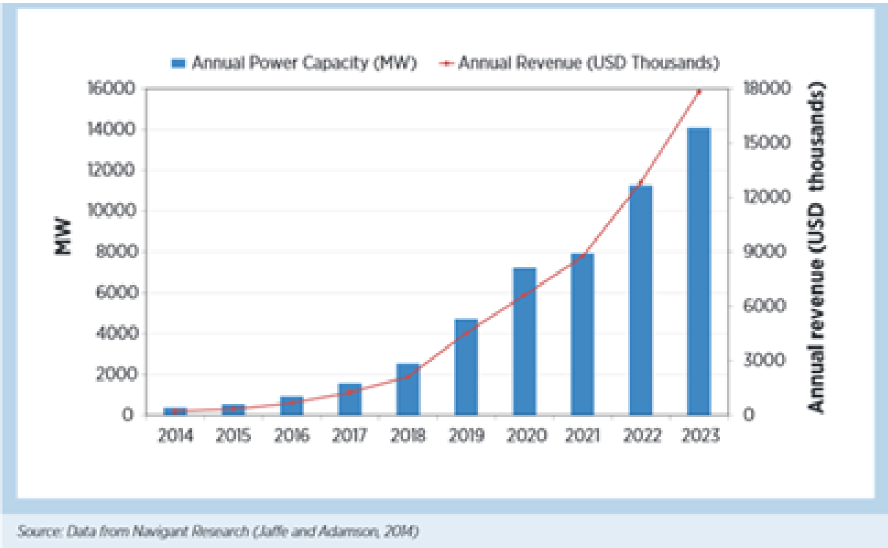

Figure 1. Worldwide forecast of battery storage capacity (MW) and annual revenue (kUSD) for utility scale applications[ii].

Moreover, the further cost reduction of battery storage systems is expected to continue together with market increase (economy of scale). On the other hand, this is expected to be (to some extent) self-driving cost decline as cost reduction in storage opens new business model opportunities and in consequence increases market size. Figure 2 presents the rapid decline in price for residential storage in Germany in the 4 years' time by a factor of approximately 33% for both lead-acid and Li-ion batteries.

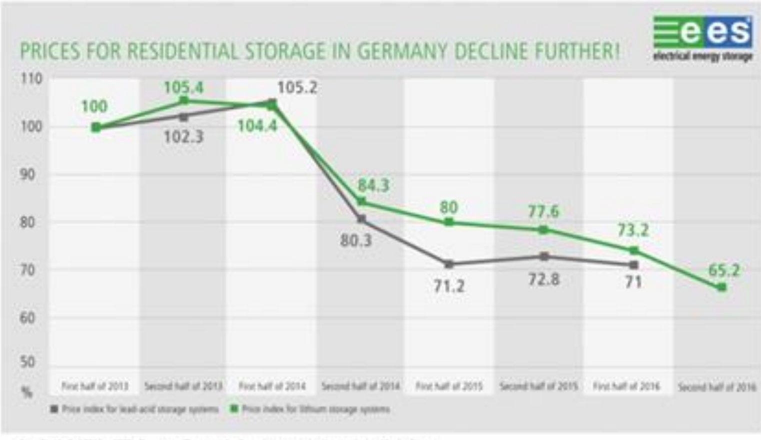

Figure 2. The price decline for residential storage in Germany (in %). Lead -acid (grey) and Li-ion (green) [iii].

Battery storage market growth is expected to be exponential and driven especially by the e-mobility, and residential and utility scale storage sectors (integration of volatile renewables).
The pace of the storage market development in Europe will depend on implementation relevant regulatory frameworks and the pace of the storage systems cost reduction and technology development [iv].

2.2 Technology Readiness Level / Technology versus Price versus Efficiency

There are several different storage technologies available on the market. They differ in many aspects and they are on different maturity levels. Figure 3 presents the TRL level of different storage technologies. Amongst battery systems, lead-acid followed by NiCd, NaS and Li-ion battery systems are currently the most mature technologies. However, NiCd batteries are losing attention and market due to environmental concerns and lower performance in comparison to e.g. Li-ion battery systems.

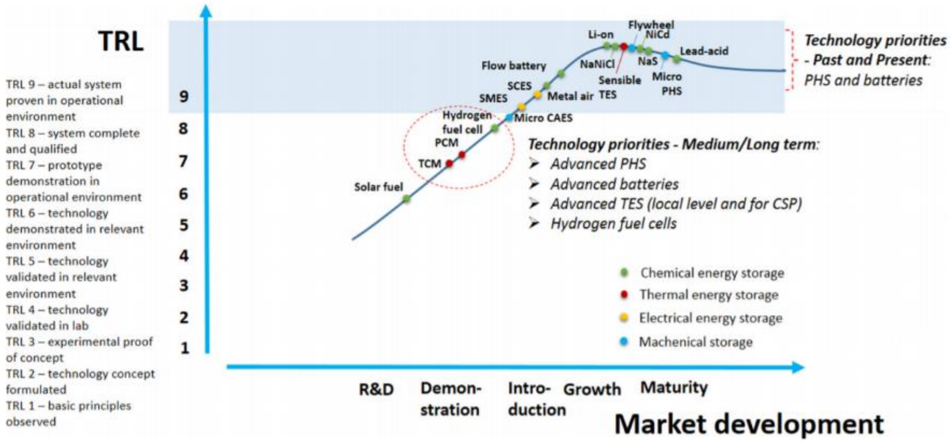

Figure 3. Technology readiness level of different storage technologies.

A short overview of the most mature battery technologies is presented in

Table 2.1.

Table 2.1. Comparison of different parameters of selected battery storage technologies [ii].

Parameter	Lead-acid	Li-ion	NaS	NiCd
Main types	Flooded, sealed, AGM	NMC, NCA, LFP, LTO, LMO, …	N/A	N/A
Power density	150 -180 W/kg	500 - 2000 W/kg	90 – 230 W/kg	150–300 W/kg
Energy density	30 - 40 Wh/kg	75–250 Wh/kg	150-240 Wh/kg	40–60 Wh/kg
Cell voltage	2.0V	2.0 – 3.7V	2.0V	1.2V
Response time	ms	ms	N/A	ms
Round – trip efficiency	80 – 85 %	85 – 95%	65 – 80%	70 – 90%
Self-discharge	3 – 20% per month	<5% per month	20%-per day	0.2-0.6% per day
Balancing circuits	No	Yes	No	No
Life cycle/ Depth of Discharge (DOD)	300 – 2000 / 80%	4000 – 16000 / 80%	4200/80%	2000/ 80%

Li-ion batteries are currently the most often utility scale installed battery chemistry [v]. This trend is expected to continue together with further price reductions and technology improvements. Figure 4 presents the expected battery technology roadmap for e-mobility batteries. Figure 5 provides expected timeframe for the Li-ion battery technology improvements.

The e-mobility battery sector will require high energy density batteries with fast charging feature and low price. On the other hand, utility scale and residential storage systems will need battery systems with low cost per cycle, long cycle and calendar lifetime and low standby losses. Both battery types will need to be based on the abundant, recyclable and safe materials.

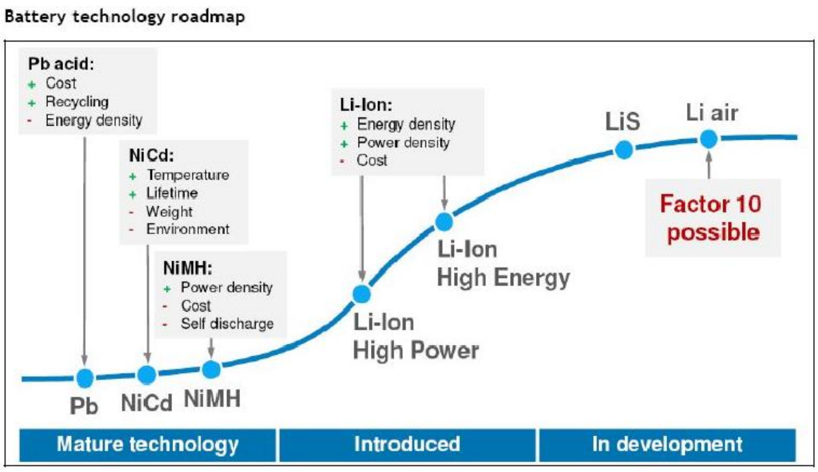

Figure 4. Battery technology roadmap [vi].

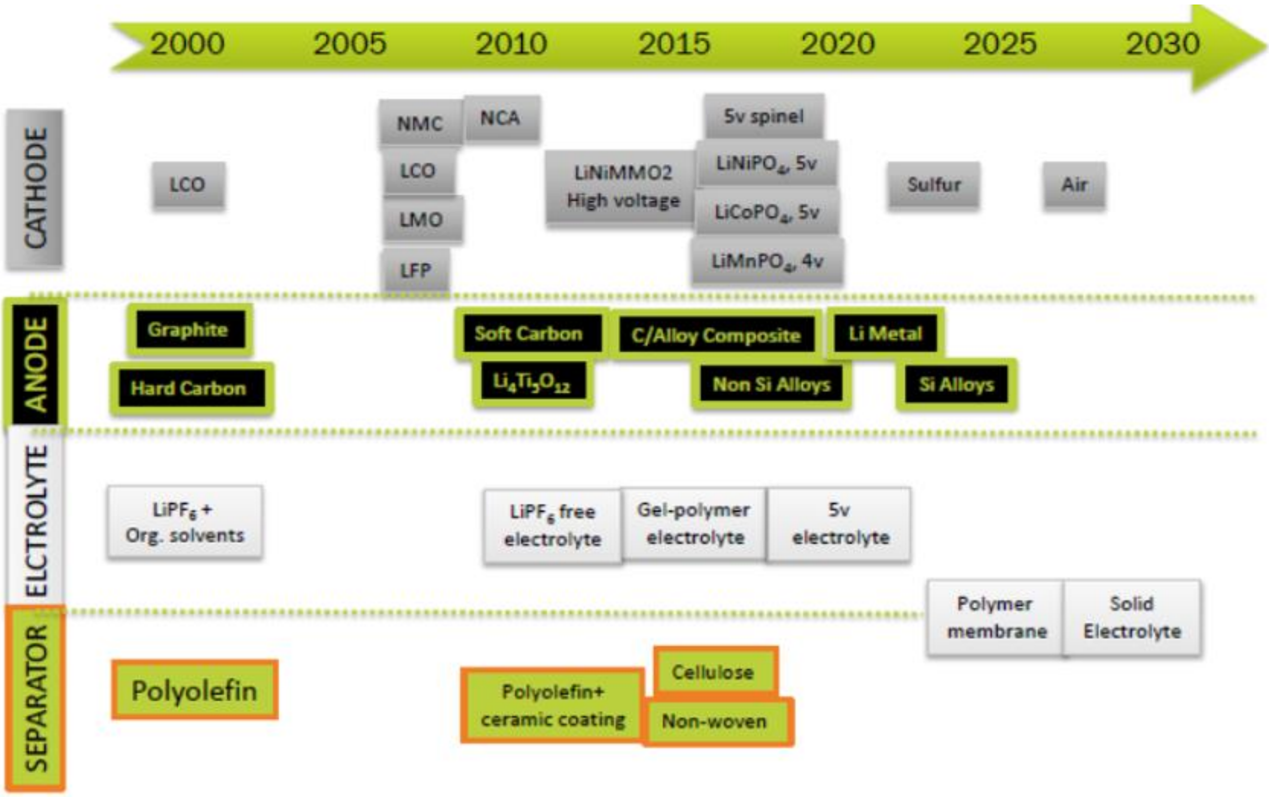

Figure 5. Li-ion battery technology development timeframe[vii].

2.3 Stakeholders

Here is presented the different stakeholders and their possibilities in a future storage market with ancillary services.

2.3.1 DSO

The Distribution System Operators (DSO) has the obligation to be compliant in grid stability namely the voltage level. When private house owners invest in PV-systems the voltage will locally increase and if the voltage reach its limits, the DSO needs to grid strengthen or do other actions to overcome the problem. Future actions may be investing in local storage or buying ancillary services from locally placed and owned storage. The storage may defer the grid strengthening, but that is also interesting for the DSO if the business-case is positive.

2.3.2 Prosumers

Private house owners are investing in Photovoltaic-systems (PV) to be self-sufficient to a certain point and/or as a feasible investment in their houses. When both consumption and production is present, they are named prosumers. A minor but increasing part of these house owners begins to install batteries in connection to the local PV-production to increase their self-sufficiency and be more resilient. The storage systems are autonomous and focus on optimizing the business-case of the house owner. Investment in batteries at prosumer level becomes more attractive when the incentives in injecting PV energy in the grid decrease or disappear, then maximisation of self-consumption is more effective.
The future prosumer with battery gets the possibility to offer also services to the DSO, such as ancillary services, whereby the prosumer gets more income out of their investment in the PV and storage system and increase their private business case further, while the DSO may avoid (or defer) grid strengthening due to the PV-system or increased local consumption.

2.3.3 Investors

In the future, new actors in this field may be discovered, for instance commercial partners who want to invest in the green transition and secure their investment. A future concept could be storage-as-a-service, where the investor places storage at local houses or e.g. in communities/industry sector.

2.3.4 Aggregators

Other actors in the future market may be aggregators or service providers, who will be a new actor in the value chain. Aggregators make contracts with private house owners about ancillary services and bundle a community (a feeder-line or transformer station), to make the business case sustainable. Then the aggregator can offer ancillary services to the local DSO with a bigger volume and the aggregator collect all the details and take care of local control.

2.4 Policy framework

Energy policies promoting a single energy market are becoming more and more defined at the EU level. In addition to the geographic challenge, the role of energy storage is also changing. The new challenge is no longer to store base-load overcapacity, but to handle an increasing amount of intermittent renewable generation. Different types of energy storage at different levels in the energy value chain can play a role to accommodate intermittency and to balance supply and demand of electricity. In order to reach EU goals, energy policies and regulations shall allow the changing roles of storage and incentivise them for being competitive against other available flexibility options.

Fast-growing shares of intermittent renewable energy sources are being realised as a consequence of the implementation of EU's climate goals and targets set for member states. This has resulted in increasing concern over the future electricity grid stability, driven several member states to start the discussion about the need for Capacity Remuneration Mechanisms (CRMs) to increase flexibility in the electricity system.

The main internal market regulations for energy are the Gas Directive[viii] and the Electricity Directive[ix]). These Directives treat storage very differently. In the Electricity Directive storage is not mentioned and in the Gas Directive storage is explicitly mentioned in its scope as one of core elements of the gas distribution system.

The Electricity Directive regulates the unbundling of Transmission System Operators (TSO), DSO and the functions of electricity generation and supply. As energy storage is not mentioned in the Electricity Directive, the position of energy storage in relation to the unbundling requirements is not clear. As a result, electricity storage is generally regarded as a generation system[x]. The Electricity Directive also specifies that a TSO cannot "*directly or indirectly exercise control or exercise any right over any undertaking performing any of the functions of generation or supply*" of electricity. One of the elements of the Electricity Directive is the initiation of Agency for the Cooperation of Energy Regulators (ACER), which has developed the *Framework guidelines on electricity balancing*[xi], directed at the TSOs. These guidelines do not specify any technology for balancing the electricity grid and leave the use of energy storage open.

The European Network of Transmission System Operators for Electricity (ENTSO-E) has published a draft network code for electricity balancing[xii], based on ACER's guidelines that includes the possibility for energy storage facilities to become balancing service providers. ACER also coordinates the implementation of Regulation No 1227/2011 on wholesale energy market integrity and transparency (REMIT). This Regulation is valid for both electricity and gas and includes energy storage in its monitoring and transparency obligations.

ENTSO-E states in its latest Ten-Year Network Development Plan[xiii] that it is an 'open question' which players (private market operators contributing to system optimisation or regulated operators) are allowed to own and manage electricity storage systems. These statements show that ownership and control of energy storage by regulated entities under the Electricity Directive is a point of discussion. The next examples illustrate that several member states feel the need to give their TSOs a role in owning, managing or contracting energy storage for electricity. Some specific national developments on energy storage regulation are:

- Italy has stipulated that the TSO (and DSOs) can build and operate batteries under certain conditions (Italian decree law 93/11, Art 36, paragraph 4). Italian network regulator (AEEGSI) passed a Decision on

Provisions related to the Integration of Energy Storage Systems for Electricity in the National Electricity System (Decision 574/2014/eel of 10 November 2014) defining network access rules for energy storage
- The TSO in Ireland, EirGrid, has developed a program in 2017, which allows energy storage companies to provide grid services via a system of competitive bids[xiv].
- The UK National Grid held in December 2014 a first capacity market auction, which was also open for energy storage facilities.

The European Commission (EC) envisages a transition from the present electricity system to a more decentralised system where consumers can act as prosumers. In the future energy system, the challenge will not be base-load overcapacity, but intermittent renewable generation. Different types of storage at different levels in the supply chain can play a role to accommodate intermittency and balance supply and demand of electricity. Storage of energy can augment power quality and grid integrity, thereby protecting customers against fluctuations and high prices. Decentralised storage options can support the decentralisation goals.
Energy policies and regulations will have to adapt to enable flexibility options, including the changing role of energy storage. The EC has announced in its Energy Union Summer Package of 15 July 2015 that it is working on a new energy market design[xv] . This new energy market design aims at providing an opportunity to reach level playing field for energy storage, clarify the position of energy storage for both regulated and non-regulated entities and acknowledge the multiple services that energy storage can provide.

2.4.1 **EC perspective; The Winter package**

The rapidly increasing share of renewable energy sources (RES) in electricity generation (targeted to be at least 50% by 2030), together with more decentralised production and self-consumption, has also called into question traditional electricity market models, on which the EU's current 'third package' of legislation is based.

Greater intermittency in electricity supplies has created a need for more flexibility and responsiveness both on the supply and the demand side. The market needs to price the costs involved in providing that flexibility and reflect them in the overall price of energy and/or energy services. Flexibility services can and should be provided across an interlinked market. If the market does not function properly Member States will be tempted to take unilateral measures to ensure generation adequacy. These so-called capacity remuneration mechanisms, if not properly designed, can have major adverse consequences on the functioning of the internal electricity market, as the EC has established in its final report on the Sector Inquiry on Capacity Mechanisms. These types of mechanisms can distort market prices, favour certain actors above others, and create new barriers to trade.

Challenges in generation
- Ensuring long-term stability and predictability for investors in RES.

Attracting investments in the medium and long term and by reducing administrative burdens on RES producers, including prosumers. Investments needed in generation from renewable energy sources to meet the targets for 2030 (i.e. those between 2015-2030 are estimated at Euro 1 trillion). Strengthening investors' certainty is crucial and is one of the specific objectives of the proposal.
- Member States shall ensure that the level of, and conditions attached to, the support granted to renewable energy projects are not revised in a way that negatively impacts the rights conferred thereunder and the economics of supported projects.
- Member States shall ensure that investors have sufficient predictability of the planned support for energy from renewable sources. To this aim, Member States shall define and publish a long-term schedule in relation to expected allocation for support, covering at least the following 3 years and including for each scheme the indicative timing, the capacity, the budget expected to be allocated, as well as a consultation of stakeholders on the design of the support.

- Decision making process in case when EU misses its own targets: Member States shall collectively ensure that the sum of their contributions must add up to the Union-wide target of at least 27% by 2030. Also, to produce a national integrated energy and climate plan for the period 2021 to 2030 by 1 January 2019, and for subsequent ten years periods.
- A mechanism in place so that RES suppliers in one Member State benefit from subsidies in another. Mandatory opening of national support schemes to RES installations located in other Member States even if this is only on a gradual basis. At least 10% of newly supported capacity must be opened up annually between 2021 and 2025, and at least 15% for the period 2026 to 2030. It is up to the individual Member State to decide on the mechanics of opening its schemes up to cross-border participation.
- The legitimate role of so-called 'capacity markets'. Although the EU as a whole is currently in a situation of overcapacity, some countries may well face genuine security of supply challenges. Large numbers of existing power plants will be phased out in the near future, as they cannot meet EU emission and environmental standards.

Challenges in wholesale markets

- *The Role of Regional Operational Centres;* Regional operational centres (ROCs) shall complement the role of transmission system operators by performing functions of regional relevance. They shall establish operational arrangements in order to ensure the efficient, secure and reliable operation of the interconnected transmission system. These tasks are to ensure a "coordinated capacity calculation", "facilitate the regional procurement of balancing capacity", draw up "regional week ahead to intraday system adequacy forecasts and preparation of risk reducing actions", and a number of tasks relating to coordinated management of crisis situations.
- *A mechanism for ensuring a market place for ROCs:* The E-Regulation is silent on this matter yet the costs and benefits of regional cooperation may not always be shared equally among the members. The E-Regulation states that ROCs shall complement the role of TSOs by performing "functions of regional relevance". ROCs are to be equipped with all the relevant resources, including financial resources for fulfilling their obligations and carrying out their functions.
- *A mechanism for ensuring a place in the regulatory landscape for ROCs:* Stronger regulatory cooperation within ACER is seen as prerequisite to achieving the EU Energy and Climate goals. The principal role of ACER as a coordinator (or a platform for the co-ordination) of the actions of national regulatory authorities is preserved but limited new competencies are to be assigned to ACER when fragmented national decision making on issues of cross-border relevance could lead to problems or inconsistencies for the internal market.
- *Activation of the demand side*: The Commission claims that there is a lot to be done on the demand side of electricity markets to ensure that they work for the full benefit of business and household consumers, as well as for "prosumers", who produce energy through self-generation or sell surplus electricity back to the grid. Demand response embraces more than just efficient use of energy. It is an important source of flexibility in the power system.

