

Clean Energy Storage Workshop [†]

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[†] Presented at the Sustainable Places 2019 (SP 2019), Sardinia, Italy, 5–7 June 2019.

Published: 26 July 2019

Abstract: The Clean Energy Package foresees a strong roll out of decentralized energy systems with renewable generation and storage. The STORY project has designed and tested six different storage solutions for a decentralized renewable energy system. In the workshop organised in the frame of SP19 conference, we highlighted some of the economic, social and technical barriers to storage in Europe and how these have been addressed.

Keywords: investing in energy efficiency; clean energy for EU Islands; clean Energy storage options and roll-out

1. Introduction

The workshop on Clean Energy Storage organised in frame of SP19 conference focused on real life examples giving participants insights on the challenges and opportunities of storage. Technology integration and interoperability, market and regulatory barriers, as well as social aspects affecting roll-out of energy storage innovation are three central issues that need to be addressed in the ongoing policy debate. These lessons learned during the STORY project can inform the development of the future energy policy agenda and help better target and address the possible bottle necks to a roll-out of energy storage innovation in the near future.

1.1. General Information on STORY Project

The main objective of STORY is to show the added value storage can bring for a flexible, secure and sustainable energy system. This will be achieved through efforts of the 18 STORY partners by showing the inter-relations between technologies and stakeholders as well as the potential and the impact of policy and regulatory framework. Six demonstrations were set up to feed knowledge into the further analysis of large-scale impact assessment and on market models, policy & regulation. The six demonstrations are located in four different member states (see map below in Figure 1) and cover industrial and residential environments, with the scales ranging from the individual building to the district. The demonstrations deliver input on technological performance, stakeholder acceptance and on the overall process of storage integration. An in-depth practice-oriented analysis on grid challenges, hardware requirements and ICT deliver insights for the demonstrations that in turn support the deployment and impact analysis [1].



Figure 1. The location of the eight countries of the 18 STORY partners, and the six demonstrations in four countries.

2. Design and Learnings from the Demonstrations

A STORY Framework Matrix (in Figure 2) was designed in order to successfully define the demo cases and to fully utilize all involved actors and storage implementation possibilities. The Framework matrix connects all the project activities, which all are related and connected to demos, but spread out into several important elements, which are all covered within the STORY project.

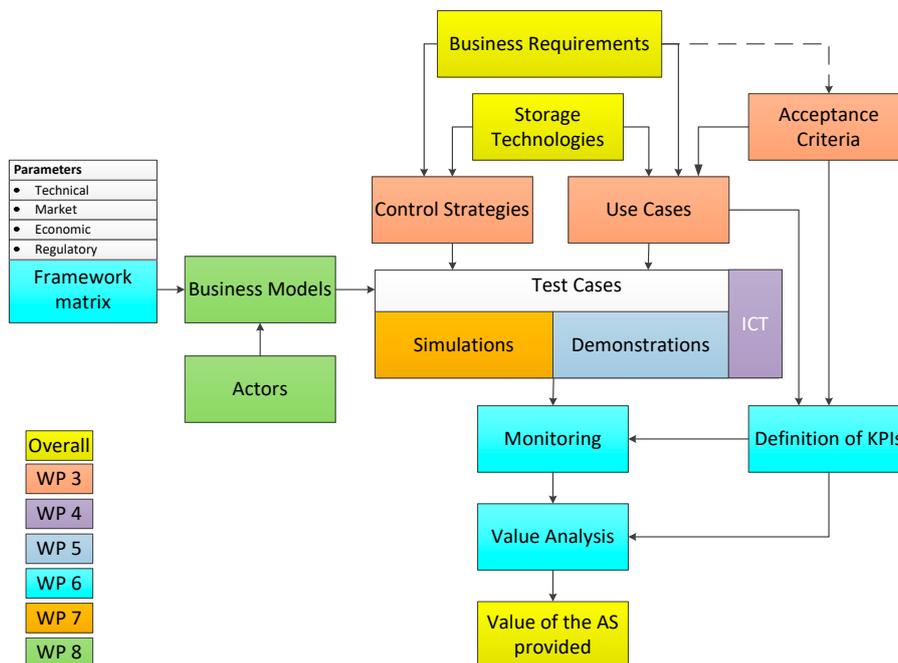


Figure 2. The STORY project Framework Matrix.