Challenges in distribution

- *Incentives to innovate:* The level of network investment that is required from the DSOs to facilitate the energy transition may span several regulatory periods, and this may pose a challenge to traditional forms of incentive regulation where network charging methodologies are fixed for, three to five-year intervals. Regulators need to make sure that the DSOs have adequate financial incentives to innovate and upgrade their networks, to procure and connect distributed generation and to contract with other service providers, as well as to deal with local congestion management.
- *DSO-TSO cooperation:* In a system where distribution networks are no longer passive but are expected to provide various services for the entire system, the exchange of information between TSOs and DSOs will increase considerably and this aspect should be managed adequately.

- *A new DSO entity for electricity:* Given the large number of DSOs in the EU and the heterogeneous nature of this sector, it is likely to be a major challenge for the new entity (in cooperation with ACER) to draw up a set of rules of procedure which can be both effective and representative of its potentially high diverse membership.
- *Storage and EV- charging infrastructure:* As a general rule DSOs shall not be allowed to own, develop, manage or operate energy storage facilities unless (a) following an open tender procedure no other party has expressed an interest in entering this market and (b) storage facilities are necessary for the DSOs to fulfil their regulated tasks for the reliable and secure operation of the distribution system.
- *Community networks:* One has to evaluate the risk that the principle of the socialisation of network costs is compromised if consumers in low cost areas (e.g. located near production centres) set up their own networks, leaving remaining consumers to finance networks in higher cost areas (e.g. rural areas).

Challenges in (market) price

- *Towards market-based retail prices:* Electricity suppliers shall be free to determine the price at which they supply to customers.
- *Billing:* In order to deal with supplementary issues raised by billing processes, the following information should be displayed in or with bills and periodical settlement bills: (a) current actual prices and actual consumption of energy; (b) comparisons of customers' current energy consumption with consumption for the same period in the previous year in graphic form; (c) contact information for consumer organizations, energy agencies or similar bodies.
- *Data management:* Issues such as access to data, privacy and data protection, as well as cyber-security and issues of open standards and technology remain high on the EC's agenda. Member States are obliged to specify who may have access to the data of the final customer with the customer's explicit consent. Data in this context includes metering and consumption data and data required for switching and the 'eligible' parties potentially gaining access to these data are customers, suppliers, TSOs, DSOs, aggregators and other parties providing energy or other services to customers. The parties granted access to this data shall gain access to them simultaneously in a non-discriminatory manner and on clear and equal terms.
- *Prosumers and aggregators:* Such entities (new actors on the market) should not be required to pay compensation to suppliers or generators but may exceptionally be required to pay compensation to balance responsible parties.

2.4.2 **Grid codes**

The network code(s) for System Operation (SO) shall elaborate on relevant subjects that should be coordinated between TSOs, as well as between TSOs and DSOs, and with significant grid users, where applicable. The network codes for System Operation shall ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities.

There is close interrelationship between issues related to SO, grid connection, cross-border capacity allocation and congestion management, grid development and maintenance, obligations for data provision and the functioning of balancing and reserve power market. In drafting the network code(s) the ENTSO-E should take into consideration a set of requirements, among which for the S4G direct interest are:

- Grid connection - Issues affecting mainly system operators, with less role for grid users, where issues involving the active participation by grid users are mainly addressed in the Framework Guidelines on Electricity Grid Connection (EGC FG). Balancing and reserve power markets - Issues dealing with the integration, coordination and harmonisation of balancing and reserve power markets are addressed in the Framework Guidelines on Electricity Balancing (EB FG). Obligations for data provision – Including data sharing between system operators, and between system operators and significant grid users to ensure operational security, for operation planning and scheduling.

Of special interest is the Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators.
The process of adopting the network code(s) and adapting to national specificity is undertaken by each individual TSO and reviewed by the respective National Regulatory Authority (NRA) and shall require coordination with the adjacent TSOs and relevant DSOs.
The applicability of the standards and requirements to pre-existing significant grid users shall be decided on a national basis by the NRA, based on a proposal from the relevant TSO, after a public consultation. The TSO proposal shall be made on the basis of a sound and transparent quantitative cost-benefit analysis that shall demonstrate the socio-economic benefit, in particular of retroactive application of the minimum standards and requirements. Where it is not demonstrated that the socio-economic benefits outweigh the costs of requiring compliance, pre-existing (and, in exceptional cases, new) grid users with significant role on electricity market (including system services) The network code(s) shall provide for regular re-assessment (including public consultation) of the "significance test" and cost-benefit analysis to cope with evolving system requirements (e.g. penetration of renewable energy sources, smart grids, distributed generation, household demand response, etc.). The network code(s) shall define the physical connection point between the significant grid user's equipment and the network to which they apply. Furthermore, the network code(s) shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including:

- Frequency and voltage parameters;
- Requirements for reactive power;
- Load-frequency control related issues;
- Short-circuit current;
- Requirements for protection devices and settings;
- Fault-ride-through capability; and
- Provision of ancillary services.

The network code(s) shall set out necessary minimum standards and requirements to be followed by DSOs when connecting significant grid users to the distribution network. For DSOs that are defined as significant grid users, the network code(s) shall set out minimum standards and requirements for their equipment installed at the connection point between the transmission and distribution system networks.
Regarding significant grid users connected to the distribution network, any requirements on system operators for adaptation of existing arrangements and for ensuring that distribution-connected significant grid users meet the requirements set out in the network code(s) shall be the responsibility of the DSO.

Special requirements on significant grid users for critical grid situations
The network code(s) shall define situations in general (e.g. which kinds of network faults, which electrical distance), and the detail of possible deviations of significant parameters (e.g. voltage, frequency) that generation units must withstand, while remaining connected to the grid.
Different definitions may apply to different types of generation units. The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state.
The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation outside these operating states will be agreed bilaterally between generation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities. In particular, for the following services the network code(s) shall set out the minimum requirements for those generators providing them on a contractually-agreed basis:

- House load operation including the minimum duration of house load operation;
- Black start; and

- Island operation.

Compliance testing, compliance monitoring and enforcement

The network code(s) shall define clear and transparent criteria and methods for compliance monitoring, including the requirements for compliance testing. In particular the network code(s) shall introduce an obligation for system operators to regularly assess the compliance of generation units with the standards and requirements defined for the connecting installation, including electrical safety.

New grid users defined as significant must provide evidence of compliance with specifications and requirements before the responsible system operator allows for connection. The system operator must transparently define the exact contents of the compliance testing within the provisions of network code(s). The network code(s) shall foresee the possibility of repeated compliance testing by the system operator even after the significant grid user is connected to the grid. The network code(s) shall specify which data from the actual operation of connected installations should be used to verify compliance with the applicable minimum standards and requirements.

The network code(s) shall provide for regular monitoring of the alignment of EU and national codes and provide for corrective measures if any discrepancies are detected. The network code(s) shall always require the system operators to optimise between the highest overall efficiency and lowest total cost for all involved stakeholders. In that respect, National Regulatory Authorities (NRAs) shall ensure, that, whatever the cost-sharing scheme is, the cost split follows the principles of non-discrimination, maximum transparency and assignment to the real originator of the costs. Nothing in the network code(s) shall prevent commercial arrangements being used for the provision of ancillary services[xvi].

3 Business modelling framework in S4G

The business modelling framework used in S4G has been carried out as a number of steps, where the **1. Step** has its focus on the Business environment, the so-called PESTLE analysis[xvii,xviii].

The next steps are to analyse each business model generated from the use cases described in D2.1– "Initial Storage Scenarios and Use cases" [D2.1]. **2. Step** is a Stakeholder analysis, how to identify stakeholders, their roles and impact on the business model. **3. Step** is the SWOT analysis with input from the PESTLE analysis. The SWOT analysis is developed with focus key stakeholders. The External part of the SWOT analysis further investigates opportunities and threats as inputs to the risk analysis. **4. Step** the Risk Analysis, where level of risk and actions to avoid risks is analysed. **5. Step** is profitability calculations, the economic business model. All analyses are collected in the business model canvas as **6. Step**, where the value proposition, among others, is being investigated.

3.1 PESTLE analysis

PESTLE Analysis is a simple and widely used tool that helps to analyse the Political, Economic, Socio-Cultural, Technological, Legal and Environmental (PESTLE) changes in a business environment. This helps to understand the "big picture" forces of change that something is exposed to, and, from this, take advantage of the opportunities that they present. The PESTLE analysis is carried out with special focus on S4G elements and business areas.

It is very critical for one to understand the complete depth of each **PESTLE** letters. It is as follows:

Political: These factors determine the extent to which a government may influence the economy or a certain industry. For example, a government may impose a new tax or duty due to which entire revenue generating structures of organizations might change. Political factors include tax policies, fiscal policy, trade tariffs etc. that a government may levy around the fiscal year and it may affect the business environment (economic environment) in a great extent.

Economic: These factors are determinants of an economy's performance that directly impacts a company and have resonating long term effects. For example, a rise in the inflation rate of any economy would affect the way companies price their products and services. Adding to that, it would affect the purchasing power of a consumer and change demand/supply models for that economy. Economic factors include inflation rate, interest rates, foreign exchange rates, economic growth patterns etc. It also accounts for the Foreign Direct Investment (FDI) depending on certain specific industries which are undergoing this analysis.

Socio-Cultural: These factors scrutinize the social environment of the market, and gauge determinants like cultural trends, demographics, population analytics etc. An example for this can be buying trends for Western countries like the US where there is high demand during the Holiday season.

Technological: These factors pertain to innovations in technology that may affect the operations of the industry and the market favourably or unfavourably. This refers to automation, research and development and the amount of technological awareness that a market possesses.

Legal: These factors have both external and internal sides. There are certain laws that affect the business environment in a certain country while there are certain policies that companies maintain for themselves. Legal analysis takes into account both of these angles and then charts out the strategies in light of these legislations. For example, consumer laws, safety standards, labour laws etc.

Environmental: These factors include all those that influence or are determined by the surrounding environment. This aspect of the PESTLE is crucial for certain industries particularly for example tourism, farming, agriculture etc. Factors of an environmental analysis include but are not limited to climate, weather, geographical location, global changes in climate, environmental offsets etc.

The following steps can be used to analyse the business environment, and the opportunities and threats that it presents.

1. Brainstorming the changes happening around us.
2. Brainstorm opportunities arising from each of these changes.

3. Brainstorm threats or issues that could be caused by them.
4. Take appropriate action – input to SWOT analysis.
   The output can be shown in Table 3.1

Table 3.1. PESTLE analysis.

	Factor	Opportunity	Threat
Political			
Economical			
Socio-Cultural			
Technological			
Legal			
Environmental			

The results from the PESTLE Analysis are input to specially opportunities and threats in the SWOT analysis.

3.2 Stakeholder analysis

Stakeholder analysis[xix] is where it is identified the most important stakeholders. The first stage of this is to brainstorm who the stakeholders are, the people who are affected by S4G business models, the ones that have influence or power over it, or have an interest in its successful or unsuccessful conclusion. This is being reported in Table 3.2.

Table 3.2. Stakeholders analysis.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder

Some of these stakeholders may have the power either to block or advance the business model. Some may be interested in what is being done; others may not care. The next step is to prioritize them by power and interest, and to plot this on a Power/Interest grid as shown in Figure 6.

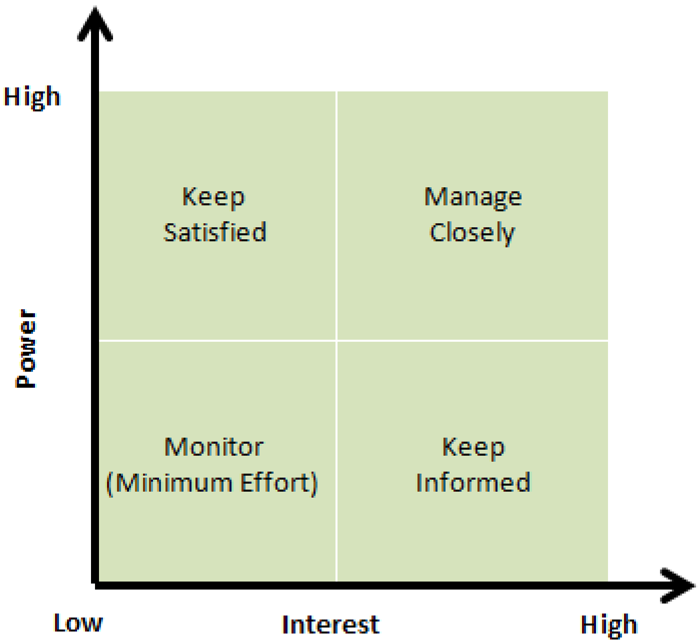

Figure 6. Power / Interest grid.

The final stage is to get an understanding of what motivates the stakeholders and how they can collaborate in the S4G project.

3.3 SWOT analysis

Strength, Weaknesses, Opportunities and Threats (SWOT) analysis[xx] is a useful technique for understanding Strengths and Weaknesses in business models, and for identifying both the Opportunities open and the Threats faced. Strengths and weaknesses are often internal to the organization, while opportunities and threats generally relate to external factors (Table 3.3).

Table 3.3. SWOT analysis.

Strength **What do you do well?** **What unique resources can you draw on?** **What do others see as your strength?**	**Weaknesses** **What could you improve?** **Where do you have fever resources than others?** **What are others likely to see as weaknesses?**
Opportunities **What opportunities are open to you?** **What trends could you take advantage of?** **How can you turn your strengths into opportunities?**	**Threats** **What threats could harm you?** **What is your competition doing?** **What threats do your weaknesses expose you to?**

SWOT helps to focus on strengths, minimize threats, and take the greatest possible advantage of opportunities available to the business model.

3.4 Risk analysis

Risk is made up of two parts: the probability of something going wrong, and the negative consequences if it does. To carry out a Risk analysis, it should be first identified the possible threats from the SWOT analysis, and estimate the likelihood that these threats will materialize (Table 3.4).

Table 3.4. Risk analysis.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions

The actions list extract was to have special focus on, when implementing the business models.

3.5 Business Model Generation

3.5.1 The Business Model Generation Framework

There are a few generic Business Model Frameworks and tools for developing and maintaining business models. Typically, the generic business model frameworks often focus on having good answers to all the dimensions of a business model. Some authors describe these dimensions as the 'who', 'what', 'when', 'why', 'where', 'how' and 'how much' of delivering value to the customers and getting paid for it[xxi,xxii,xxiii,xxiv,xxv,xxvi].

One of the most popular and systemised tools for developing and creating new business models and tools for communicating new business models is the Business Model Generation Framework (BMG) developed by Alexander Osterwalder and Yves Pigneur.

The Business Model Generation Framework (BMG) encapsulates many of the different key content dimensions of business models in the literature and offers executives, practitioners, entrepreneurs and consultants a simple and tested tools for understanding, designing, creating and implementing new business models in all types of companies, industries and for different customer segments, both Business-to-business (B2B) and Business-to-consumer (B2C)[xxvi].

The tool has been co-created and co-authored by 470 Business Model Canvas practitioners from 45 different countries. These companies use the BMG framework to help positioning their business model within an intensely competitive landscape, in an environment of disruptive innovations, but also to lead the redesign of the company's own business model.

The Business Model Generation Framework consists of nine building blocks describing the different elements that are relevant to address when creating a new Business Model. As illustrated in the left column of Table 3.5there are four main pillars or areas: Product or Offer, Customer and Customer Interface, Infrastructure Management, and Financial Aspects[xxvi].

Table 3.5. The 9 Business Model Building Blocks[xxvii].

Pillar	Business Model Building Block	Description
Product	Value Proposition	Gives an overall view of a company's bundle of products and services.
Customer Interface	Target Customers	Describes the segments of customers a company wants to offer value to.

	Distribution Channel	Describes the various means of the company to get in touch with customers.
	Relationship	Explains the kind of links a company establishes between itself and its different customers' segments.
Infrastructure Management	Value Configuration	Describes the arrangement of activities and resources.
	Core Competency	Outlines the competencies necessary to execute the company's business model.
	Partner Network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value.
Financial Aspects	Cost Structure	Sums up the monetary consequences of the means employed in the business model.
	Revenue Model	Describes the way a company makes money through a variety of revenue flows.

It is important to point out that developing a good business model is not about optimising each of the individual nine building blocks on their own but about optimising the entire business model and the delivery of the value proposition, based on a combination of all the nine building blocks. How a value of a product or a service is delivered often characterises the most successful and the most unique business models and one which can change an entire industry.

3.5.2 The Business Model Canvas

The Business Model Canvas, developed in the context of the Business Model Generation Framework offers a tool to visualise the framework of the business model, mapping the different building blocks and making the model easier to communicate and understand.

In order to have a visual framework of the business model the different building blocks have been made into a map, which helps the company communicate the business model and which makes it easy for partners and employees to understand it within that specific area. This tool is called the Business Model Canvas (Figure 7). It is a central part of the framework as it should help the company visualise the final business model, making it easy to communicate to other employees or to external partners.

Therefore, the Business Model Canvas can be perceived as a communication instrument and a dynamic paper which can be updated and adapted to the business model so that it matches the current challenges and meets always the customer demands. This will help the company prepare for the future and reduce also risk and uncertainty by being one step ahead of the development, making fast updates and changes to existing business models, as the business model environment changes.

It is important to note that the Business Model Canvas is the result of the Business Model Generation process and is used for documenting and communicating this result.

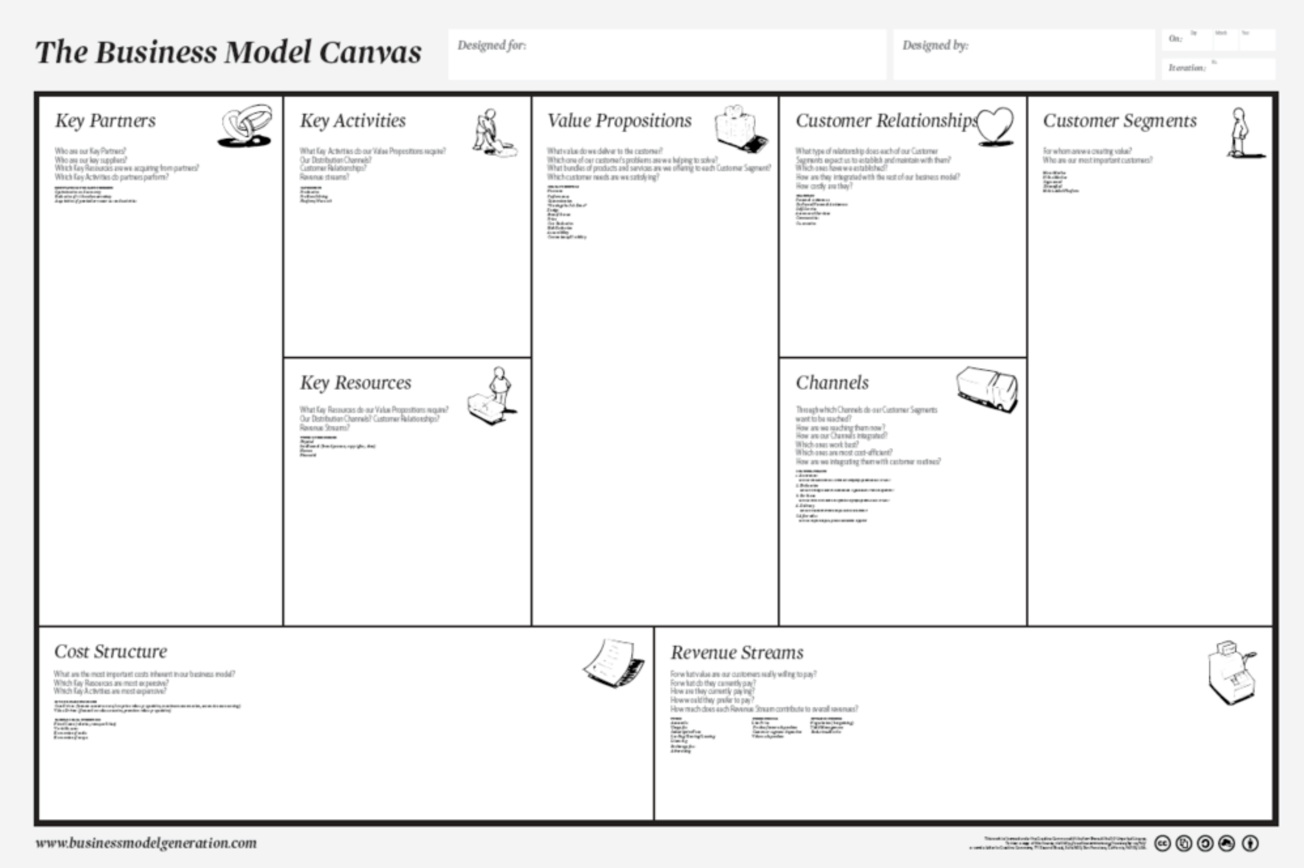

Figure 7. The Business Model Canvas.