For each of the storage implementation pilot location, business requirements were defined. Demo leading partners selected their location, because a specific problem was present there or a specific storage benefit was possible to be presented there. Based on the demo needs, the storage technology was selected for implementation and important actors and partners selected. Once the storage was chosen, we defined what Use Cases or applications the storage will be used for and what control strategies are needed for that purpose or aim of the demo. Models of the demonstration locations and involved assets were created in order to create, evaluate and update control strategies. Control strategies were evaluated first through the simulations and afterwards on the field

implementation of the modelled storage and control algorithm. How the storage impacted the operation of the demo location, and to what extent benefit was achieved for individual Use Case, was evaluated through monitoring process. Key Performance Indicators were defined and the values brought overview of storage performance, network conditions, environmental and business improvements. For all included actors in the specific demo, business models were defined, and legislation recommendations will be prepared once the demonstrations are concluded and results analysed [2].

In the following, a short description of the individual established demo site is presented, with a list of key insights, and their relation to the technical, market and regulatory or social aspects is noted (Tables 1–5). These insights indicate where potential replication sites or large-scale implementation will face challenges and what obstructions can be expected when implementing new technologies into existing system, at large scale unit size and with innovative advanced control strategies.

2.1. Demonstrations at Residential Building and Neighborhood Scale, Belgium

These two demonstrations show the value of storage for the end user, the distribution grid operator, the energy provider and a potential third party aggregating the flexibility. In the first demo a dozen of houses in a residential street in Oud-Heverlee, Belgium, were equipped with a range of technologies that provide a maximum of load shifting potential: fuel cells, batteries, small scale thermal storage, seasonal thermal storage and improved monitoring and control. The energy is provided e.g., by PVT and solar panels. Interoperability receives considerable attention, in order to pave the way for cooperation between different technology providers and the move to plug and play solutions. In a second demo the goal is to take the houses in Oud-Heverlee off-grid by creating a microgrid at the end of the distribution line. The aim is to demonstrate the synergy of a neighbourhood strategy for flexibility and grid balancing. [1] The key insights from Oud-Heverlee demos are presented in Table 1 below, with their relations to technical aspects, market or regulatory aspects and social aspects.

Table 1. Key insights from Oud-Heverlee demos.

Key insight	Technical	Market/Regulatory	Social
Installation of measurement equipment: main power meters, thermal sensors, smart plugs is resource intensive, requires a lot of coordination	x	x	x
Setting up the stable connection is challenging, backup system plan is suggested	x		x
Quality of sent data must be at accurate level	x		
External services: weather forecast, market prices > availability & synchronization requires efforts	x	x	
Comfort of the residents is highly important	x	x	x
Cycling of the storage defines proper technology selection	x	x	x
Proper ‘customer support’ and fast troubleshooting is essential for success			x

2.2. Demonstration of Storage in Factory Conditions, Spain

The site is located in an industrial zone in Navarra. This factory produces professional fridge rooms and uses equipment that requires a large amount of power (800 kW peak values) that represents a considerable financial burden. In addition to the existing 113 kWp PV on the site we added a 50 kW battery energy storage system to improve the cost savings and create a business case for industrial self-consumption. [1] The key insights from the Navarra demo are presented in Table 2 below, with their relations to technical aspects, market or regulatory aspects and social aspects.

Table 2. Key insights from Navarra demo.