In S4G, business model canvases have been created to map out the different models and document the result of the business model generation process.

4 Initial Business models in Bucharest High Level Use Case-1 (HLUC-1)

One business model is related to minimizing losses, i.e. to use surplus energy production as close as possible to the production site, in order to avoid grid losses, especially by using local storage technologies.
Particularly to HLUC-1 is the assumption that a prosumer can have different levels of intelligence and complexity of the local resources embedded in local architectures around an energy router, which include also availability of loads (mostly residential type, legacy AC-type) operating by directly connecting them to direct voltage (DC). Such loads, which accept DC connection, increase the value of using a 220V DC bus mediating the energy transfer at direct voltage from/to storage, from PV and to loads and are added value to the primary use cases PUC-2 and PUC-3.

Due to the low-TRL nature of HLUC-1 and the small-scale of the test-site in Bucharest, a complete validation of business models is out of scope for S4G. The preliminary business cases associated with the test site in Bucharest (low TRL) are summarized below:

- **High Level Use Case-1-Primary Use Case -1- Situation-1 (HLUC-1-PUC-1-S-1)** is about testing Storage as a Service between two entities, from which at least one has available storage on site, connected to the same low-voltage network. If one prosumer has spare storage capacity, it can absorb surplus energy from another prosumer, which otherwise will be curtailed by the DSO due to grid constraints reasons.

- **HLUC-1-PUC-1-S-2** is about testing Storage as a Service between the grid operator and prosumers connected to the [legacy] low-voltage network. If there is a high consumption which may ask for consumption reduction, due to network constraints, the prosumer can use its stored energy in the local ESS to inject energy in the local LV network, thus being able to reduce the power requested on the upstream MV/LV transformer. This is a service for enhancing network capacity without investing in copper (additional wiring) and can be also seen as a transaction between two actors (the energy provider from storage and the utility) connected on the same LV grid. In fact, it can be a stacked business case, combining peer-to-peer energy transaction and also network capacity enhancement.

- **HLUC-1-PUC-1-S-3** is about testing a grid service, seen as an ancillary service in case of a microgrid operating in isolated mode. The prosumer, which is able to deliver such black-start and grid-former service, is expected to be paid for the system service. The tests will be simulated by a small grid with consumption only and this load will be supplied from the microgrid with black-start capability based on frequency provision and necessary power needed to preserve a certain voltage level at the Point of Common Coupling (PCC).

- **HLUC-1-PUC-2** is about testing resilient prosumers, with hybrid solution in the prosumer area, having a DC bus to which all sensitive loads are directly connected. It is a resilience by design service.

- **HLUC-1-PUC-3** is about testing more advanced resilient prosumers, with hybrid solution in the prosumer area, having a DC bus for all sensitive loads and with a DC exchange line with the neighbourhood. It is a cooperative resilience by design service.

4.1 Background and expected impact

4.1.1 PESTLE analysis

PESTLE analysis for business models in Bucharest – HLUC-1 is show in Table 4.1.

Table 4.1. PESTLE analysis of HLUC-1 business models.

	Factor	Opportunity	Threat
Political	Change in green certificates policy; change of energy policy (to promote or not the local PV generation etc.).	PV installations at the end of lifetime → new solutions to enhance the profitability for prosumers by using local storage.	Energy market and prices for equipment due to new connection codes.
Economical	Economic incentives by local and state government for low power PV systems. Decreasing battery costs and increasing quality and life.	People have the possibility to buy more PV and storage systems.	Price of inverters and other components might be still high due to lack of economy of scale (the case is still a "market niche").
Socio-Cultural	Self-sufficient prosumers can induce "independent" life style; Increasing popularity of low-carbon lifestyles.	Popularity of energy communities.	Impact of collaboration at low scale for limited resources and unequal investments (PV, storage) not studied enough.
Technological	More effective storage, higher efficiency of energy use through avoiding double conversion DC-AC-DC, EVs and PV systems will witness an increasing market in the future, economy of scale will reduce prices.	Modern appliances can operate at versatile voltage levels (including DC) and can be connected directly at a prosumer's local DC bus	Local optimum of energy generation and use might not comply with the planning of existing grids→ not clear who has to pay for investments in the grid to ensure PQ levels for a minority of customers.
Legal	Prosumers are discouraged to self-consume: the VAT must be applied and paid for both generation and consume, and not to the net transferred energy (which can be zero);	The development of business for energy brokers, aggregators, etc.	Change in energy law (as to address the installations on the premises of the individuals/end users/ LV customers) including DC distribution grids
Environmental	Climate change. Government aims to achieve carbon reduction as every other nation.	EVs help to reduce carbon emissions into the environment. Lots of opportunities but very depending on policy and taxes.	Poor communication of the RES-based solutions (i.e. local optimum can be perceived less economical than the global one, at system level)

4.1.2 Business rationale

The business rationale is that it is possible to make a business out of using all the local generated renewable energy. Private house owners or other investors are encouraged to install batteries in connection to local PV production. Using all the produced energy, the customer can pay off the initial sum invested and reduces the green gas emission, offering also an independency from the grid.
The PV and battery owner can pay a connection fee to the DSO, thanking into account that the owner will use less energy from the grid, and only when they need it (i.e. energy from renewable sources are not available).

4.2 Overview of use cases and related business cases for the Bucharest test site (year 1)

Table 4.2 gives an overview of use cases and related business cases for the Bolzano test site.

Table 4.2. Overview of key notes for business models related to HLUC-1.

Business Model ID	Title	Key Pains targeted	Value Proposition	Target market	Time horizon
HLUC-1-PUC-1-BM-1	Handle over-generation from RES into the grid (avoid curtailment orders from DSO)	Over generation at DSO level and RES-based energy	Avoids curtailment due to overgeneration at DSO level	Prosumer and DSO	Long
HLUC-1-PUC-2-BM-1	Prosumer will act always as a consumer from the grid side	Maximization the RES-based electricity generation	Resilient prosumer, with hybrid solution in the prosumer area	Prosumer and DSO	Long
HLUC-1-PUC-3-BM-1	Enabling energy services to connected neighbourhood prosumers and consumers	Reduction of the energy/electricity losses	The prosumer will act always as a consumer from the grid side	Prosumer, neighbour energy community and DSO	Long

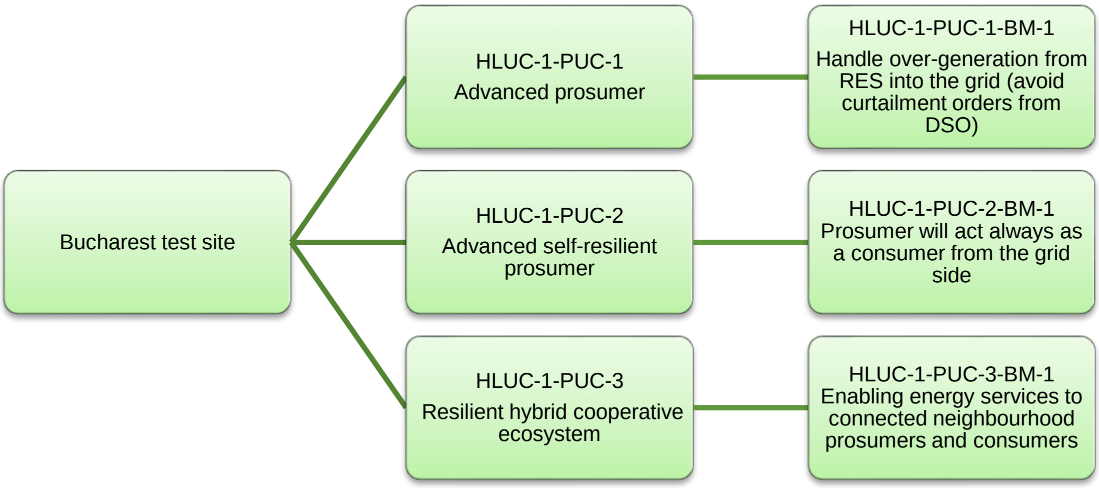

Figure 8. Overview of use cases and related business case for the Bucharest test site.

4.3 Related use case: Advanced Prosumer, HLUC-1-PUC-1

Handle over-generation from RES into the grid (avoid curtailment orders from DSO).

Local DSO can install new technology composed of Unbundled Smart Meters (USM), energy routers (ER), batteries for storage and the Decision Support Framework (S4G DSF) software. ER and USMs allow for sophisticated remote-control capabilities and offer additional services to the local DSOs (e.g. such as U-Q-Control or grid constraints avoidance), which allows for the seamless integration of energy from prosumers into the grid. USMs communicate with the local DSO and forwards demands and storage requests to the ER, regulating the electricity flow inside the prosumer's micro (DC) grid and provides ancillary services to the DSO's grid. The setup corresponds to an Advanced Prosumer (AP) functionality.

4.3.1 Business model HLUC-1-PUC-1-BM-1

Business model HLUC-1-PUC-1-BM-1 consists in providing surplus energy coordination services offered by DSO or other service company to the prosumer, coordinating the prosumers excess energy to be absorbed by a low voltage local grid connected storage resource during peak production periods. By mediating the transfer of surplus renewable energy from PVs to grid-connected storage resources, DSO avoids congestion on the medium to low voltage transformer and the prosumer avoids being curtailed.

4.3.1.1 *Preconditions for the business model*

- Prosumers with local generation controllable by DSO or by other service company.
- At least one user exists in the same network, with storage (electricity) declared availability.

4.3.1.2 *Stakeholder analysis*

- DSO.
- Prosumer (having renewable energy production – usually PV, with or without storage), with risk to be curtailed.
- Storage owner, this entity may be a subsidiary of the DSO, as DSO by itself may have not the right to invest and operate storage assets by its own (depending also on country rules).
- Service company acting as mediator between the prosumer with excess energy production and the storage owner. This entity may be also the DSO.

Table 4.3. Stakeholder analysis of HLUC-1-PUC-1-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Prosumer	Investor	Avoids curtailment due to over generation at DSO level (wide area)	Invests in own storage or in energy router/ communication with other entities (DSO, storage owners, other prosumers)	Incentives included in the connection agreement and contract with DSO
DSO	Balance Compliance	Grid-owner, committed to ensure maximum RES-based energy (sustainability), has the means to dispatch energy and power among the controlled entities	Invest in communication and accepts different contractual agreements with prosumers and storage owners	Regulator accepts/ incentivizes the local energy flows
Storage owner	Investor	Essential contributor to local balance compliance and contributes to sustainability by enabling higher RES-based production and avoids curtailment of another entity	Invest in communication and accepts different contractual agreements with prosumers	Incentives included in the connection agreement and contract with DSO
Service company	Service provider - Mediator	Mediator between prosumer and storage owner, in order to maximize income of prosumer and storage owner, while respecting DSO constraints	Invest in ICT platform to mediate and operate the service	Agreement and contract with other stakeholders (Prosumer, DSO, storage owner)

4.3.1.3 *SWOT analysis*

The SWOT analysis from the prosumer perspective is show in Table 5.104.4.

Table 4.4. SWOT analysis of HLUC-1-PUC-1-BM-1.

Strength	**Weaknesses**
Investment already exists, the service is an "extra" Maximizing the RES-based electricity generation (due to network constraints, part of this available energy will not be wasted)	Needs communication to DSO/control entity; needs "declared availability" of storage storage is depreciated by extra- cycles to serve the prosumer (who is not the owner of storage)
Opportunities	**Threats**
Avoid curtailment; most benefits directed to the prosumer which in this way is maximizing initial investment in (for example) PV	Storage owner is not incentivized to cover depreciation of storage life;

4.3.1.4 *The Business Model Canvas*

The Business Model Canvas of HLUC-1-PUC-1-BM-1 is show in Table 4.5.

Table 4.5. The Business Model Canvas HLUC-1-PUC-1-BM-1.

<table>
<tr><th colspan="5">Handle over-generation from RES into the grid (avoid curtailment orders from DSO)</th></tr>
<tr>
<td rowspan="2">Key Partners
Energy Storage suppliers
Installers
Mediator
ICT

<u>Value chain network:</u>
DSO
Prosumers
Storage owners</td>
<td>Key Activities
Curtailment activities
Selling batteries
Setting set-points at local owned batteries</td>
<td rowspan="2">Value Proposition
<u>Why:</u> using all the local generated renewable energy

<u>What:</u>
the customer can pay off the initial sum invested and to reduce

<u>How:</u>
integration of energy from prosumers into the grid. controlled by the service provider (can be DSO)</td>
<td>Customer Relationship
Customers are encouraged to become "partners", cooperative prosumers</td>
<td rowspan="2">Customer Segments
Prosumers or PV owners</td>
</tr>
<tr>
<td>Key Resources
Salespeople
Grid-Planning people
Grid-operation people</td>
<td>Channels
Personal sale
Campaigns</td>
</tr>
<tr>
<td colspan="2">Cost Structure
Payment for ancillary services
Operation cost</td>
<td colspan="3">Revenue Streams
Postpones or avoid reinforcement, savings</td>
</tr>
</table>

4.3.1.5 *Risk analysis*

DSO will not "play fair" to offer this service for the RES owner (price for the energy delivered during this service might be too low compared to normal operation). Independent service provider can produce competition.

4.3.1.6 *Profitability calculations – the business case*

For such a low TRL level it is not possible to make profitability calculations.
However, the profit is foreseen to come from increased use of PV production and of grid-connected storage means, in a grid with high penetration for renewables (e.g. more than 50% of the local consumption), by efficiently coordinating storage resources connected to the low voltage grid, thus avoiding excess PV production curtailment in case of grid constraints.

4.3.1.7 *Conclusion of HLUC-1-PUC-1-BM-1*

In the considered use case, the opportunities are significant, when the RES-based energy need to be fully exploited and/or targets for sustainability are at risk. However, considering the low TRL of this project and the existing regulatory framework (for example, in Romania, utilities are not obliged to purchase the electricity (mostly RES-based) from the prosumers), it is difficult to demonstrate this business case. The threat is represented by the fact that storage owner is not incentivized to cover depreciation of storage life and this can block the business case.

4.4 Related use case: Advanced self-resilient prosumer, HLUC-1-PUC-2

Battery management in such a way that the prosumer will act always as a consumer from the grid side. It needs only local information for optimal energy management. It does not receive set points from the DSO.

This use case introduces a new approach for managing the energy transfer towards prosumers making use of a smart management of the local energy storage. The proposed grid design (including storage dimensioning procedure) is based on several operation scenarios in which the prosumer is operating as a "load only" entity (from grid perspective) exhibiting self-resilience and higher energy efficiency. One of the major advantages of this restriction in prosumer operation is the preservation of resilience against changing regulatory environment. This can be realized within a newly proposed Uni-directional Resilient Consumer (UniRCon) architecture[xxviii] . Savings can be expressed as opportunity savings arising from difference in tariffs while charging and discharging the storage unit and due to avoidance of curtailment as well as special taxes for PV connection (depending of regulatory environment). It is based on the idea of reducing the prosumer costs using the interplay PV-based generation, electricity local use and storage. The impact of PV electricity production has been already studied in scenarios considering massive deployment of PV installations, and the duck chart of California is one of the well-known case studies (see Figure 9) showing that there is a need for new measures to cope with excess renewables energy in order to avoid the classic curtailment.

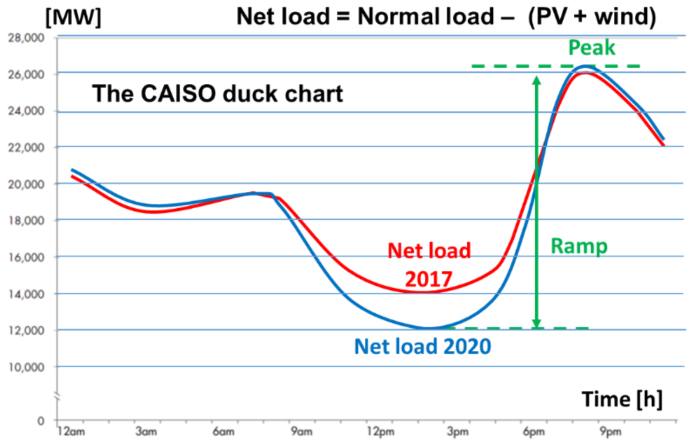

Figure 9. Californian duck curve (high solar penetration).

According to D2.1 [D2.1], 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). The connection of the ER to the DSO grid is designed or programmed to be unidirectional, therefore the advanced self-resilient prosumer becomes an UniRCon, meaning that he is adapting the internal strategies to be consumer-only when seen from the DSO side. This is transforming the prosumer in a pure consumer from the DSO side, which simplifies the responsibilities and requirements of connection and allows a complete control of internal resources.

The business-as-usual scenario is described next: let's consider a roof-mounted PV installation (1 kWp) which can produce, with variation due to latitude and season, up to 4 kWh/day during summertime, and only 1 kWh/day during the winter period. This summarizes for a 10 kWp installation up to 40 kWh energy during a summer day, significantly higher than the average daily energy consumption of about 20 kWh.

In this traditional scenario which was encouraged in the past by attractive green certificates, there is, by design, an excess of electricity produced locally on a major part of the year. For the future high PV penetration, this excess energy, if injected into the network, might lead to curtailment orders (due to voltage limits and grid capacity violation, or even due to stability constraints) or penalties. This scenario is also including the case when subsidies for RES and priority on renewables dispatch are cancelled or highly diminished. Moreover, the scenario considers an increase of self-consumption, which becomes a viable approach enforced by the situation of reaching or approaching grid parity price (situation already encountered in many European countries), thus collecting feed-in tariff or green certificates being less and less profitable. Therefore, sizing the generation and storage units becomes a techno-economic problem since the profitability and internal rate of return are decisive for choosing a solution.

The proposed business case is related to the scenario of a complete self-consumption, i.e. no locally generated electricity is injected back into the network.

This type of operation of the user installation is labelled as a "no-back generation" solution, translating into a scenario where, even with local electricity production, the control of the energy production on the prosumer premises ensures that the prosumer appears always as a pure consumer ($P_{consumed}>0$) on the LV network side.

4.4.1 Business model HLUC-1-PUC-2-BM-1

Business model HLUC-1-PUC-2-BM-1 consists in an advanced self-resilient prosumer, with hybrid grid solution in the prosumer area, having a DC bus for supplying all sensitive loads. This case is taking in consideration three possible aspects:

- The customer is buying PV and storage with the intention of receiving from the state green certificates (for PV). However, when the state plan is ending, the intention is to maximize the initial investment by using the price differences between the local generation grid-based consumption. This situation is enabled by grid parity attendance (local generation becomes cheaper than grid-supplied energy).
- The customer is buying PV and storage systems because he does not want to remain without energy in case of a voltage gap/blackout. With this solution he aims to become resilient or even immune to grid outages, being locally supplied until entire local stored energy is used. The green certificates are not seen as an objective.
- The customer is buying PV and storage because he does not want to consume energy from the grid and support this market which involves reduction of green gas emissions. He wants to use as much as possible only RES-based electricity energy sources.

The main actors and assumptions of this business case can be found in Table 4.6.

Table 4.6. Main actors and assumptions of HLUC-1-PUC-2-BM-1.

Actor	Type	Role	Assumption	Actors goal
DSO	Company	Accommodates a lower average load when planning has been done for higher power (for example, Pmax=10 kW)	Supplier will not apply charges for grid-connection (remains the usual contract based on energy consumption)	To avoid change in income when based on energy sold; to avoid re-enforcement of the network based on PQ constraints arising due to 0-load nodes;
Prosumer (PV and battery owner)	Private entity	Private house owner, who has invested in storage system placed at his private house, connected to the PV-system and the grid	Can change the contract of energy supply (associated with the inverter installations)	Better business case, higher self-consumption Consume all the local produced renewable energy, attain resilience against network faults etc.
Appliances Supplier	Company	Ensure the necessary equipment compatible both AC and DC, at a convenient price	It will provide the appliance with a "DC" label as well	Interested in larger markets and meet the expectations of customers to have versatile power supply (AC and/or DC)

4.4.1.1 *Preconditions for the business model*

- PV and battery installation are in place.
- Regulations (permission) for directly connected DC appliances are in force and allow coupling appliances to the prosumer's DC grid

4.4.1.2 *Stakeholder analysis*

Results of the Stakeholder analysis are show in Table 5.14.7

Table 4.7. Stakeholder analysis of HLUC-1-PUC-2-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Prosumer	Investor	Maximizes the use of RES-based electricity (avoids curtailment) by self-consumption and increase resilience against price variability and market rules valid for local generation, by dealing only with price schemes for energy supply	Invest in own storage and in ER/ selects the DC-loads and the overall loads' priority, invests in storage based on assumed scenarios	Incentives included in the connection agreement (based on maximum load) and contract with DSO
DSO	Energy distribution	Grid-owner, committed to ensure maximum RES-based energy	Avoids back generation and has protected the	To support the operational costs, one has to include

		(sustainability), has the means to plan the distribution of energy, based on load/generation modelling	installations against effects of local, intermittent generation; has to deal with new load models (P_load<<P initially approved for connection)	in the contract a connection fee, independent from the energy delivered; Regulator needs to consider this new context of self-consumption in the loss compensation package of DSO;

4.4.1.3 *SWOT analysis*

The SWOT analysis from the prosumer perspective is show in Table 5.104.8

Table 4.8. SWOT analysis of HLUC-1-PUC-2-BM-1.