Key Insight	Technical	Market/regulatory	Social
Legal constraints: restricted storage operation		x	
Delays in commissioning due to change of production location, lack of producer’s personnel on the field	x	x	
Change of factory production: extension from peak demand reduction to additional load shifting	x		
Regulatory changes: registration of storage possible—grid interaction enabled	x	x	
Demo becomes role model for regulatory development		x	
Stability of the system was impacted by the contactor’s sensibility, causing shut down of the system	x		
Many factors and technologies apart from the energy storage system itself have an impact in the operation and reliability of these plants	x	x	

2.3. Demonstration of a Compressed Air Energy Storage (CAES) in a Residential District, Northern Ireland

The demonstration unit will take electricity from the grid that is produced by wind, PV and tidal generators to drive a compressor for storing compressed air in air storage cylinders (Compressed Air Energy Storage, CAES). The heat released in this process will be recovered and stored in molten salt tanks. When electricity is required for export, the compressed air is directed through an expander with heat injection from the heat store to drive a generator. The CAES plant can appear on the grid as either a controllable load or a controllable generator. There will be times when the CAES unit will be restricted as a generator and times when the CAES unit will be restricted as a load, during the evening peak in consumption when thermal limits on heavily loaded lines may be reached. [1] The key insights from the Lecale demo are presented in Table 3 below, with their relations to technical aspects, market or regulatory aspects and social aspects.

Table 3. Key insights from Lecale demo.

Key Insight	Technical	Market/regulatory	Social
In proposal phase tenders were received, but not available at project start > new strategy by partly own design		x	
Design of LP and MP systems needed	x	x	
Site preparation and tenders for CAES equipment, development of service agreements to enable revenue streams	x	x	
Single tender response, no agreement reached, move to separate technical solution (lower cost, faster build time)	x	x	
Design of the system, modelling and simulations performed	x		
LP system operational	x		
MP system: components designed, build and installed, certification needed	x	x	

2.4. Demonstration of Flexible Medium Scale Storage Unit in Industrial and Residential Area, Slovenia

In this demo, a 340 kW storage unit was built that provides a flexible and robust energy supply for diverse applications. The battery storage unit is designed to support substations at the medium voltage level in order to stabilize the grid, improve power quality and efficiency, moderate peak demand and integrate renewable energy sources (RES). The same unit is tested and demonstrated in two different settings. The aim is to demonstrate the flexibility and robustness of the unit and its control management system, and the ease with which it can be integrated into the existing infrastructure. This battery storage unit will first be connected to a residential grid operated by Elektro Gorenjska to supply energy to the village of Suha in Slovenia. In the second stage, the storage unit will be connected to a low voltage industrial grid at Elektro Gorenjska headquarters in Kranj,

Slovenia. [1] The key insights from the Suha demo are presented in Table 4 below, with their relations to technical aspects, market or regulatory aspects and social aspects.

Table 4. Key insights from Suha demo.

Key insight	Technical	Market/regulatory	Social
BESS production process from design to final commissioning revealed the complexity of the system	x	x	
First of a kind installation in Slovenia attracted a lot of attention (Slovenian distribution companies, Slovenian Energy regulatory Agency, Slovenian TSO, EG control board members and private companies, Presidents of Slovenia and Finland visited the site)	x	x	x
Different demo sites aims and needs brought high technical challenges	x		
Modular structure is a must	x		
Technology providers could not foresee all problems: high noises, PCU unit processing and communication abilities, harmonics pollution	x	x	
The batteries are not available to the extent that is generally assumed and marketed. This is a similar learning as in Navarra.	x	x	
The grid environment is different in each case, and the systems have to be designed separately for each case, although some advantage can be gained from the flexibility	x	x	