Strength	**Weaknesses**
• The price for the energy generated locally is lower than the price for consumed energy (grid parity) • "Consumer- only" behaviour is protected against regulatory changes (preserves Business as usual load supply from DSO perspective) • "Consumer only" behaviour allows a simplified cost-effective connection to the grid (compliance with simpler consumer grid code rather than to more demanding generators related grid code).	• Solution too new to achieve a critical mass of potential users • Communication on the benefits of storage not good enough; electricity storage might be seen as opposite to clean technology;
Opportunities	**Threats**
• Electricity prices; PV incentives (green certificates) at the end of life time • Storage costs decrease dramatically due to EV • Electronics costs decreases while technical specs are strengthened.	• Can the customer rely on this solution in the long term? • Regulation barriers may prohibit such solutions

4.4.1.4 *Risk analysis*

Risks related to HLUC-1-PUC-2-BM-1 are show in Table 4.9.

Table 4.9. Risks analysis of HLUC-1-PUC-2-BM-1 (low risk 1 to high risk 5).

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Not enough storage flexibility	4	4	16	Invest in local storage (Prosumer)
Connection fees too high	3	3	9	Use existing contracts (load only), no connection fees
Reduction of the energy price	1	2	2	Rethink the storage operation (lower number of cycles, allow loss of PV electricity, add non-electricity storage)
DC regulations not in place	5	3	15	Prepare the necessary DC regulation to ensure local deployment; use existing application notes for 220V dc supply in protection cabinets); change the voltage level (48V) for which ETSI regulations exist
High price of energy converters	4	5	20	Address emerging markets for converters (EV charging), enable economy of scale which generates lower prices; set lower the constraints on efficiency
Low life of the battery system	4	4	16	Improve control algorithm to decrease the number of deep charging/discharging cycles; use performant predictions for the PV generation and load curves (learning algorithms);

4.4.1.5 *The Business Model Canvas*

The Business Model Canvas of HLUC-1-PUC-2-BM-1 is show in Table 4.10.

Table 4.10. The Business Model Canvas HLUC-1-PUC-2-BM-1.

<table>
<tr><th colspan="5">Advanced self-resilient prosumer (ASRP) - Prosumer will act always as a consumer from the grid side and has internal DC network for high resilience</th></tr>
<tr><td rowspan="2">Key Partners
Energy Storage suppliers
Installers
ICT

<u>Value chain network:</u>
DSO</td><td>Key Activities
Setting the prosumer as a consumer-only
Selling batteries
Setting set-points at local owned batteries</td><td rowspan="2">Value Proposition
<u>Why:</u> preservation of resilience against changing regulatory environment

<u>What:</u></td><td>Customer Relationship
Customers are encouraged to become only consumer</td><td rowspan="2">Customer Segments
Prosumers</td></tr>
<tr><td>Key Resources
Salespeople</td><td>Channels
Personal sale</td></tr>
</table>

Prosumers	Grid-Planning people Grid-operation people	Using ER and a resilient DC bus available for connecting resilient DC loads <u>How:</u> connection of the ER to the DSO grid is designed or programmed to be unidirectional	Campaigns	
Cost Structure Payment for ancillary services Operation cost			**Revenue Streams** Postponing or avoid reinforcement, savings.	

4.4.1.6 *Profitability calculations – the business case*

The HLUC-1-PUC-2 scenario allows the configuration of a DC bus on the prosumer premises, with advantages for integrating "naturally DC entities" like PV production and storage[xxviii]. This architecture is even more attractive than the storage-based net-metering, as it gives additional savings (4.3% versus 6.7% [xxviii]) in the simulated scenarios, corresponding to optimistic and traditional approach in PV and storage investment calculation, respectively. This can be explained by the higher efficiency of conversion and local energy use, a less sophisticated connection of resilient loads and by the capacity of achieving local optimum for the energy use.

4.4.1.7 *Conclusion of HLUC-1-PUC-2-BM-1*

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

4.5 Related use case: Resilient hybrid cooperative ecosystem, HLUC-1-PUC-3

Battery management in such a way that the prosumer will act always as a consumer from the grid side. The local energy management will coordinate local PV generation, local storage and resilient loads connected on DC bus and also the exchange of energy with the neighbour through a DC connection, for using/sharing the resources own by each part. As being a consumer-only entity from DSO perspective, it does never receive curtailment orders from the DSO. The solution targets also higher energy efficiency, as native DC-oriented entities (PV, storage, DC-compatible loads) do not need double conversion (from DC to AC and back to DC), having a potential of increasing the system efficiency.

The solution enables energy services (based on new technology) to connect neighbourhood prosumers and consumers. Key to the solution is a Modular Energy Router with resilient DC bus and with a DC connection for exchanging energy with neighbours (Figure 10).

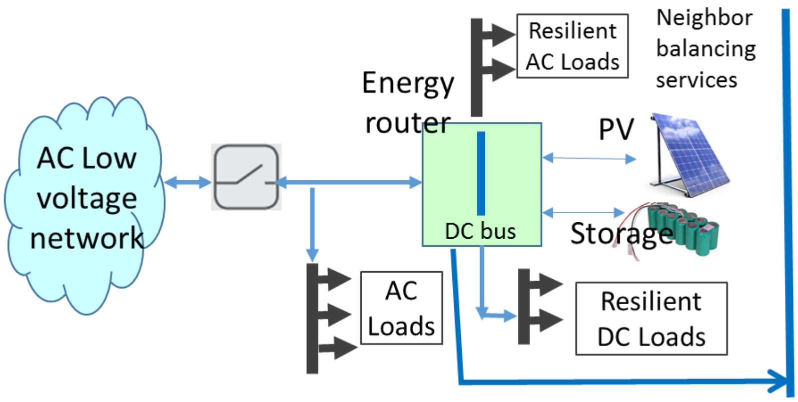

Figure 10. Unidirectional resilient consumer (UniRcon) architecture.

The solution can have in its most complex situation local AC and DC buses, to supply resilient consumers, as well as neighbour DC link, to balance energy within neighbours. Resilient local AC bus is also a possible extension; however, it is not studied in the use case. 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 EMS to control energy production, storage and consumption for its local needs as well as to provide energy services to its neighbour consumers and prosumers.

4.5.1 Business model HLUC-1-PUC-3-BM-1

4.5.1.1 *Preconditions for the business model*

- Agreement to have an operational DC link between 2 entities, from which at least one is prosumer with local storage unit.
- Energy prices known to both entities; agreement reached to supply loads with a price less than the utility price.
- Contractual (mutual) agreement between the two entities participating in the energy "dispatch" using the DC link.

4.5.1.2 *Stakeholder analysis*

- DSO.
- Prosumer (with DC connection).
- Cluster of prosumers acting as an energy community.
- Storage owner (not necessarily with prosumer installation).

Results of the Stakeholder analysis are show in Table 4.11.

Table 4.11. Stakeholder analysis of HLUC-1-PUC-3-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Prosumer	Investor	Avoids curtailment due to over generation at DSO level (wide area), increase	Invests in ER/ communication with other	Incentives included in the connection agreement and

		resilience, increase self-consumption	entities (DSO, storage owners, other prosumers)	contract with DSO; legal contractual agreements with the storage owner (can be also another prosumer); meters for local energy exchange (outside the DSO network)
Energy community	Investor	Increase resilience against outages, increase self-consumption	Invests in ER/ communication with other entities (DSO, storage owners, other prosumers)	Incentives included in the connection agreement and contract with DSO; legal contractual agreements inside the energy community
DSO	Energy distributor	Grid-owner, committed to ensure maximum RES-based energy (sustainability), has the means to dispatch energy and power among the controlled entities	Invests in communication and accepts different contractual agreements with prosumers and storage owners;	Regulator accepts/incentivizes the local energy flows
Storage owner	Investor	Essential contributor to local balance compliance and contributes to sustainability by enabling higher RES-based production and avoids curtailment of another entity	Invests in communication and accepts different contractual agreements with prosumers	Incentives included in the connection agreement and contract with DSO and prosumers

4.5.1.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 4.12.

Table 4.12. SWOT analysis of HLUC-1-PUC-3-BM-1.

Strength	**Weaknesses**

• Traditional load behaviour is maintained, Business as usual from DSO perspective • Production stochastic behaviour is not present in the grid, allowing better grid management from DSO perspective • Load behaviour can be more predictable • Full control of local electricity inflow and energy balance • Allows the deployment of new optimization strategies	• Lack of "examples" for contractual agreement intra-neighbours; • Who is paying and maintain the dc link? • Lack of standards • Potential high cost of "operation history" and accountability of operation
Opportunities	**Threats**
• To reduce the energy/electricity consumption cost on the long term	• Can the customer rely on this solution in the long term? • What happens if the owner of one of the households is changing?

4.5.1.4 *Risk analysis*

Risks related to HLUC-1-PUC-2-BM-1 are show in Table 4.13.

Table 4.13. Risks analysis of HLUC-1-PUC-3-BM-1 (low risk 1 to high risk 5).

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Not enough storage flexibility	4	4	16	Invest in local storage (Prosumer)
Connection fees too high	3	3	9	Use existing contracts (load only), no connection fees
Reduction of the energy price	1	2	2	Re-think the storage operation (lower number of cycles, allow loss of PV electricity, add non-electricity storage)
DC regulations not in place	5	3	15	Prepare the necessary DC regulation to ensure local deployment; use existing application notes for 220V dc supply 9in protection cabinets); change the voltage level (48V) for which ETSI regulations exist
High price of energy converters	4	5	20	Address emerging markets for converters (EV charging); set lower the constraints on efficiency

Low life of the battery system	4	4	16	Improve control algorithm to decrease the number of deep charging/discharging cycles; use performant predictions for the PV generation and load curves (learning algorithms);

4.5.1.5 *The Business Model Canvas*

The Business Model Canvas of HLUC-1-PUC-3-BM-1 is show in Table 4.14.

Table 4.14. The Business Model Canvas HLUC-1-PUC-3-BM-1.

<table>
<tr><th colspan="5">Resilient hybrid cooperative ecosystem - Enabling energy services to connected neighbourhood prosumers and consumers</th></tr>
<tr><td rowspan="2">Key Partners
2 entities, from which at least one is prosumer with local storage unit
Energy Storage suppliers
Installers
ICT

<u>Value chain network:</u>
Prosumers
Energy community</td><td>Key ActivitiesSelling batteries
Setting set-points at local owned batteries</td><td rowspan="2">Value Proposition
<u>Why:</u> create a resilient hybrid ecosystem

<u>What:</u>
Using a Modular Energy Router for exchanging energy grid

<u>How:</u>
control energy production, storage and consumption for its local needs as well as to provide energy services to its neighbour consumers and prosumers</td><td>Customer Relationship
Customers are encouraged to become “partners” and to create an ecosystem</td><td rowspan="2">Customer Segments
Prosumers</td></tr>
<tr><td>Key Resources
Battery systems
Customer service</td><td>Channels
Personal sale
Campaigns</td></tr>
<tr><td colspan="3">Cost Structure
Payment for ancillary services
Operation cost</td><td colspan="2">Revenue Streams
Postponing or avoid reinforcement, savings.</td></tr>
</table>

4.5.1.6 *Profitability calculations – the business case*

For such a low TRL level it is not possible to make profitability calculations.

4.5.1.7 *Conclusions of HLUC-1-PUC-3-BM-1*

This business case will be relevant by enabling energy services (based on new technology) to connected neighbourhood prosumers and consumers (with storage facilities). An important opportunity consists in the reduction of the energy/electricity losses, increased share of RES-based energy use which results in lower electricity consumption cost on the long term. The self-organizing of such “energy cells” enabling local energy management with the objective of maximizing the local use of the electricity generated (and potentially harvested, as based on RES) can become a first step in planning the future energy systems; energy exchange using DC connectors can improve the energy efficiency at the end user by enabling co-existence, on the same regulated market, of several power quality and quality of service levels, including acceptability of lower levels than those enforced by standards of performance of DSOs.

4.6 Conclusion business models in Bucharest HLUC-1

This business case is related to minimize losses, i.e. to use (including by charging the local storage) surplus production as close as possible to the production site, to avoid grid losses.
Due to the low-TRL nature of HLUC-1 and the small-scale of the test-site in UPB, a complete validation of business models is out of scope of S4G.

In the business case of PUC-1 a threat is represented by the fact that storage owner is not incentivized to cover depreciation of storage life and this can block the business case.

For the business case of PUC-2 the resulting solution is ensuring a load-only pattern on distribution grid side for an existing prosumer, just by adding the storage unit and an intelligent ER, is superior to classic net-metering, with or without storage behind the meter, in both two: savings attractiveness and in resilience, including resilience against regulatory changes and market variability for the locally (prosumer) generated electricity.

In the PUC-3 the business case will be relevant by enabling energy services (based on new technology) to connected neighbourhood prosumers and consumers. An important opportunity consists in the reduction of the energy/electricity consumption cost on the long term.

5 Initial Business models in Bolzano HLUC-2

This chapter will elaborate the Italian business-cases related to use cases presented in D2.1 [D2.1]. Business models are elaborated in different levels depending on how close to the market they are estimated to be and the possibility to implement them in the test site.

5.1 Background and expected impact

Alto Adige – Südtirol is an alpine region in northern Italy, characterized by a high share of RES, mainly hydropower, but the last decade showed a large increase in the amount of small, distributed PV plants connected to the low voltage grid. Edyna, the main DSO of the area, connects to its MV and LV grid more than 4.5 thousand PV plants with an overall installed power of 146 MW.

On the other hand, large predictable loads (e.g. from high-consuming, heavy industry) are quickly decreasing in the area. Distributed, less predictable loads (e.g. EV fast-charging stations) are taking their place. As of today, around 250 EVs are already active in Alto Adige - Südtirol, using a network of 35 public charging stations operated by the local utility Alperia, but the diffusion of EVs is currently growing significantly. Therefore, Alperia has already scheduled high investments to activate a larger number of charging stations within the next years. In order to allow European utilities, such as Alperia, to pursue their ambitious deployment plan regarding the EV charging infrastructure, while avoiding heavy investments in strengthening the grid, methodologies for planning, evaluating and controlling storage installations communicating and cooperating with EV charging systems are studied within the S4G project.

This scenario, called "Cooperative EV charging" is tested in a Residential case and a Commercial case. For both cases, new Business Models should be investigated.

5.1.1 PESTLE analysis

The PESTLE analysis has been carried out. Results of the PESTLE analysis are show in Table 5.1.

Table 5.1. PESTLE analysis of HLUC-2 business models.

	Factor	Opportunity	Threat
Political	Change in energy policy.	Information about the best solutions for customers and DSOs.	The policy can change rapidly and make good investments bad.
Economical	Economic incentives by local and state government for EVs. Decreasing battery costs and increasing quality and life.	People have the possibility to buy more EVs and storage systems.	Charging infrastructure has to grow along with the increase of EVs.
Socio-Cultural	Buying EV can be depicted as a status symbol, people are becoming more environmental conscious. Increasing popularity of low-carbon lifestyles.	More PV systems with storage to be more self-consuming.	More grid problems, due to more installations at feeder lines and more PV systems at the same feeder lines.
Technological	More effective storage and PV systems may cause an increasing market in the future.	More local production and less distribution from big power plants meaning less grid losses.	Local production must be consumed locally to avoid grid losses. Imbalances in the grid.

Legal	The energy market is very hard regulated in Italy: most of the energy bill is taxes and fixed prices.	Gives a good incentive to be self sufficient	Are you able to consume when you are producing? There is no possibility to control from the DSO point of view.
Environmental	Climate change. Government aims to achieve carbon reduction as every other nation.	EVs help to reduce carbon emissions into the environment. Lots of opportunities but very depending on policy and taxes.	Time is short. Climate change is already happening and all stakeholders involved need to act soon.

The results from the PESTLE analysis is further elaborated in the SWOT analysis.

5.1.2 Business rationale

As the cost of batteries, fuel cells, and renewable energy decreases, it is becoming clear that energy storage will be a big business in the future. It can smooth out the variability inherent with wind and solar, provide valuable services to the grid, and shift cheap renewable energy produced during the daytime hours, to when it is most needed, as for example in the evening.

In Bolzano, the business rationales are various, according to the different business models, and they will be described in the following sections. In general, the business rational for the Cooperative EV charging scenario is that it is possible to make business by installing and controlling batteries for maximizing the consumption of self-produced PV energy and for minimizing the maximal power of the grid connection (peak shaving).

5.1.3 Actors, assumptions and actor's goals

Results of the Actor analysis are show in Table 5.2.

Table 5.2. Main actors, assumptions, and goals.

Actor	Type	Role	Assumption	Actors goal
DSO	Company	Compliance with technical (Italian Energy Authority) and voltage quality (EN 50160) Balance – dispatching (in the future?)	Demand local voltage regulation Demand local balancing aggregates	Lower maintenance cost, and reduced and/or defer reinforcement
Prosumer and battery owner	Private person	Private house owner, who has invested in storage system placed at his private house, connected to the PV system and the grid and/or with EV charging station	Can offer ancillary services with storage, being able to control voltage and autonomous peak shaving	Better business case, higher self-supply
Battery Owner/ Investor	Company	Investor, who has invested in storage system placed at a private house and	Offers ancillary services with storage, being able to control voltage and peak shaving / network	Positive business case, new business

		connected to a private PV-system and the grid	controlled demand side management	
Aggregator	Company	Service provider who makes contract between the battery owner and the DSO about specific services and comfort levels. *(can be ESS owner)*	Offers ancillary services with storage, being able to control voltage and peak shaving / network controlled demand side management	Positive business case, new business
System operator (TSO)	Company	Responsible for load balancing and dispatching	Demand local balancing aggregates	To keep the system balanced without curtailment of RES

5.2 Overview of use cases and related business cases for the Bolzano test site (year 1)

Table 5.3 gives an overview of use cases and related business cases for the Bolzano test site.

Table 5.3. Overview of use cases and related business cases for the Bolzano test site.

Business Model ID	Title	Key Pains targeted	Value Proposition	Target market	Time horizon
HLCU-2-PUC-1-BM-1	Prosumer with ESS "stand alone" (base line)	Time-Imbalance between production and consumption	Maximising the self-consumption	Private houses with RES	Short
HLCU-2-PUC-1-BM-2	Prosumer with grid integration	Imbalances in the local grid in power and energy	Maximising the self-consumption and increase own-production	Private houses with RES + DSO	Medium
HLCU-2-PUC-1-BM-3	DSO coordinates a group of distributed prosumers	Imbalances in the local grid in power and energy	Maximising the self-consumption and increase own-production	Private houses with RES + DSO	Medium
HLCU-2-PUC-1-BM-4	Aggregator coordinates a group of distributed prosumers	Imbalances in the local grid in power and energy	Maximising the self-consumption and increase own-production	Private houses with RES + Aggregator + DSO	Long
HLCU-2-PUC-2-BM-1	Cooperative charging at commercial or fleet level	Imbalances in the local grid in power and energy	Maximising the self-consumption and increase own-production	Commercial sites with EVs fleet	Medium

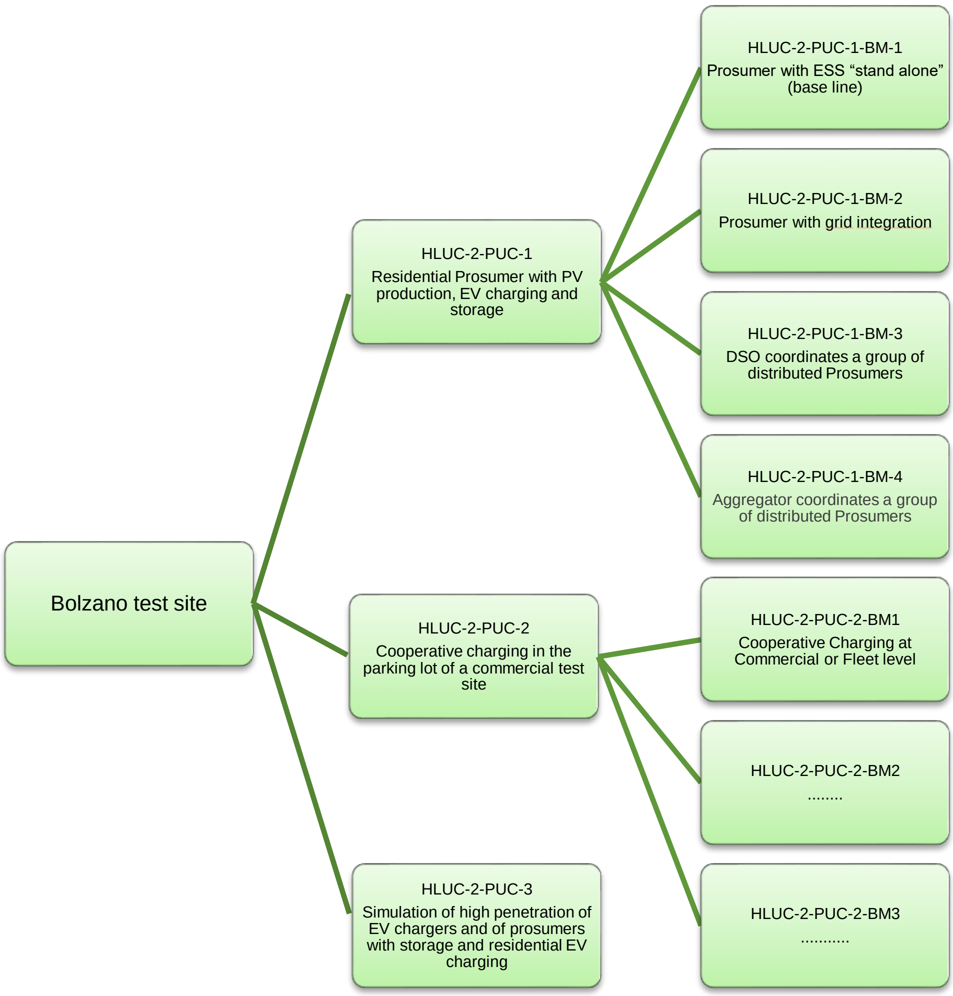

Figure 11.Overview of use cases and related business case for the Bolzano test site.

5.3 Related use case: Residential prosumer with storage, HLUC-2- PUC-1

This use case focuses on the residential installation of individual charging systems for EVs. The residential case is tested in a private house provided with a PV roof plant of 9,6 kW, and 1 plug for classical charging of the EV. During the first year of the project the house was provided by Alperia with an Energy Storage System (ESS) of 12 kWh.

5.3.1 Business model HLUC-2-PUC-1-BM1: prosumer with ESS "stand alone"

This business model is the baseline for the other business models concerning the Residential Prosumer in the Italian context and in the Bolzano test site, and will investigate if it is profitable for a residential prosumer with an EV charging station to invest money in a residential ESS. The prosumer has the following advantages, by adopting an ESS:

- Can store the surplus of local energy and use it during the evening, thus maximizing the self-consumption of the PV production;
- Avoids the upgrade of the contractual maximum power at the Point of Delivery (POD), thanks to the "peak shaving" effect of the ESS.

5.3.1.1 *Preconditions for the business model*

Private costumers have invested in RES such as PV systems, which in certain circumstances increase the voltage level and affect the flux and creates reverse energy flow in the feeder lines of the local DSO. The same private customers have EV with a charging station at home, which requests a higher contractual power with the DSO.

A high number of EV charging stations is a potential threat for the distribution network because of the relative high request on power. The preconditions for this business model are:

- Investment in storage solutions must be more economically beneficial for the prosumer than to inject the overproduction of electricity into the grid;
- The ESS can be controlled in such a way that peaks of injected or withdrawn power are avoided (peak shaving).

The business rationale is that it is possible to make a business for prosumers by installing batteries for maximizing the consumption of self-produced energy and for minimizing the maximal power of the grid connection (peak shaving). If this statement is confirmed, private house owners, or other investors, are encouraged to install batteries in connection to local PV production and/or EV charging.
This way the prosumer can offer a sustainable solution to the DSO, whereby the prosumer gets as much out of his investment in the PV-system and increase his private business case, and the DSO avoids or postpones grid strengthening.
This business model does not take in account the possibility to offer ancillary services to the DSO, but the DSOs can indirectly benefit from the installation of ESS in terms of enhanced voltage quality and defer investments in traditional grid reinforcements.
The whole electrical system can benefit of ESS in terms of production – load balancing.

5.3.1.2 *Stakeholder analysis*

The stakeholder analysis of HLUC-2-PUC-1-BM-1 is presented in Table 5.4.

Table 5.4. Stakeholder analysis of HLUC-2-PUC-1-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Prosumer with EV	Investor	The prosumer wants to increase self-consumption and to maximize the investment	Invests in storage	Information about the advantages of the storage
DSO	Balance Compliance	Grid-owner, monopole	None	None

5.3.1.3 *SWOT analysis*

SWOT analysis for this business model from the prosumer and DSO perspective is show in Table 5.5 and Table 5.6.

Table 5.5. SWOT analysis of HLUC-2-PUC-1-BM-1 – PROSUMER perspective.

Strength	Weaknesses
• Easy to establish • Autonomous	• At the moment in Italy is not very convenient due the possibility to use the grid as storage with the exchange on site • Still too expensive at the moment (even if in some regions in Italy there are public incentives)

Opportunities	Threats
• In the future, maybe economically interesting to increase self-consumption and reduce costs	• Time for return of investment is very long and in the meantime external conditions (legal, economical…) could change

Table 5.6. SWOT analysis of HLUC-2-PUC-1-BM-1 – DSO perspective.

Strength	Weaknesses
• No investment for the DSO	• At the moment in Italy is not very convenient due the possibility to use the grid as storage with the exchange on site • DSO has no possibility to control and rely on the prosumer
Opportunities	**Threats**
• If the EV market will expand, it will be necessary to have peak shaving of power needed for charging EVs • If the PV market will expand, it will be necessary to avoid load peaks in the evening hours • Increasing the solar penetration can lead the system operator to curtail solar to balance the grid during peak hours	• There is no possibility to control from the DSO point of view

5.3.1.4 *Risk analysis*

The risk analysis of HLUC-2-PUC-1-BM-1 is presented in Table 5.7.

Table 5.7. Risk analysis of HLUC-2-PUC-1-BM-1.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Change of legislation	2	5	10	Participate in national and European decision-making tables
Life/ quality of battery system	2	3	6	To include warranty in purchasing ESS; market research for tested products
Long black outs of the DSO grid (extreme weather)	1 3 (control)	5	5 12	Improve the resilience of the grid

5.3.1.5 *Profitability calculations – the business case*

An economical simulation (discounted cash flow) has been carried out from the point of view of the prosumer, who has invested in an ESS.
The input data have been taken from the residential test site. The cost of the ESS, the feed in tariffs, and the cost of the energy are taken from the real case. As revenue, only the maximization of the self-consumption has been considered but not the peak shaving effect, because presently the regulation of the inverter does not allow peak shaving. The necessary investment in a ESS for the residential use case is show in Figure 12.

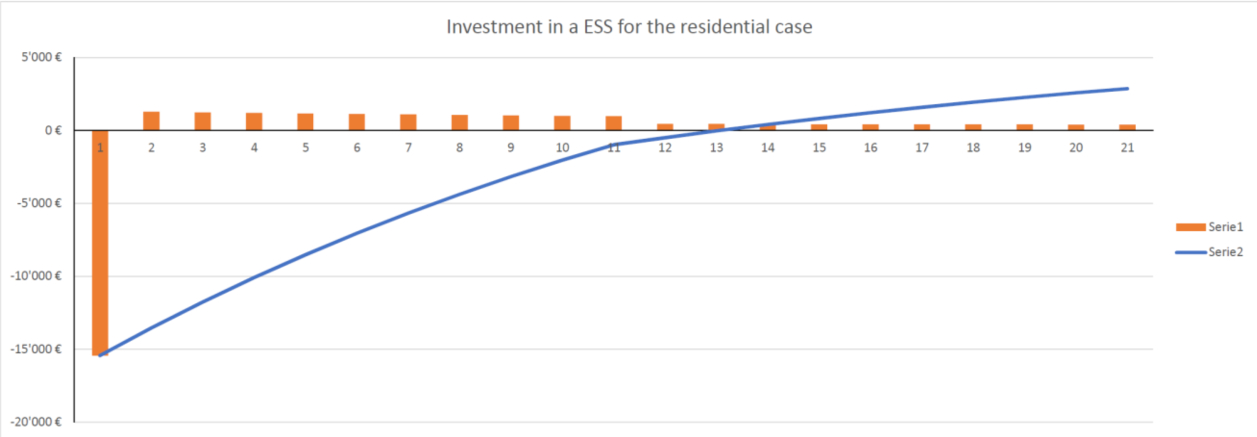

Figure 12. The discounted cash flow (Serie 1) and the cumulated discounted cash flow (Serie 2).

The principal outputs of the simulation are:

- The Pay Back Time is 13 years
- The Internal Rate of Return is 4.13 %
- The Net Present Value is 2800 €

5.3.1.6 *Conclusions of HLUC-2-PUC-1-BM-2*

Looking at the outputs of the previous sections, it is clear that the use of ESS in the residential sector is still far from being profitable with the actual conditions (costs and storage system lifetime, Italian regulatory framework). Other business models should be explored: one of them is business model HLUC-2-PUC-1-BM-2 described in section 5.3.2; other potential business models will be presented in the next deliverable D2.4 – "Final S4G Business Models".

5.3.2 Business model HLUC-2-PUC-1-BM-2: Prosumer with grid integration

The business rationale is that it is possible to make a business for prosumers by providing ancillary services to the DSO by installing batteries in addition to the benefits obtained by the BM-1 (maximizing the self-consumption and peak shaving). In this case, private house owners or other investors are encouraged to install batteries in connection to local PV production and EV charging.
This way, the prosumer can offer a sustainable solution to the DSO, whereby the prosumer gets as much out of his investment and increase his private business case and the DSO avoids or postpones grid strengthening. In this scenario, it is considered that the DSO has the possibility to control the battery management system (BMS) of the prosumer and to coordinate ESS and EV charging. The DSO's business model is:

- To avoid or defer investments in traditional grid strengthening;
- To enhance the voltage quality without other investments;
- To keep the system balanced – without curtailment of RES.

5.3.2.1 *Preconditions for the business model*

Private costumers have invested in RES such as PV systems, which in certain circumstances increase the voltage level and affect the flux creating reverse energy flow in local feeder lines.
The same private customers use one or more EVs, with a charging station at home, which requests a higher contractual power with the DSO.
Investment in storage solutions must be more economically beneficial for the prosumer than to inject the overproduction of electricity into the grid. In addition to this benefit, it is possible for the prosumer to sell ancillary services to the DSO.
The prosumer gives the possibility to the DSO to control the BMS, and receives for this an economical benefit. The ESS must be controlled in such a way that the DSO needs have priority over the prosumer needs.

5.3.2.2 *Stakeholder analysis*

The stakeholder analysis for HLUC-2-PUC-1-BM-2 is presented in Table 5.8.

Table 5.8. Stakeholder analysis of HLUC-2-PUC-1-BM-2.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Prosumer with EV	Investor	Invests in storage and offers ancillary services to the DSO	Gives to the DSO the possibility to control the BMS	Information
DSO	Balance Compliance Grid stability	Grid-owner, monopole	Taking new business models into account, and buying ancillary services	None

5.3.2.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 5.9.

Table 5.9. SWOT analysis of HLUC-2-PUC-1-BM-2 (DSO perspective).

Strength	Weaknesses
• Easy to establish • Autonomous • No investment for the DSO	• Reliability of the storage is not guaranteed • The DSO has to control a high number of little storages (complexity)
Opportunities	**Threats**
• Possibility to find new business models for the DSO	• Necessity to use external signal • Need of a communication infrastructure Data security

The SWOT analysis from the prosumer perspective is show in Table 5.10.

Table 5.10. SWOT analysis of HLUC-2-PUC-1-BM-2 (prosumer perspective).

Strength	Weaknesses
• Autonomy	• The prosumer makes an investment, but it's controlled by an external (DSO) • The prosumer assumes the business risk • Less autonomy than BM-1
Opportunities	**Threats**
• Possibility to find new business models for the Prosumer	• Time for return of investment is very long and in the meantime external conditions (legal, economical…) could change

5.3.2.4 *Risk analysis*

The risk analysis of HLUC-2-PUC-1-BM-2 is presented in Table 5.11.

Table 5.11. Risk analysis of HLUC-2-PUC-1-BM-2.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Change of legislation	2	5	10	Participate in national and European decision-making tables
Life/quality of battery system	2	3	6	To include warranty in purchasing ESS; market research for tested products
The DSO is no more interested in buying ancillary services	1	5	5	To make long terms contracts with the DSO

5.3.2.5 *The Business Model Canvas*

The Business Model Canvas of HLUC-2-PUC-1-BM-2 is show in Table 5.12.

Table 5.12. Business Model Canvas of HLUC-2-PUC-1-BM-2.

Prosumer with grid integration				
Key Partners Energy Storage suppliers Installers ICT <u>Value chain network:</u> DSO Prosumers	**Key Activities** Investigating claims from prosumers (or other customers with voltage issues) Selling batteries Setting set-points at local owned batteries **Key Resources** Salespeople Grid-Planning people Grid-operation people	**Value Proposition** <u>Why:</u> Stable grid at lowest cost <u>What:</u> Using private storage to manage demands in voltage without reinforcing the grid <u>How:</u> Charge/discharge on demand controlled by the DSO	**Customer Relationship** Customers are encouraged to become "partners", cooperative prosumers **Channels** Personal sale BtC	**Customer Segments** Prosumers or small SME
Cost Structure Payment for ancillary services Operation cost		**Revenue Streams** Postponed reinforcement		

5.3.2.6 *Conclusions of HLUC-2-PUC-1-BM-2*

This business model appears to be more economically attractive from the point of view of the prosumer, because it allows a multiple use of the batteries, that in addition to maximizing the self-consumption and reducing the contractual power can provide ancillary grid services and thus have an additional revenue.
No detailed profitability calculations have been made so far as it is difficult, at the moment, to estimate the value of the above mentioned additional revenues.
This business case will be relevant to defer reinforcement for the DSO, but it is foreseen a big risk in having third party owned storage to secure grid stability.

5.4 Related use case: Cooperative charging in the parking lot of a commercial test site, HLUC-2-PUC-2

Installation at the prosumer parking lot of ESS (with components USM, DSF and GUI) after the POD at customer level, for PV energy storage to avoid a rise of the available power needed at his POD.
For clarity is important to remember that a complete ESS is governed by a Decision Support Framework (DSF) tool suitable to analyse, monitor and control (LV) grid scenarios. Figure 13 shows the typical S4G system architecture.

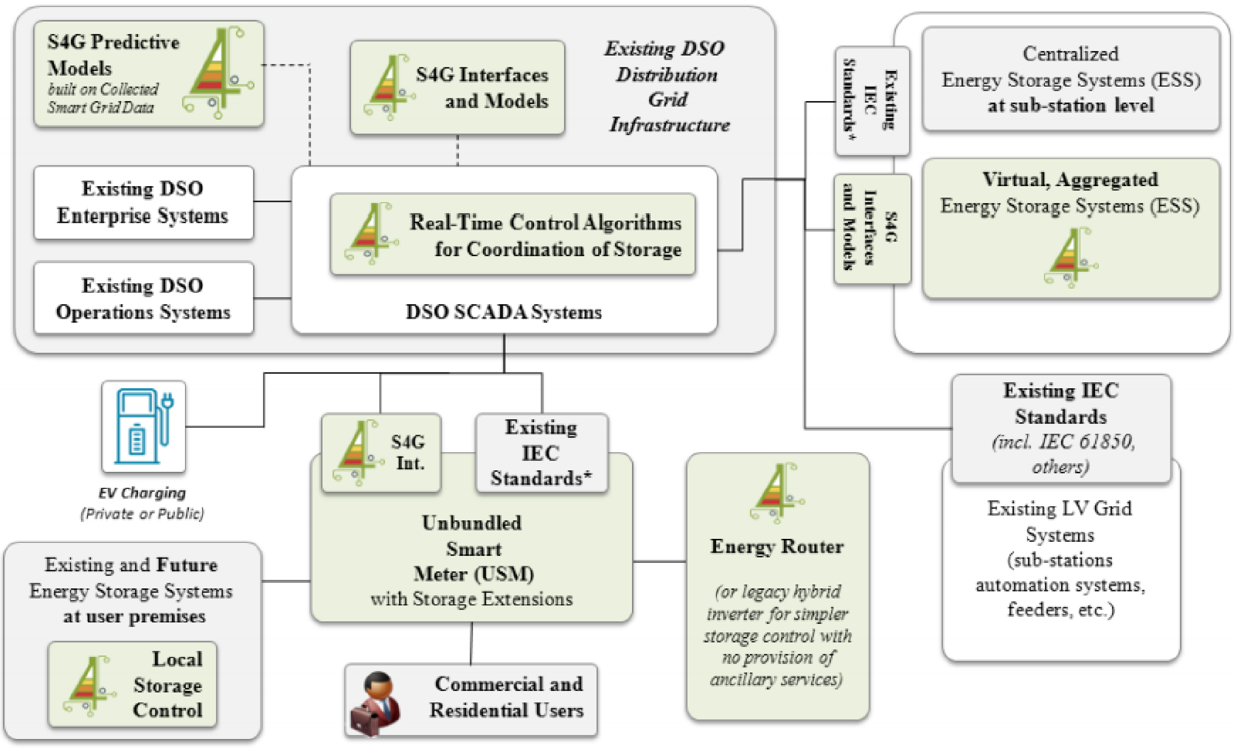

Figure 13. S4G system architecture.

5.4.1 Business model HLUC-2-PUC-2-BM-1: Cooperative Charging at Commercial or Fleet level

This business model will investigate if it is profitable for a commercial site (or a Company Fleet site) with some EV charging stations to invest money in an ESS with or without a PV plant. The commercial site has the following advantages by adopting an ESS:

- Can store the surplus of local energy (eventually produced by the PV plant) and use it for charging EVs in the evening or in other high load moments, thus maximizing the self-consumption of the PV production.
- Avoids the upgrade of the contractual maximum power at the POD, due to the peak shaving effect of the ESS.
- The commercial site avoids important modification of internal electrical plant (installation of transformer cabin).
- The DSO avoids strengthening the grid.

Only this business model is analysed, where no active role of DSO is considered, which leads to general conclusions valid for commercial sites willing to do the investment itself internally or for provider aiming to offer a new service to customers (commercial sites or companies having fleet of EVs).

5.4.2 Preconditions for the business model

The commercial site has invested in RES such as PV systems, which in certain circumstances increase the voltage level and affect the flux and creates reverse energy flow in the feeder lines of the local DSO. The same commercial site has or accept many EVs with charging stations, which requests a higher contractual power with the DSO. A high number of EV charging stations is a potential threat for the distribution network because of the relative high request on power. The preconditions for this business model are:

- Investment in storage solutions must be more economically beneficial for the commercial site than to inject the overproduction of electricity into the grid;
- The ESS can be controlled in such a way, that peaks of requested power over contractual conditions with DSO for EV charging can be managed.

The business rationale is that it is possible to make a business for the commercial site by installing ESS for maximizing the consumption of self-produced energy and for minimizing the maximal power of the grid connection (peak shaving). If this statement is confirmed, private commercial sites owners or other investors are encouraged to install batteries in connection to local PV production and/or EV charging.

This way the commercial site can offer a sustainable solution to the DSO, whereby the commercial site gets as much out of his investment in the PV system and increase his private business case, and the DSO avoids or postpones grid strengthening.

This business model does not take in account the possibility to offer ancillary services to the DSO, but the DSOs can indirectly benefit from the installation of ESS in terms of enhanced voltage quality and defer investments in traditional grid reinforcements.

The whole electrical system can benefit of ESS in terms of production – load balancing.

5.4.3 Stakeholder analysis

The stakeholder analysis for HLUC-2-PUC-2-BM-1 is presented in Table 5.13.

Table 5.13. Stakeholder analysis of HLUC-2-PUC-2-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
Commercial site with internal or accepting external EVs	Investor	Needs to optimize consumption and available connection power	Invest in storage and PV	information
DSO	Balance Compliance	Grid-owner, monopoly		None

5.4.4 SWOT analysis

The SWOT analysis from the DSO perspective is show in Table 5.14.

Table 5.14. SWOT analysis of HLUC-2-PUC-2-BM-1 (DSO perspective).

Strength	Weaknesses
• Easy to establish • Autonomous • No investment for the DSO	• At the moment in Italy not very convenient due the possibility to use the grid as storage with the exchange on site • Still too expensive at the moment (in some regions in Italy there are public incentives) Still too expensive at the moment (even if in some regions in Italy there are public incentives) • To find trade off with the alternative of reinforcing internal electrical distribution (change transformer, increase power)

Opportunities	Threats
• In the future, maybe economically interesting • If the EV market will expand, it will be necessary to have peak shaving of power needed for charging EVs • If the PV market will expand, it will be necessary to avoid load peaks in the evening hours • Increasing the solar penetration can lead the system operator to curtail solar to balance the grid during peak hours • Does not require electrical and civil modifications	• There is no possibility to control from the DSO point of view

5.4.5 Risk analysis

The risk analysis of HLUC-2-PUC-2-BM-1 is presented in Table 5.15Table 5.11.