2.5. Demonstration of a Private Multi-Energy Grid in an Industrial Area, Belgium

The demo is located at the Beneens factory that manufactures wood-based products. At the demonstration, a new wood fired boiler (1.6 MW) with a heat delivery of 150°C has been built that is fuelled by waste generated from the manufacturing process. This boiler is connected to an Organic Rankine Cycle (ORC) that can provide 90 kW of electric power. To increase the flexibility of the system, thermal energy storage based on a hot water storage tanks have been added. Within the demo there are efficiency enhancements and active controls of ORC using thermal storage. The aim is to increase the self-consumption of locally produced electricity in the new office building and diminish reliance on the grid for energy. The use of local batteries will reduce congestion and peak demand on the private grid. [1] The key insights from the Beneens demo are presented in Table 5 below, with their relations to technical aspects, market or regulatory aspects and social aspects. A main insight was the need to have a technology integrator, as a range of issues on the demo were caused by an insufficient interplay between boiler, ORC and other components that were implemented by different actors.

Table 5. Key insights from Beneens demo, relations to market or regulatory aspects and social aspects.

Key insight	Technical	Market/regulatory	Social
The system is stable and operational, however the full output was not achieved (850kW, although designed for 1600kW)	x	x	
Lower thermal power has resulted in multiple start/stop sequences of the ORC combined with limited hours of operation. This has several times resulted in a broken shaft sealing.	x	x	
The boiler is in the mean time used for heating purposes, while ORC adaptations are investigated: high temperature circle did experience uncoordinated way of power flows	x		
A major issue in effectively implementing the valve control was the lack of a flow information.	x	x	
Discrepancies in energy balance, still investigated	x	x	
Lack of integrator creates unclarity on the responsibilities of different parties for fixing the problems.	x	x	

3. Conclusions

As a general conclusion it can be said that the technical, market, regulatory and social issues are highly interrelated, and putting attention to all of these in parallel will pave the way to more efficient roll out of small and medium sized storages.

3.1. Integration of Storage Devices (Presented by Jernej Zupančič, University of Ljubljana)

Integrating storage devices and control equipment with new or existing infrastructure can be challenging. STORY faced multiple issues from non-responsive intelligent thermostats to control algorithm commands for primary-level battery management systems ignoring SCADA control signals. Solutions include improved control algorithms and proactive communication with equipment manufacturers.

Key learnings summarised:

- Time plan is imperative
- Parallel activities reduce the time needed
- High need for reserve options and mitigation measures
- Equipment compatibility needs to be ensured in planning
- Not off-the-shelf solution will bring unforeseen challenges

3.2. Business and Regulatory Issues, (Presented by Dr. Andreas Tuerk, Joanneum Research)

Market liquidity is low even for simple technologies, leading to long delivery times and barriers for maintenance and repair. Regulatory changes also hinder fast market roll out. Contingency plans based on market surveys of available technologies and alternative suppliers can help avoid these barriers. The possible impact of regulatory changes should also be considered in real operation and control definition of the storage systems.

- Also maintenance and repair activities of implemented storage solutions sometimes are still very slow.
- The maturity of the technologies: components are OK, but trying to implement them in grid level is not mature yet.
- Information gaps (permitters): Storage is not well taken into account in current regulations, and the permitting authorities do not know how to address storages.
- It is not very clear who are allowed to own and operate storages.
- Takes time before the clean energy for all package is implemented in the countries.

3.3. Social Issues (Presented by Mia Ala-Juusela, VTT)

A successful roll-out of storage requires a high level of social acceptance. Deliberate actions on customer engagement and minimizing disruption from technical site visits are critical elements. Special attention to children and vulnerable groups in residential settings all help uptake of storage solutions. The advantages and disadvantages of a storage must be understood by the household both from a financial and energy use perspective. Without this engagement there is a risk of households being disappointed with the amount of energy they get and the level of financial costs vs financial savings. In remote or end of line areas, where storages would be most beneficial in the beginning, there might be limitations on data transfer solutions. This calls for more robust technological solutions and customer engagement. In STORY there were e.g., old houses with thick walls, weak mobile network etc., which could be handled with new installations. The customer engagement could help, when the residents could more easily agree on visible changes in their buildings and environment.

Funding: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646426.

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