Table 5.15. Risk analysis of HLUC-2-PUC-2-BM-1.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Change of legislation	2	3	6	Participate in national and European decision-making tables
Life/quality of battery system	2	5	10	To include warranty in purchasing ESS; market research for tested products
Long black outs of the DSO grid (extreme weather)	1	1	1	Verify possibility of backup DSO connection lines before investing
Need for more charging stations	2	5	10	Reduce power available pro charger (speed of charge)

5.4.6 Profitability calculations – the business case

A model able to take in account every possible variable should be implemented:

- Identification of variables (number of EVs, PV parameters, energy incentives)
- Estimation of investment cost for normal internal grid potentiation (Transformer change, lines etc.)

- Estimation of costs for increase in contractual power
- Estimation of costs for DSO grid potentiation
- Estimation of investment costs for Storage arrangement

Then the definition of break-even point of the investment can lead to rentability evaluation for possible investors.

5.4.7 Conclusions of HLUC-2-PUC-2-BM-1

This business model appears to be more economically attractive from the point of view of the commercial site, because it allows multiple use of the ESS, that in addition to maximizing the self-consumption and reducing the contractual power can provide grid services and thus have an additional revenue.
No detailed profitability calculations have been made so far as it is difficult, at the moment, to estimate the value of the above mentioned additional revenues.
This business case will be relevant to defer reinforcement for the DSO.
The rentability analysis is general, so it can be both used by commercial sites willing to invest internally or by an external provider aiming to offer the complete service to third parts.

5.5 Related use case: Simulation of high penetration of EV chargers and of prosumers with storage and residential EV charging, HLUC-2-PUC-3

With respect to a future scenario with higher EV penetration, the DSF will simulate the maximum possible amount of EVs and charging stations which can be supported by the existing grid (without additional grid strengthening). The outcomes will show the potential and limits of storage and cooperative charging in today's grid topology. For this use case, the business model has not been elaborated further in this initial deliverable as not enough data are available at this stage. These business models will be elaborated in the next deliverable D2.4 – "Final S4G Business Models".

5.6 Conclusion business models in Bolzano HLUC-2

Five business models have been developed both for the residential and the commercial test sites.
HLUC-2-PUC-1-BM-1 is the baseline for all other business calculations and shows that the use of ESS in the residential sector is still far from being profitable with the actual conditions (costs and lifetime of the storage system, Italian regulatory framework).
Looking at the outputs of this initial study on possible business models for Bolzano, it is clear that to be economically attractive from the point of view of the commercial and residential sites, a multiple use of the ESS is required, that in addition to maximizing the self-consumption and reducing the contractual power can provide grid services and thus have an additional revenue.
All the presented Business Models will be analysed in more detail in the next deliverable D2.4 – "Final S4G Business Models" and a few more will most likely be developed.

6 Initial Business models in Fur HLUC-3

This chapter will elaborate the Danish business cases related to use cases presented in D2.1 [D2.1]. Business models are elaborated at different levels depending on how close they are estimated to be to the market and the possibility to implement them in the test site.

6.1 Background and expected impact

As society is focusing on becoming more environmentally friendly and zero CO_2 emitting, the DSOs will experience an added pressure on their grid both on MV and LV grid. Basically, there are two topics that will influence the DSOs in the future: more DER production from RES installed, and added consumption of electric energy as heating and transport are shifted from fossil fuels towards electricity.

Decentralized production in the LV grid in the form of PV and small wind generators gives a new energy flow. In the past, the energy flow was always top down as the energy was generated in big power plants in the HV grid and then distributed to the consumers at the LV 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 LV grid towards the higher voltage levels, causing grid loss. Besides the necessary transformation from DC produced by the RES to AC used in the HV 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, thereby trimming is a manual task as one person must go to the transformer.

The added amount of 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 EVs, 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 increase the lower voltage in the grid, less reliable supply of electricity and more grid loss.

Same situation, but reversed, will be present when DER are producing more than the consumption is in the local grid and a unintended rise in voltage occurs, leading to grid loss and low electricity quality for the consumer, besides lower prices on selling former stored energy.

The normal way of coping with the above two problems from the DSO side will be grid strengthening by installing more and bigger cables and transformers. However, installing some kind of remote controlled storage in the grid might help avoiding these situations and thereby avoid grid strengthening. Expected impact by installing storage is a more economical and technical business.

6.1.1 PESTLE analysis

The PESTLE analysis has been carried out. Results of the PESTLE analysis are show in Table 6.1.

Table 6.1. PESTLE analysis of HLUC-3 business models.

	Factor	Opportunity	Threat
Political	Change in energy policy: energy production and consumption is controlled by grid tariffs, taxes and feed-in tariffs	Information about the best solutions for customers and DSOs	The policy can change overnight and make good investments bad
Economical	There is a stable minor boom in the Danish Economy, which means that residents have greater financial flexibility, besides low unemployment.	Residential have the possibility to buy more RES and EV's or Hydrogen cars (depending on policy about taxes and others)	Growth in the Danish Economy can stagnate and unemployment can increase
Socio-Cultural	The average age is increasing and an urbanization takes place. (22% in DK lives in the cities)	More PV systems with storage to be more self-consuming. In most cities, there are district heating – so less heat pumps	More grid problems, due to more installations at feeder lines and more PV-systems at the same feeder lines.
Technological	More effective storage and PV systems may cause an increasing market	More local production and less distribution from big power plants meaning less grid loss	Local production must be consumed locally to avoid grid loss. Imbalances in the grid.
Legal	The energy market is very hard regulated in Denmark, more than 70% of the energy bill is taxes and fixed prices	Gives a good incentive to be self-sufficient	Less revenue to the DSO, because of self-supply
Environmental	The target is to be fossil free in 2050. The initiatives go through positive business models	Lots of opportunities but very dependent on policy and taxes	The short-term business model is not yet positive

The results from the PESTLE analysis is further elaborated in the SWOT analysis.

6.1.2 Business rationale

The business rationale is that it is possible to make a business out of controlling batteries both for the owner and the DSO. Private house owners or other investors are encouraged to install batteries in connection to local PV production. The storage system may be controlled by an external aggregator, who makes contracts with the DSO and the PV owner, and/or an investor. This way the battery owner can offer a sustainable solution to the DSO, whereby the PV owner gets more out of their investment in the PV-system and increase their private business case and the DSO avoids grid strengthening. The PV owner thereby get the possibility to offer ancillary services to the DSO as a solution to:

- Overcome voltage problems by managing household load and PV production with storage system
- Increase shortcut capacity in the grid with storage system (increasing robustness of grid)
- Increase both own-production and self-consumption and thereby lowering the grid losses
- And/or at grid side instead of reinforcing the local feeder lines to decrease maintenance cost or defer reinforcement.

6.1.3 Actors, assumptions and actors' goals

The Actor analysis - HLUC-3 is show in Table 6.2.

Table 6.2. Main actors, assumptions, and goals.

Actor	Type	Role	Assumption	Actors goal
DSO	Company	Balance Compliance	Issues with voltage level at local feeder line Demand local voltage regulation Demand local balancing aggregates	Lower maintenance cost, and reduce and/or defer reinforcement
Prosumer	Private person	Prosumer Private house owner, who has invested in PV system	Offer ancillary services as demand side management, and/or curtailment in power injection (regulatory)	Better business case, higher self-supply
Prosumer and battery owner	Private person	Private house owner, who has invested in storage system placed at his private house, connected to the PV-system and the grid	Offer ancillary services with storage, being able to control voltage and autonomous peak shaving	Better business case, higher self-supply
Battery Owner/ Investor	Company	Investor, who has invested in storage system placed at a private house and connected to a private PV system and the grid	Offer ancillary services with storage, being able to control voltage and peak shaving / network controlled demand side management	Positive business case, new business
Consumer	Private person	Customer with a battery	Offer network controlled ancillary services	Consumer will have business case for demand side management
Aggregator	Company	Service provider who makes contract between the battery owner and the DSO	Offer ancillary services with storage, being able to control voltage and peak shaving /	Positive business case, new business

		about specific services and comfort levels.	network controlled demand side management	

6.2 Overview of use cases and related business cases for the Fur test site (year 1):

Table 6.3 gives a more detailed overview of the different business models and some key notes.

Table 6.3. Overview of key notes for business models related to HLUC-3.

Business Model ID	Title	Key Pains targeted	Value Proposition	Target market	Time horizon
HLUC-3-PUC-1-BM-1	Baseline	State of the art	-	-	-
HLUC-3-PUC-3-BM-1	Voltage control at grid side battery	High voltage levels due to PV penetration	The DSO can easily be compliant in voltage	DSOs	Medium
HLUC-3-PUC-4-BM-1	"Autonomous" voltage control at household battery	Grid stability, security in supply	Stable grid at lowest cost	Private houses with batteries	Short
HLUC-3-PUC-4-BM-2	Voltage control at both household and grid side battery and Energy Flux control at grid side battery	Grid stability, security in supply. Much more production than consumption in local feeder lines	Stable grid at lowest cost	Private house owners and DSO	Medium
HLUC-3-PUC-4-BM-3	Flux control and load shaving at households with PV and battery	Grid stability, security in supply	Stable grid at lowest cost	Private houses with batteries	Medium
HLUC-3-PUC-4-BM-4	Flux control at household battery by introducing network controlled demand side management	Grid stability, security in supply	Stable grid at lowest cost	Private houses with RES	Long
HLUC-3-PUC-4-BM-5	Privately owned virtual storage plant	Grid stability, security in supply Self sufficiency	Stable grid at lowest cost	Private houses with RES	Long

Figure 14 gives an overview of use cases and related business models.

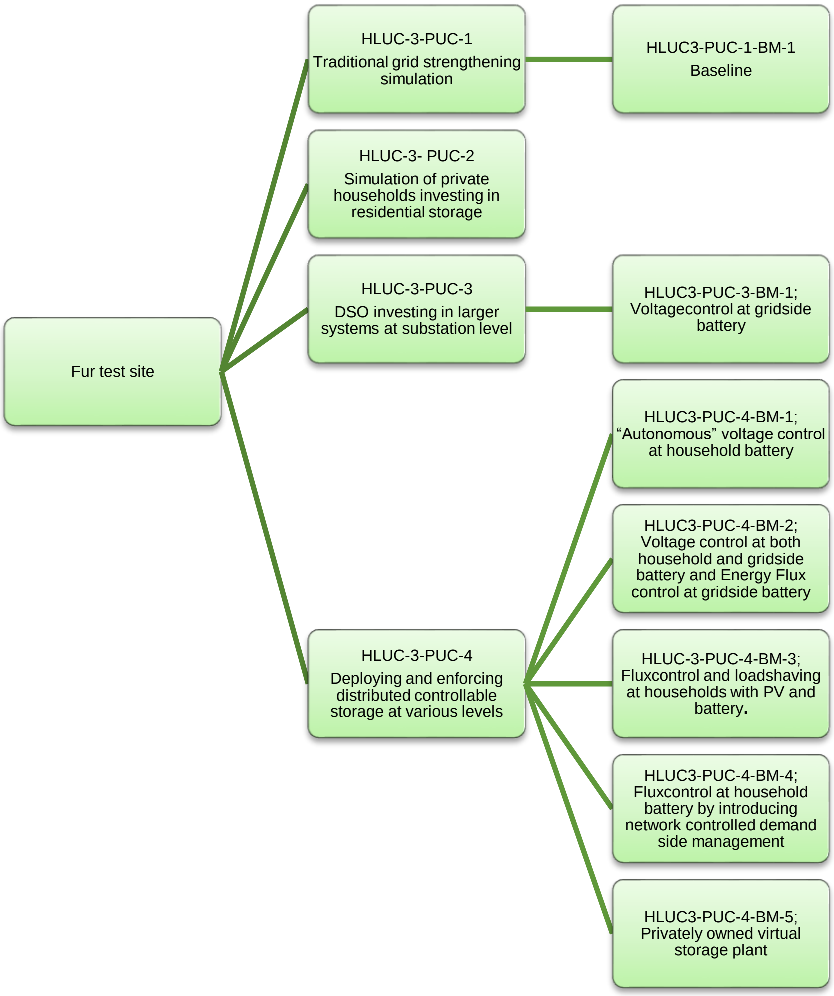

Figure 14. Overview of use cases and related business case for the Fur test site.

6.3 Related use case: Traditional grid strengthening simulation, HLUC-3-PUC-1

This use case elaborates the daily operation, when grid strengthening is needed. This use case is the baseline for the other use cases in the Danish context and the Fur test site. Simulation of the baseline will run and interactions with customers are only necessary if there is the need to rent more land for transformers or if the cables need to be replaced.

6.3.1 Business model HLUC-3-PUC-1-BM-1; Baseline

This business model calculates the cost of traditional strengthening of the grid, when more PV-systems are installed in local feeder lines.

6.3.1.1 *Preconditions for the business model*

Private house owners have invested in local PV production, this causes increasing voltage in local feeder lines. Which also can cause capacity issues, due to higher production compared to local consumption, this means export of electricity through the transformer representing additional grid loss. Traditionally cables are dimensioned for consumption and not for production.
The baseline is very dependent on the current topology. An overlooked of all transformer stations and feeder lines at the island of Fur were made to find feeder lines with a large penetration of PV-systems. The selected

feeder line (purple) is shown in Figure 15, where the penetration is 23.73% (kWp PV divided by size of transformer). This is a pretty high penetration for a feeder line in Denmark.

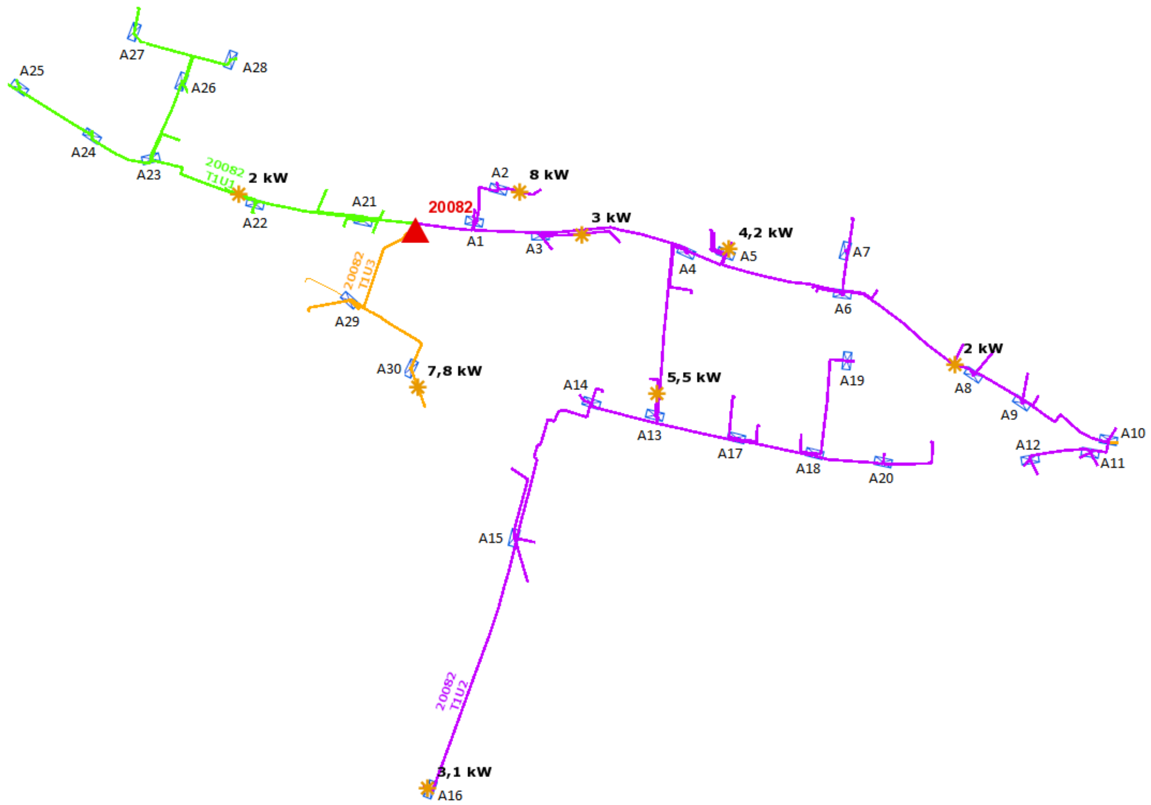

Figure 15. Current topology in the Fur island.

This feeder line was stressed until grid strengthening is needed to create a feasible case for this baseline scenario. PV penetration is 23.73% today (35.6 kWp/150 kVA), this we increase more and more, see the results in Table 6.4

Table 6.4. Different scenarios of HLUC-3-PUC-1-BM-1.

PV penetration	PV power	PV power/consumer	Problems
24%	36 kWp	1.24 kWp	
64%	96 kWp	3.31 kWp	ΔU
74%	111 kWp	3.83 kWp	ΔU
84%	126 kWp	4.34 kWp	ΔU
94%	141 kWp	4.86 kWp	ΔU
100%	150 kWp	5.17 kWp	ΔU

Note! U = ΔVoltage rises caused by PV production is too high. The dimension case will be on a sunny day with typical consumption in private houses. In the selected case, it was discovered that there must be flicker problems at the end of the feeder line, but no claims were received from customers. To dimension the new cases, it was chosen to use the feeder line as-is and have not strengthened it to today demands. The assumption is, that the DSO might have more feeder lines as this one, which needs to be evaluate in the future.

In each test case, it was calculated the necessary grid strengthening and related cost. These calculations are a static calculation with predesigned consumption and PV profiles. The calculations are made in the program NETPRO[xxix], developed by Danish Energy Association.

6.3.1.2 *Profitability calculations – the business case*

When the grid strengthening is necessary, it is calculated the necessary cost for traditional grid strengthening. The calculation includes cables, digging, connection equipment, such as cable boxes. The calculation is excluding project design, management and documentation, since this will be similar as with battery calculations.
The results are indicated in Table 6.5.

Table 6.5. Profitability calculations of HLUC-3-PUC-1-BM-1.

PV penetration	PV power	PV power/consumer	Strengthening cost
24 % - flicker	36 kWp	1.24 kWp	27.300 €
64 %	96 kWp	3.31 kWp	9.850 €
74 %	111 kWp	3.83 kWp	21.000 €
84 %	126 kWp	4.34 kWp	41.600 €
94 %	141 kWp	4.86 kWp	43.100 €
100 %	150 kWp	5.17 kWp	47.500 €

In the very high penetration cases, the DSO might install a new transformer instead of traditional grid strengthening, but this has not been taken in account at this stage.

6.3.1.3 *Conclusions of HLUC-3-PUC-1-BM-1*

Interesting findings are that if the grid was strengthened up till todays standard (24% flicker), the grid would be capable of consuming around 74% PV penetration without additional cost (places to strengthen the grid are almost the same for both flicker and PV penetration).
Another finding is that it is not very costly to strengthen the grid until is reached 84% of PV penetration, when more cables needs to be strengthened, which includes more cable boxes and other equipment.
In 2016 the average size of PV systems at households in Denmark was 4.33 kWp. The average is that 3.5% of all houses have PV systems (not the same as penetration according to transformer size).

6.4 Related use case: Simulation of private households investing in residential storage, HLUC-3-PUC-2

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

This use case affects the grid in a positive way most of the time, see Figure 16, but could be optimized from a grid/DSO perspective. This leads to HLUC-3-PUC-4.

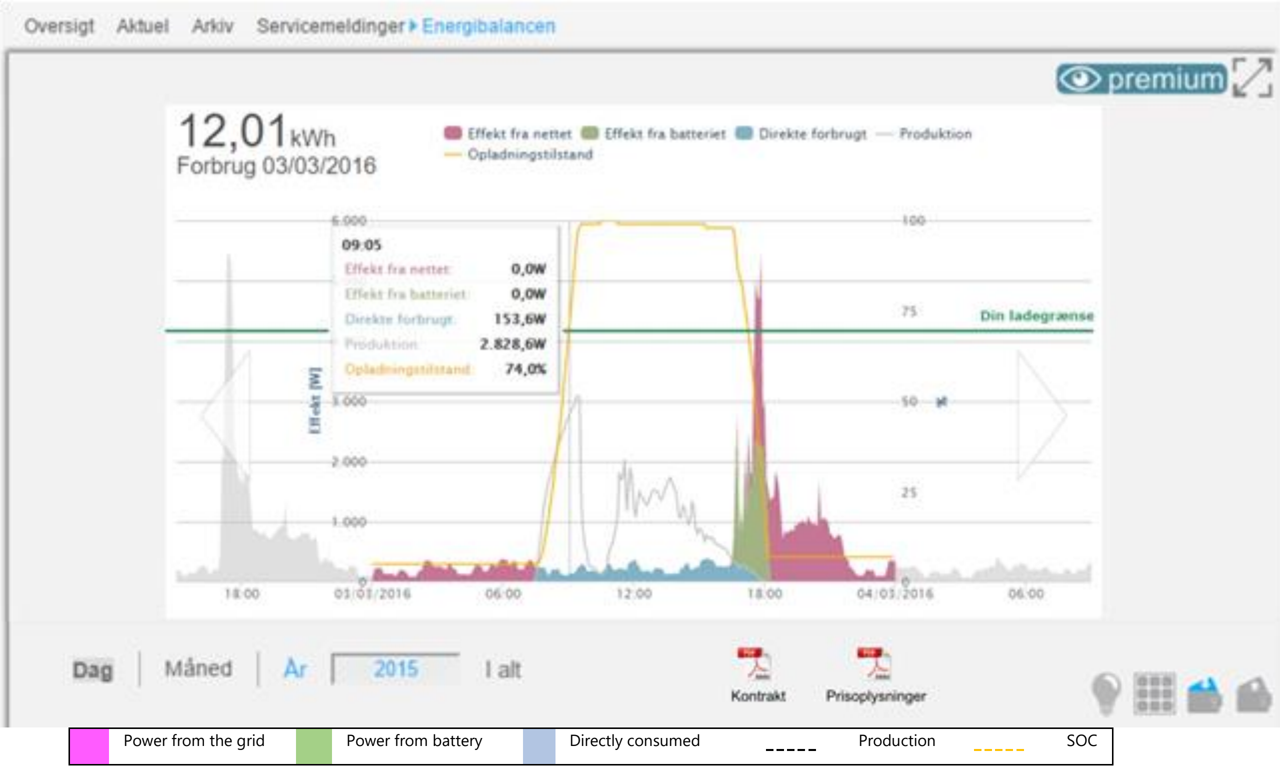

Figure 16. Typical PV battery house consumption/production/SOC curve.

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

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

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

6.5 Related use case: DSO investing in larger systems at substation level, HLUC-3-PUC-3

This use case investigates if the battery systems can be placed in the LV grid and its ideal location. Due to either high local consumption or production it may be feasible to place storage at local feeder lines to overcome increasing or decreasing voltage levels and/or to control the flux, especially upwards flow in the grid. The optimal position of where to place the storage to gain the most positive effect will be addressed in this use case, taking consumption and production into account, as well as lifetime and operational cost. The owner and operator of the battery will be Eniig (as a preliminary assumption) which allows for enhanced storage coordination all over the grid with respect to the current grid situation, generation, and consumption.

6.5.1 Business model HLUC-3-PUC-3-BM-1; Voltage control at grid side battery.

High local production may cause higher voltage levels locally, which can be eliminated by increasing consumption from batteries or other consecutive consumption.

6.5.1.1 *Preconditions for the business model*

For the business model to be sustainable, the following preconditions have been identified:

- Private costumers have invested in RES such as PV systems, which increase the voltage level and affects the flux and create reverse energy flow in local feeder lines.
- Investment in storage solutions must be more economically beneficial than traditional investments (i.e. capacity reinforcement of the distribution grid and cable installations).
- It is allowed for the DSO to own and use the battery as a technical solution for grid stability.

6.5.1.2 *Stakeholder analysis*

The Stakeholder analysis is show in Table 6.6.

Table 6.6. Stakeholder analysis of HLUC-3-PUC-3-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
DSO	Balance Compliance	Grid-owner, monopole	Raises the demand Invests in storage	None
Private house owner	Creates the voltage problem	Delivers high voltage into the grid	Higher self-consumption on critical days e.g. Storage, heat-pumps or EVs	None (no legal regulation in this field) / Information about behaviour change

Another business case could investigate whether information and change of behaviour would have effect on private house owner to change behaviour or invest in new consumables (see more in HLUC-3-PUC4).

6.5.1.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 6.7.

Table 6.7. SWOT analysis of HLUC-3-PUC-3-BM-1 (DSO perspective).

Strength	Weaknesses
• DSO control of the storage system	• Lifetime of battery is shorter than traditional grid strengthening • Maintenance costs
Opportunities	**Threats**

• Flexible service, which can be moved around in the grid depending on the need. • Defer reinforcement of the grid	• More units to be controlled in the grid • Data security

A huge advantage of the DSO owned storage is that the DSO is independent of third party owned storage, which causes a big risk. The DSO must be able to rely on the storage 24/7/365. Threats is that implementing storage creates more units to control in the SCADA centre, even if it is expected that the storage is self-controlled. Another threat is data security. When creating more data communication lines, the risk for hacking or breaking down will increase. This is outlined in the risk analysis.

6.5.1.4 *Risk analysis*

The Risk analysis from the DSO perspective is show in Table 6.8.

Table 6.8. Risk analysis of HLUC-3-PUC-3-BM-1.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
More units in the grid to be controlled	3	4	12	Set-up processes as for other units
ICT solution instead of physical solution Software can fail Hardware (cables) can be damaged	2	4	8	Regular control
Data security	1 (read-only) 3 (control)	4	4 12	Regular security control

Storage installation increases the risks in the grid, compared with traditional grid strengthening. Although, this is an innovative economical way of controlling the grid.

6.5.1.5 *Conclusions of HLUC-3-PUC-3-BM-1*

It seems as a feasible solution for the DSO to invest and control grid side storage, in this way the DSO still have control of the grid state. The baseline calculation (HLUC-1-PUC-1) shows that storage must be cheap before the business case is positive, since grid strengthening is not that costly.

The former project GreenCom and participating islanders from Fur also participates in the ERA-Net Smart Grids Plus project MATCH[xxxi] (Markets – Actors – Technologies: A comparative study of smart grid solutions). The MATCH project analyses among others small consumers' involvement in smart island energy systems with a focus on technical feasibility of PV systems in combination with batteries.

Results indicate a tendency towards aggregated batteries being more favourable from a systems perspective, while on the other hand, individual batteries are more motivating and involving the consumers. The importance of minimizing flows to and from the grid as a result from fluctuating energy sources are addressed in both approaches. While individual batteries improve the individual household electricity supply, an aggregated battery would further regulate other inputs and demands[xxxii].

6.6 Related use case: Deploying and enforcing distributed controllable storage at various levels, HLUC-3-PUC-4

Installation of storage systems at different levels in the grid are considered by the DSO as a potentially interesting solution to help improving self-consumption, increase grid flexibility and deferring grid reinforcement. Such systems must be controlled externally to achieve adaptation to current grid conditions; achieving coordinated behaviour e.g. to exploit synergies arising between houses connected to the same radial and/or with storage at substation level; devising evaluation techniques to properly evaluate and dimension storage investments given specific user settings or load patterns. The use case; "Operation in private households, access to local GUI" HLUC-3-PUC-5 is also related to this business model. This use case gives information and control facilities to the house-owner about state of privately owned battery.

The S4G simulation engine is used to model the situation of the grid when private storage and the storage on grid level is jointly operated and coordinated. In this situation, also ancillary services will be taken into consideration, depending on the regulatory environment.

6.6.1 Business model HLUC-3-PUC-4-BM-1; "Autonomous" voltage control at household battery

The case is that one feeder is filled with PV penetration and that one (some) customer experiences instability electricity in their house. After investigating the problem, the DSO offers the prosumer to buy a battery and have automatic voltage control within defined limits controlled by the DSO. For this service, the DSO offers a limited payment to the prosumer. The DSO avoid reinforcing the grid or defer the reinforcement. The autonomous business model is to be understood as there is no necessity for external control. The battery controls the voltage level itself within some defined limits, with no external signals exchanged with the BMS The BMS monitors the local voltage level and regulates the level inside the demands. The BMS system does not interact with any external systems or cloud solutions.
The Prosumer gets access to a local GUI (Extended Solarweb[xxxiii]), where they can be informed about state of battery, state of charge, consumption, production etc.
The business case for the house owner must balance revenue from ancillary services and feed-in tariffs. In the other hand the business case must balance the DSO reinforcing cost, and expenses on ancillary services and related operational cost.

6.6.1.1 *Preconditions for the business model*

For the business model to be sustainable, the following preconditions have been identified:

- The DSO receives more claims from customers at specific feeder lines because of increased voltage levels from time to time. Specific feeders are filled with PV systems, which in specific hours increases the voltage, especially in hours with low local consumption.
- The DSO role is extended in the model by offering storage to prosumers. This is counter to legislation in some Member States, where the DSOs are facing a diminishing role in which the relation to customers is limited; the DSO being only responsible for the meter readings and distribution. This model, however, suggests a DSO role with new opportunities for smart grid engagement with customers.
- PV production sold to the grid is not in every country favourable: tariffs for selling energy to the grid are low and schemes restrict your usage (i.e. it has to be consumed what it was produced within the hour /real-time, the rest is sold (or given for free) to the grid) and a general high cost of electricity (especially distribution costs and taxes) thereby incentivising the prosumer to invest in storage.
- If the DSO shall choose this solution they must be able to trust the solution at any time, else the DSO cannot rely on this solution, therefore the prosumer has no rights to overrule DSO set-points. If the DSO cannot rely on the prosumers, they may still have voltage issues and the need of reinforcing the grid.
- Ancillary services have become common in the DSO grid

- The DSO has the possibility to limit PV injection due to high voltage issues in the grid.

6.6.1.2 *Stakeholder analysis*

The Stakeholder analysis is show in Table 6.9.

Table 6.9. Stakeholder analysis of HLUC-3-PUC-4-BM-1.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
DSO	Compliance and grid stability	Local demand and regulation	Taking new business models into account and buying ancillary services in the distribution grid Offering storage to residential	None
Residential	Causing the voltage problem by owning local production	Investing in storage and be part of balancing the grid locally	By owning storage and allow the DSO to control it, the residential is part of the solution	Information about the need for the DSO Presenting a positive business model for the residential

6.6.1.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 6.10.

Table 6.10. SWOT analysis of HLUC-3-PUC-4-BM-1 (DSO perspective).

Strength	Weaknesses
• Easy to establish • No daily operation • Automatic • Cheap	• Is the impact high enough? • Will people buy storage systems?
Opportunities	**Threats**
• Easy to test impact	• Can the DSO rely on this solution in the long term? • The DSO will not have the possibility to limit PV-injection (as-is) • Third party owned equipment to secure grid stability and be compliant.

6.6.1.4 *Risk analysis*

The Risk analysis from the DSO perspective is show in Table 6.11.

Table 6.11. Risk analysis of HLUC-3-PUC-4-BM-1.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Risk having third party controlled and owned equipment to secure compliance	5	5	25	Making contracts with storage owners/legislation change
Enough storage flexibility	5	5	25	Invest in grid site storage

This risk in the grid increase with the storage installation, compared with grid strengthening. Although, this is an innovative economical way of controlling the grid.

6.6.1.5 *Profitability calculations – the business case*

The economic business case will be presented in D2.4 – "Final S4G business models".

6.6.1.6 *The Business Model Canvas*

The Business Model Canvas of HLUC-3-PUC-4-BM-1 is show in Table 6.12.

Table 6.12. The Business Model Canvas of HLUC-3-PUC-4-BM-1.

<table>
<tr><th colspan="5">"Autonomous" voltage control at household battery</th></tr>
<tr>
<td rowspan="2">Key Partners
Energy Storage Suppliers
Installers
ICT

<u>Value chain network:</u>
DSO
Prosumers</td>
<td>Key Activities
Investigating claims from prosumers (or other customers with voltage issues)
Selling batteries
Setting set-points at local owned batteries</td>
<td rowspan="2">Value Proposition
<u>Why:</u> Stable grid at lowest cost

<u>What:</u>
Using private storage to manage demands in voltage without reinforcing the grid

<u>How:</u>
Charge/discharge on demand controlled by the DSO</td>
<td>Customer Relationship
Customers are encouraged to become "partners", cooperative prosumers</td>
<td rowspan="2">Customer Segments
Prosumers or small SME</td>
</tr>
<tr>
<td>Key Resources
Salespeople
Grid-Planning people
Grid-operation people</td>
<td>Channels
On demand
Personal sale</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Payment for ancillary services
Operation cost</td>
<td colspan="2">Revenue Streams
Postponed reinforcement</td>
</tr>
</table>

6.6.1.7 *Conclusions of HLUC3-PUC-4-BM-1*

This business case will be relevant to defer reinforcement for the DSO, but it is foreseen a big risk in having third party owned storage to secure grid stability and be compliant.
This business case is probably popular for residential, since it also raises their self-supply, and thereby give residents more credits for investing in PV systems and storage (with low or none feed-in tariffs).

6.6.2 Business model HLUC-3-PUC-4-BM-2; Voltage control at both household and grid side battery and Energy Flux control at grid side battery

The case is that one feeder is filled with PV penetration, more than 60% of the houses have PV systems and that many customers experience instability electricity in their house. The DSO monitors too high voltage in many hours during a week. Some of the houses have storage and the DSO estimates that more houses may need storage and also a grid side storage is needed. The DSO offers the prosumer to buy a battery and have automatic voltage control within defined limits, and set-points from the DSO. For this service, the DSO offers a limited payment to the prosumer.

The DSO estimated further that the grid side storage should both have voltage and flux control, because the production is much higher than consumption in many hours in this feeder line. This means that excess electricity is transformed through the 10/04 transformer to other feeder lines and this creates grid losses and is costly to the DSO.

The DSO avoids reinforcing the grid or defer the reinforcement. The business model is to be understood as there is automatic voltage control at both household and grid side level. The battery controls the voltage level itself within some defined limits, and there are no external signals exchanged with the BMS. The BMS monitors the local voltage level and regulates the level inside the demands.

The prosumer gets access to a local GUI (Extended Solarweb), where they can be informed about state of battery; state of charge, consumption, production etc.

The business case for the house owner must balance between revenue from ancillary services and feed-in tariffs. At the other hand the business case must balance between the cost of reinforcing for the DSO and expenses on ancillary services and related operational cost, besides grid loss and effectiveness of storage.

6.6.2.1 *Preconditions for the business model*

For the business model to be sustainable, the following preconditions have been identified:

- The same preconditions as for HLUC-3-PUC-4-BM-1
- Currently more production than consumption in many hours as well as yearly balance.
- More than 60% have PV systems
- More loss in transformer station than in storage.
- The profitable calculations are made with standard consumption, PV production and storage profiles for one house and aggregated.

6.6.2.2 *Stakeholder analysis*

The Stakeholder analysis is show in Table 6.13.

Table 6.13. Stakeholder analysis of HLUC-3-PUC-4-BM-2.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
DSO	Compliance and grid stability	Facilitator of local innovative solution	Taking new business models into account and buying ancillary services in the distribution grid Offering storage to residents	None
Residents with PV systems and perhaps storage	Causing the voltage problem by owning local production	Investing in storage and be part of balancing the grid locally	By owning storage and allow the DSO to control it, the resident is part of the solution	Information about the need for the DSO

				Presenting a positive business model for the residents
Residents without PV systems and storage	May be influenced by voltage issues	Consume more electricity by investing in e.g. Heat pumps	Could be part of the solution	Information about the need for the DSO

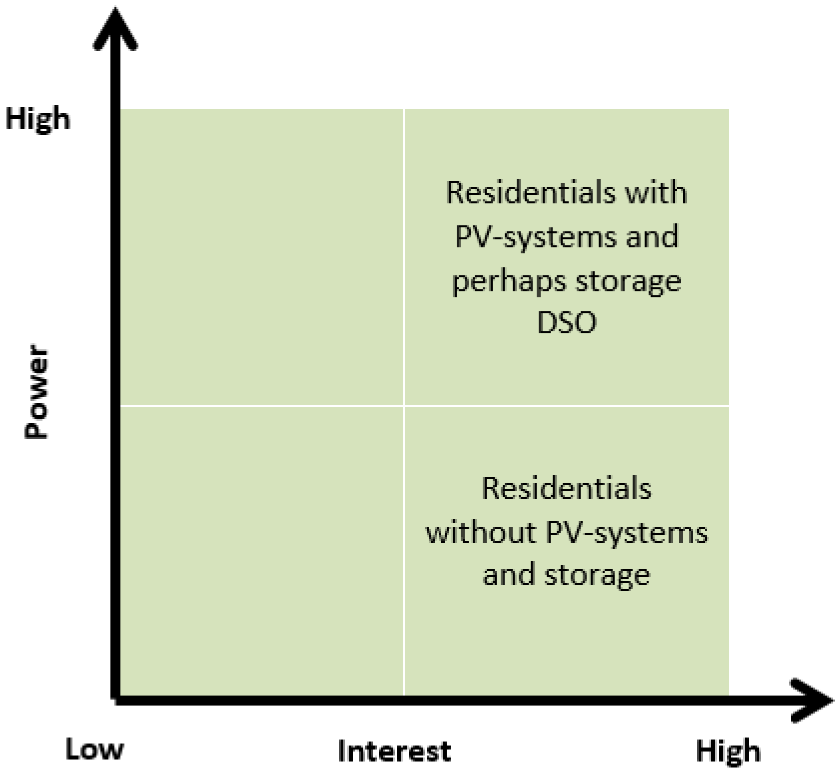

Figure 17. Stakeholder interests.

The DSO is the business model driver and the main stakeholder.

6.6.2.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 6.14.

Table 6.14. SWOT analysis of HLUC-3-PUC-4-BM-2 (DSO perspective).

Strength	Weaknesses
• DSO has control of flux • Shared business model is cheaper	• Will people by storage systems? • Voltage control is partly at third party
Opportunities	**Threats**
• High flexibility	• Can the DSO rely on this solution in the long term?

	• Some storage owned by third party • Rely on third party owned equipment to secure grid stability and be compliant.

6.6.2.4 *Risk analysis*

The Risk analysis from the DSO perspective is show in Table 6.15.

Table 6.15. Risk analysis of HLUC-3-PUC-4-BM-2.

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Risk having third party controlled and owned equipment to secure compliance	5	5	25	Making contracts with storage owners/legislation change
Enough storage flexibility	5	5	25	Invest in grid side storage
A more complex solution with more storages	3	5	15	Creating a simple and intuitive control system

This risk in the grid increase with the storage installation, compared with grid strengthening. Although, this is an innovative economical way of controlling the grid.

6.6.2.5 *Profitability calculations – the business case*

The economic business case will be presented in D2.4 "Final S4G business models".

6.6.2.6 *The Business Model Canvas*

The Business Model Canvas of HLUC-3-PUC-4-BM-2 is show in Table 6.16.

Table 6.16. The Business Model Canvas of HLUC-3-PUC-4-BM-2.

<table>
<tr><th colspan="5">Voltage control at both household and grid side battery and Energy Flux control at grid side battery</th></tr>
<tr><td rowspan="2">Key Partners
Energy Storage suppliers
Installers
ICT

<u>Value chain network:</u>
DSO
Prosumers</td><td>Key Activities
Investigating claims from prosumers (or other customers with voltage issues)
Selling batteries
Setting set-points at local owned batteries
Setting set-points at grid side battery
Interact with SCADA system</td><td rowspan="2">Value Proposition
<u>Why:</u> Stable grid at lowest cost

<u>What:</u>
Using private and grid side storage to manage demands in voltage and grid side storage to manage flux without reinforcing the grid

<u>How:</u>
Charge/discharge on demands controlled by the DSO</td><td>Customer Relationship
Customers are encouraged to become "partners", cooperative prosumers</td><td rowspan="2">Customer Segments
Prosumers or small SME</td></tr>
<tr><td>Key Resources
Salespeople
Grid-Planning people
Grid-operation people</td><td>Channels
On demand
Personal sale
BtC</td></tr>
</table>

Cost Structure Payment for ancillary services Operation cost	**Revenue Streams** Postponed reinforcement

6.6.2.7 *Conclusions of HLUC-3-PUC-4-BM-2*

This business model is very flexible and if you can rely on privately owned batteries capable of handling most problems in local feeder lines. There is a high risk in having third party owned storages and rely compliance and grid stability on them. Data security and communication lines are also a risk.

6.6.3 Business model HLUC-3-PUC-4-BM-3; Flux control and loads having at households with PV and battery.

This business model is about controlling when to charge and discharge the battery depending on grid state. The sun peak and the consumption peak does not coincide which gives imbalances in the local grid. This case is about postponing storage until sun peak (during noon) and to discharge during cooking peak (during late afternoon time 5-8 pm). This is the ideal case, mostly only during summertime. Part of the use case is also to have weather forecasts to be able to charge/discharge depending on sunshine (during spring and fall). Another case is being able to charge from the grid during night-time to consume from storage in the morning or on days without sunshine (mainly during wintertime). See details in Figure 18 and Figure 19.

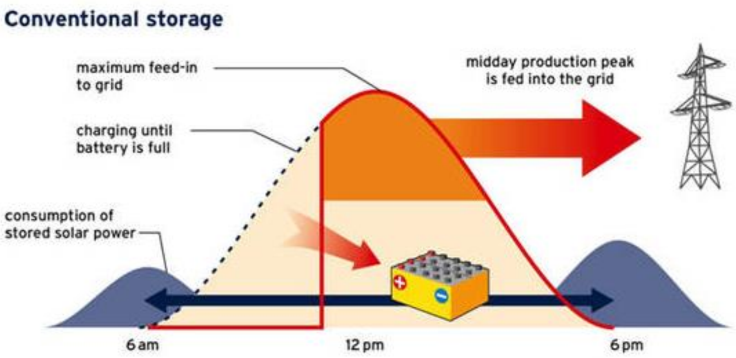

Figure 18. Self-managed battery system.

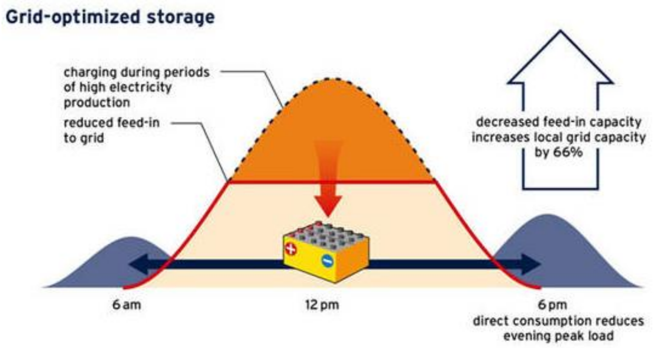

Figure 19. Grid optimization storage.

The case is a feeder line with many customers, mostly prosumers, and some prosumers with storage. The house owner gets the possibility to invest in storage to be more self-sufficient.

6.6.3.1 *Preconditions for the business model*

For the business model to be sustainable, the following preconditions have been identified:

- The DSO receives more claims from customers at specific feeders because of increased voltage levels from time to time. Specific feeders are filled with PV systems, which in specific hours increases the voltage, especially in hours with low local consumption.

- The DSO role is extended in this model by offering storage to prosumers. This is counter to legislation in some Member States, where the DSOs are facing a diminishing role in which the relation to customers is limited, with the DSO being only responsible for the meter readings and distribution. However, this model suggests a DSO role with new opportunities for smart grid engagement with customers.
- PV production sold to the grid is not in every country favourable: tariffs for selling energy to the grid are low and schemes restrict your usage (i.e. you have to consume what you produce within the hour /real-time, the rest is sold (or given for free) to the grid) and a general high cost of electricity (especially distribution costs and taxes) thereby incentivising the prosumer to invest in storage.
- If the DSO shall choose this solution they must be able to trust the solution at any time, else the DSO cannot rely on this solution, therefore the prosumer has no rights to overrule the DSO set-points. If the DSO cannot rely on the prosumers, they may still have imbalances and the need of reinforcing the grid.
- Ancillary services have become common in the DSO-grid.

6.6.3.2 *Stakeholder analysis*

The Stakeholder analysis show in Table 6.17.

Table 6.17. Stakeholder analysis of HLUC-3-PUC-4-BM-3.

Stakeholder	Role	The stakeholders' contribution and position	Possibility to affect the project	Actions toward the stakeholder
DSO	Compliance and grid stability	Local demand and regulation	Taking new business models into account and buying ancillary services in the distribution grid Offering storage to residents	None
Residents	Causing imbalances by owning local production	Investing in storage and be part of balancing the grid locally	By owning storage and allow the DSO to control it, the resident is part of the solution	Information about the need for the DSO Presenting a positive business model for the residents

6.6.3.3 *SWOT analysis*

The SWOT analysis from the DSO perspective is show in Table 6.18.

Table 6.18. SWOT analysis of HLUC-3-PUC-4-BM-3 (DSO perspective).

Strength	Weaknesses
• Easy to establish • Automatic operation • Cheap	• Is the impact high enough? • Will people by storage systems?
Opportunities	**Threats**

• Easy to test impact	• Can the DSO rely on this solution in the long term? • Rely on third party owned equipment to secure grid stability and be compliant.

The SWOT analysis from the DSO perspective is show in Table 6.19.

Table 6.19. SWOT analysis of HLUC-3-PUC-4-BM-3 (resident perspectival).

Strength	Weaknesses
• Easy to establish • Automatic operation • Cheap	• Is there a positive business case? • No possibility to optimize the investment more
Opportunities	**Threats**
• Load-shaving to secure more self-consumption	• This solution turns out not to be sufficient for the DSO and break the contract.

This business case could be a big opportunity for residents to be more self-sufficient and, at the same time, offer ancillary services to the DSO, which improve their business model. Besides taking part of being more responsible according to grid services.

6.6.3.4 *Risk analysis*

The Risk analysis from the DSO perspective is show in Table 6.20.

Table 6.20 - Risk analysis of HLUC-3-PUC-4-BM-3

Identified risk	Probability (P) Level (1-5)	Consequence (C) Level (1-5)	PxC =Risk value	Actions
Risk having 3rd party controlled and owned equipment to secure compliance	5	5	25	Making contracts with storage owners/legislation change
Enough storage flexibility	5	5	25	Invest in grid site storage

This risk in the grid increase with the storage installation, compared with grid strengthening. Although, this is an innovative economical way of controlling the grid.

6.6.3.5 *Profitability calculations – the business case*

The economic business case will be presented in D2.4- "Final S4G business models".

6.6.3.6 *The Business Model Canvas*

The Business Model Canvas of HLUC-3-PUC-4-BM-3 is show in Table 6.21.

Table 6.21. The Business Model Canvas of HLUC-3-PUC-4-BM-3.

<table>
<tr><th colspan="5">Flux control and load shaving at households with PV and battery</th></tr>
<tr>
<td rowspan="2">Key Partners
Energy Storage suppliers
Installers
ICT

Value chain network:
DSO
Prosumers</td>
<td>Key Activities
Investigating claims from prosumers (or other customers with voltage issues)
Selling batteries
Setting set-points at local owned batteries</td>
<td rowspan="2">Value Proposition
Why: Stable grid at lowest cost

What:
Using private storage to manage imbalances in flux without reinforcing the grid

How:
Charge/discharge on demand controlled by the DSO</td>
<td>Customer Relationship
Customers are encouraged to become “partners”, cooperative prosumers</td>
<td rowspan="2">Customer Segments
Prosumers or small SME</td>
</tr>
<tr>
<td>Key Resources
Salespeople
Grid-Planning people
Grid-operation people</td>
<td>Channels
Personal sale</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Payment for ancillary services
Minor operation cost</td>
<td colspan="2">Revenue Streams
Postponed reinforcement</td>
</tr>
</table>

6.6.3.7 *Conclusion HLUC-3-PUC-4-BM-3*

This business case will be relevant to defer reinforcement for the DSO, but there is foreseen at big risk in having third party owned storage to secure grid stability and be compliant.
The business case is probably popular for residents, since it also raises their self-supply, and thereby give residents more credits for investing in PV systems and storage (with low or none feed-in tariffs).

6.6.4 Business model HLUC-3-PUC-4-BM-4; Flux control at household battery by introducing network controlled demand side management.

This business model is about remote-control of different equipment’s at households according to grid state and local storage potential. The main focus is power and energy, e.g. can the operation of the heat pump or the EV charging be postponed if there is no energy available at the local storage and the grid is overloaded. Then the DSO could have the possibility to dynamically control loading or operation of the bigger consumables (heat pumps, electric boilers, hot water tanks and EVs) at private houses to be compliant. In the other hand, the DSO could have the possibility to charge the battery when the consumption in the feeder line is low (and the sun is not shining).

6.6.4.1 *Conclusion HLUC-3-PUC-4-BM-4*

This business model has not been elaborated further in this initial deliverable.

6.6.5 Business model HLUC3-PUC-4-BM-5; Privately owned virtual storage plant

Modern communications technologies make new forms of self-consumption possible. These technologies can be used to connect people who produce their own power so that excess power produced by any one member can be transferred to another member of the community who currently needs it. This business model focus only on balance in flux and economic benefit for the residents, the grid state is not taken into account.

6.6.5.1 *Conclusions of HLUC-3-PUC-4-BM-5*

This business model has not been elaborated further in this initial deliverable. This business model is out of scope in this project and more Horizon projects investigates such solutions, known as Peer-to-peer e.g. with block-chain.

6.7 Conclusion business models in FUR HLUC-3

7 business models have been developed. Not all of them are realistic to test at this initial state of the project. HLUC-3-PUC-1-BM-1 is the baseline for all other business calculations. The results from the baseline calculation are;

- If the DSO is compliant in flicker the grid becomes very strong and the PV-penetration must be very high before the DSO discovers voltage issues caused by PV-systems.
- Grid strengthening is not very costly until a certain point, which means that batteries must be inexpensive in investment and maintenance.

Results from this analysis are:

- The DSO may invest in batteries as a technical feature in the grid to avoid third party owned equipment, which the DSO may not trust (HLUC-3-PUC-3-BM-1).
- It is expected to be easier to establish storage in the grid compared to grid strengthening, but more complex to control in the SCADA system.
- There are a lot of possibilities for residential to offer ancillary services to the DSO and to increase their own business case (HLUC-3-PUC-2-BM-1, HLUC-3-PUC-4-BM-1 to 5).

The first business model to be tested in phase 1 in the Fur test site is HLUC-3-PUC-4-BM-1; "Autonomous" voltage control at household battery. See more in D6.4. [D6.4].

7 Conclusions

When the PV penetration is increasing in local feeder lines, the DSO may face issues in the local grid, which storage may be able to solve. Issues may both be voltage problems and increasing losses besides local imbalances.
Business cases related to minimizing losses and ensuring voltage levels are therefore interesting, i.e. how to use (including by charging the local storage) surplus production as close as possible to the production site in order to avoid grid losses and secure voltage control.

In the laboratory in Bucharest is being studied more innovative business models on a low TRL-level. For the first business case of HLUC-1-PUC-2 the resulting solution is to ensure a load-only pattern on distribution grid side for an existing prosumer, just by adding the storage unit and an intelligent ER. This approach is superior to classic net-metering, with or without storage behind the meter, in both aspects: savings attractiveness and in resilience, including resilience against regulatory changes and market variability for the locally (prosumer) generated electricity.
In the HLUC-1-PUC-3 the business case will be relevant by enabling energy services (based on new technology) to connected neighbourhood prosumers and consumers. An important opportunity consists in the reduction of the energy/electricity consumption cost on the long term.

Business models have been developed both for the residential, the commercial and grid test sites. For both pilot sites (Bolzano and Fur) the baseline has been calculated, showing that the use of ESS is still far from being profitable with the actual conditions (costs and lifetime of the storage system, besides regulatory framework). The incentives for the storage owner is not at the moment financial attractive. Interesting calculations also shows, if the DSO is compliant in flicker, the grid becomes very strong and the PV penetration must be very high before the DSO discovers voltage issues caused by PV systems. Grid strengthening is not very costly to a certain point, which means that batteries must be inexpensive in investment and maintenance.

Looking at the outputs of this initial study on possible business models, it is clear that to be economically attractive from the point of view of the grid, commercial and residential sites, a multiple use of the batteries is required: Such as maximising self-consumption and reduce the contractual power input, can provide grid services, such as peak-shaving and thus have an additional revenue.

Some of the business models will be analysed in more detail in the next deliverable D2.4 – "Final S4G Business Models" and a few more will most likely be developed.

Acronyms

Acronym	Explanation
AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
AP	Advanced Prosumer
B2B	Business to Business
B2C	Business to Consumer
BMS	Battery Management System
BtC	Business to Consumer
CAES	Compressed Air Energy Storage
CBA	Cost Benefit Analysis
CRM	Customer Relation Management
DC	Direct Current
DER	Distributed Energy Resources
DOD	Depth of Discharge
DSF	Decision Support Framework
DSO	Distribution Service Operator
EB FG	The Framework Guidelines on Electricity Balancing
EC	European Commission
EGC FG	Framework Guidelines on Electricity Grid Connection
EMS	Energy Management System
ENTSO-E	The European Network of Transmission System Operators for Electricity
ESS	Energy Storage System
EV	Electric Vehicle
FDI	Foreign Direct Investment
GUI	Graphic User Interface
HLUC	High Level Use Case
IRR	Internal Rate of Return
kWp	Kilo Watt Peak

Li-ion	Lithium-ion
LV	Low Voltage
MV	Middle Voltage
MW	Megawatt
NaS	Natrium Sulphur
NICd	Nickel Cadmium
NPV	Net Present Value
NRA	National Regulatory Authority
PBT	Pay Back Time
POD	Point of Delivery
PUC	Primary Use Case
PV	Photo Voltaic
RE	Renewable
RES	Renewable Energy Sources
ROC	Regional Operational Centres
S4G	Storage4Grid
SWOT	Strength Weaknesses Opportunities Threats
TRL	Technology Readiness Level
TSO	Transmission Service Operator
UniRCon	Uni-directional Resilient Consumer
USM	Unbundled Smart Meter
ΔU	Voltage difference

List of figures

Figure 1. Worldwide forecast of battery storage capacity (MW) and annual revenue (kUSD) for utility scale applications.... 8
Figure 2. The price decline for residential storage in Germany (in %). Lead -acid (grey) and Li-ion (green) 9
Figure 3. Technology readiness level of different storage technologies.. 9
Figure 4. Battery technology roadmap 10
Figure 5. Li-ion battery technology development timeframe...11
Figure 6. Power / Interest grid...20
Figure 7. The Business Model Canvas. 23
Figure 8. Overview of use cases and related business case for the Bucharest test site. 27
Figure 9. Californian duck curve (high solar penetration). 30
Figure 10. Unidirectional resilient consumer (UniRcon) architecture. 36
Figure 11.Overview of use cases and related business case for the Bolzano test site. 44
Figure 12. The discounted cash flow (Serie 1) and the cumulated discounted cash flow (Serie 2). 47
Figure 13. S4G system architecture..51
Figure 14. Overview of use cases and related business case for the Fur test site. 59
Figure 15. Current topology in the Fur island..60
Figure 16. Typical PV battery house consumption/production/SOC curve. 62

Figure 17. Stakeholder interests. 69
Figure 18. Self-managed battery system. 71
Figure 19. Grid optimization storage. 71

List of tables

Table 2.1. Comparison of different parameters of selected battery storage technologies [ii]. 10
Table 3.1. PESTLE analysis. 19
Table 3.2. Stakeholders analysis. 19
Table 3.3. SWOT analysis. 20
Table 3.4. Risk analysis. 21
Table 3.5. The 9 Business Model Building Blocks. 21
Table 4.1. PESTLE analysis of HLUC-1 business models. 25
Table 4.2. Overview of key notes for business models related to HLUC-1. 26
Table 4.3. Stakeholder analysis of HLUC-1-PUC-1-BM-1. 28
Table 4.4. SWOT analysis of HLUC-1-PUC-1-BM-1. 29
Table 4.5. The Business Model Canvas HLUC-1-PUC-1-BM-1. 29
Table 4.6. Main actors and assumptions of HLUC-1-PUC-2-BM-1. 32
Table 4.7. Stakeholder analysis of HLUC-1-PUC-2-BM-1. 32
Table 4.8. SWOT analysis of HLUC-1-PUC-2-BM-1. 33
Table 4.9. Risks analysis of HLUC-1-PUC-2-BM-1 (low risk 1 to high risk 5). 34
Table 4.10. The Business Model Canvas HLUC-1-PUC-2-BM-1. 34
Table 4.11. Stakeholder analysis of HLUC-1-PUC-3-BM-1. 36
Table 4.12. SWOT analysis of HLUC-1-PUC-3-BM-1 37
Table 4.13. Risks analysis of HLUC-1-PUC-3-BM-1 (low risk 1 to high risk 5). 38
Table 4.14. The Business Model Canvas HLUC-1-PUC-3-BM-1. 39
Table 5.1. PESTLE analysis of HLUC-2 business models. 41
Table 5.2. Main actors, assumptions, and goals. 42
Table 5.3. Overview of use cases and related business cases for the Bolzano test site. 43
Table 5.4. Stakeholder analysis of HLUC-2-PUC-1-BM-1. 45
Table 5.5. SWOT analysis of HLUC-2-PUC-1-BM-1 – PROSUMER perspective. 45
Table 5.6. SWOT analysis of HLUC-2-PUC-1-BM-1 – DSO perspective. 46
Table 5.7. Risk analysis of HLUC-2-PUC-1-BM-1. 46
Table 5.8. Stakeholder analysis of HLUC-2-PUC-1-BM-2. 48
Table 5.9. SWOT analysis of HLUC-2-PUC-1-BM-2 (DSO perspective). 48
Table 5.10. SWOT analysis of HLUC-2-PUC-1-BM-2 (prosumer perspective). 49
Table 5.11. Risk analysis of HLUC-2-PUC-1-BM-2. 49
Table 5.12. Business Model Canvas of HLUC-2-PUC-1-BM-2. 50
Table 5.13. Stakeholder analysis of HLUC-2-PUC-2-BM-1. 52
Table 5.14. SWOT analysis of HLUC-2-PUC-2-BM-1 (DSO perspective). 52
Table 5.15. Risk analysis of HLUC-2-PUC-2-BM-1. 53
Table 6.1. PESTLE analysis of HLUC-3 business models. 56
Table 6.2. Main actors, assumptions, and goals. 57
Table 6.3. Overview of key notes for business models related to HLUC-3. 58
Table 6.4. Different scenarios of HLUC-3-PUC-1-BM-1. 60
Table 6.5. Profitability calculations of HLUC-3-PUC-1-BM-1. 61
Table 6.6. Stakeholder analysis of HLUC-3-PUC-3-BM-1. 63
Table 6.7. SWOT analysis of HLUC-3-PUC-3-BM-1 (DSO perspective). 63
Table 6.8. Risk analysis of HLUC-3-PUC-3-BM-1. 64
Table 6.9. Stakeholder analysis of HLUC-3-PUC-4-BM-1. 66
Table 6.10. SWOT analysis of HLUC-3-PUC-4-BM-1 (DSO perspective). 66
Table 6.11. Risk analysis of HLUC-3-PUC-4-BM-1. 67
Table 6.12. The Business Model Canvas of HLUC-3-PUC-4-BM-1. 67
Table 6.13. Stakeholder analysis of HLUC-3-PUC-4-BM-2. 68
Table 6.14. SWOT analysis of HLUC-3-PUC-4-BM-2 (DSO perspective). 69

Table 6.15. Risk analysis of HLUC-3-PUC-4-BM-2. 70
Table 6.16. The Business Model Canvas of HLUC-3-PUC-4-BM-2. 70
Table 6.17. Stakeholder analysis of HLUC-3-PUC-4-BM-3. 72
Table 6.18. SWOT analysis of HLUC-3-PUC-4-BM-3 (DSO perspective). 72
Table 6.19. SWOT analysis of HLUC-3-PUC-4-BM-3 (resident perspectival). 73
Table 6.20 - Risk analysis of HLUC-3-PUC-4-BM-3 73
Table 6.21. The Business Model Canvas of HLUC-3-PUC-4-BM-3. 74

References

[i] Nguyen, Thu-Trang, et al. "A review on technology maturity of small scale energy storage technologies." Renewable Energy and Environmental Sustainability 2 (2017): 36.
[ii] Battery Storage for Renewables: Market Status and Technology Outlook', IRENA, 2015.
[iii] Falling prices boost energy storage', PV Europe, EES Europe 15/5/2017.
[iv] European Commission, 'Energy storage – the role of electricity', Brussels, 1.2.2017 SWD (2017) 61 final.
[v] Available at: https://insideevs.com/lithium-ion-now-dominate-chemistry-grid-energy-storage/
[vi] A. Rosenman, E. Markevich et al., Review on Li-Sulfur Battery Systems: An Integral Perspective (2015)
[vii] Avicenne Compilation, Fraunhofer ISE
[viii] Directive 2009/73/EC concerning common rules for the internal market in natural gas
[ix] Directive 2009/72/EC concerning common rules for the internal market in electricity
[x] WIP, CENER, et al, European Regulatory and Market Framework for Electricity Storage Infrastructure. Analysis and recommendations for improvements based on a stakeholder consultation, Deliverable 1.4, stoRE project, 2013
[xi] ACER, Framework guidelines on electricity balancing, Ljubljana, 2012
[xii] ENTSO-E, Network Code on Electricity Balancing, draft publication, ENTSO-E, Brussels, 2013
[xiii] ENTSO-E, Ten Year Network Development Plan 2014 –full report, ENTSO-E, Brussels, 2014
[xiv] (Stone, 2015: Stone, M., Is Ireland's Energy Storage Market Awakening? published by Greentech Media http://www.greentechmedia.com/articles/read/irelands-energy-storageawakening, 17 April 2015
[xv] https://ec.europa.eu/energy/en/publication-type/latest-communications
[xvi] Framework Guidelines on Electricity System Operation (2 December 2011 – FG2011-E-003)
[xvii] https://www.mindtools.com/pages/article/newTMC_09.htm
[xviii] http://pestleanalysis.com/what-is-pestle-analysis/
[xix] https://www.mindtools.com/pages/article/newPPM_07.htm
[xx] https://www.mindtools.com/pages/article/newTMC_05.htm
[xxi] Mitchell & Coles, 2003
[xxii] Magretta, 2002
[xxiii] Morris, Schindehutte, & Allen, 2003
[xxiv] Schweizer, 2005
[xxv] Zott & Amit, 2010
[xxvi] Osterwalder & Pigneur, 2010
[xxvii] Osterwalder, Pigneur & Tucci, 2005
[xxviii] Sanduleac, M.; Ciornei, I.; Albu, M.; Toma, L.; Sturzeanu, M.; Martins, J.F. Resilient Prosumer Scenario in a Changing Regulatory Environment—The UniRCon Solution. Energies 2017, 10, 1941.
[xxix] NETPRO Program developed by the Danish Energy Association to the Danish DSO's
[xxx] http://www.greencom-project.eu/
[xxxi] http://www.match-project.eu/
[xxxii] Aalborg University, "Match," Aalborg University, February 2016. [Online]. Available: http://www.match-project.eu/.
[xxxiii] https://www.solarweb.com/