Cooperation between Horizon 2020 Projects in the field of Smart Grids and Energy Storage

How the BRIDGE projects are addressing the battery topic?

August 2018

Authors:

Coralie Badajoz, Sophie Dourlens-Quaranta, Daniel Hernandez Maldonado, Eric Peirano (DOWEL MANAGEMENT)

This report has been elaborated by DOWEL MANAGEMENT within the INTENSYS4EU Coordination and Support Action. The INTENSYS4EU Project supports BRIDGE activities and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731220.

More information at http://www.h2020-bridge.eu/.

Summary for policy makers

Introduction

The use of batteries to support the large-scale integration of renewable energy and a consumer-centred energy transition has been identified as key by the European Commission.

Developing a **sustainable and competitive battery manufacturing sector** in Europe is the main objective of the EU Battery Alliance launched in October 2017.

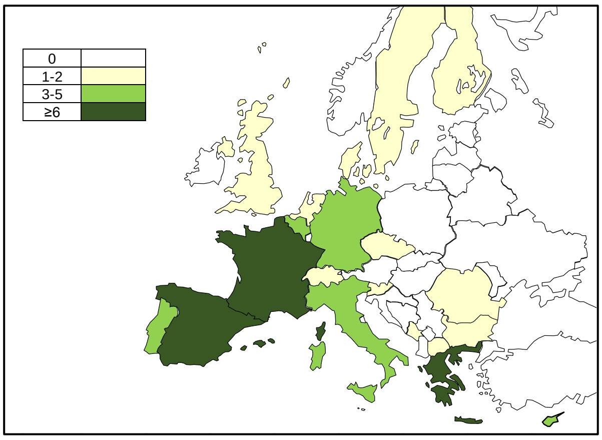
When it comes to batteries deployment for energy sector use, it is important to better understand how batteries can provide **innovative services**, which battery technologies are the best suited for **each type of application**, what are the **barriers** (for instance regulatory) **faced to deploy batteries**, what could be the role of **electric vehicles' batteries** to support power network management, etc.

To provide first set of answers to these questions the European Commission asked Intensys4EU project to look into research and innovation (R&I) projects under the **Horizon 2020 program** fostering smart energy systems.

The present report has been elaborated in the framework of the **BRIDGE initiative**, which is the cooperation group of Horizon 2020 projects in the field of Smart Grids and Energy Storage[1]. It is based on **15 ongoing R&I projects** involving battery integration in the energy system. They cover the whole range of scales from cross-border level down to building level. In addition, one project is mostly dealing with battery technology development (see Box 1).

Main findings

Geographical coverage



Most of the demonstrations dealing with batteries within the H2020 projects considered here are located in **Southern Europe**, which tends to confirm that this is where batteries make the highest economic sense, in particular to store excess of solar power. **Islands** (not only Southern) are also very attractive for deployment of batteries in combination with RES given high cost of diesel-based electricity generation.

Technologies

Several battery technologies are tested within H2020 projects. **Lithium-ion batteries** (with different variations of Li-ion technology) are the most widely used: roughly 2/3 of demos. This quickly expanding technology with competitive prices and multiple experience feedbacks provides fast responsiveness, high number of cycles, efficiency and durability. Here it should be stressed that H2020 smart energy system calls are technology neutral: even battery use as such is not prescribed and even less so the use of specific battery chemistry. Calls for proposal are mostly targeting global objectives such as integration of high share of renewables, efficiency and resilience of energy system. Sometimes they target transmission level, sometimes –distribution, etc.

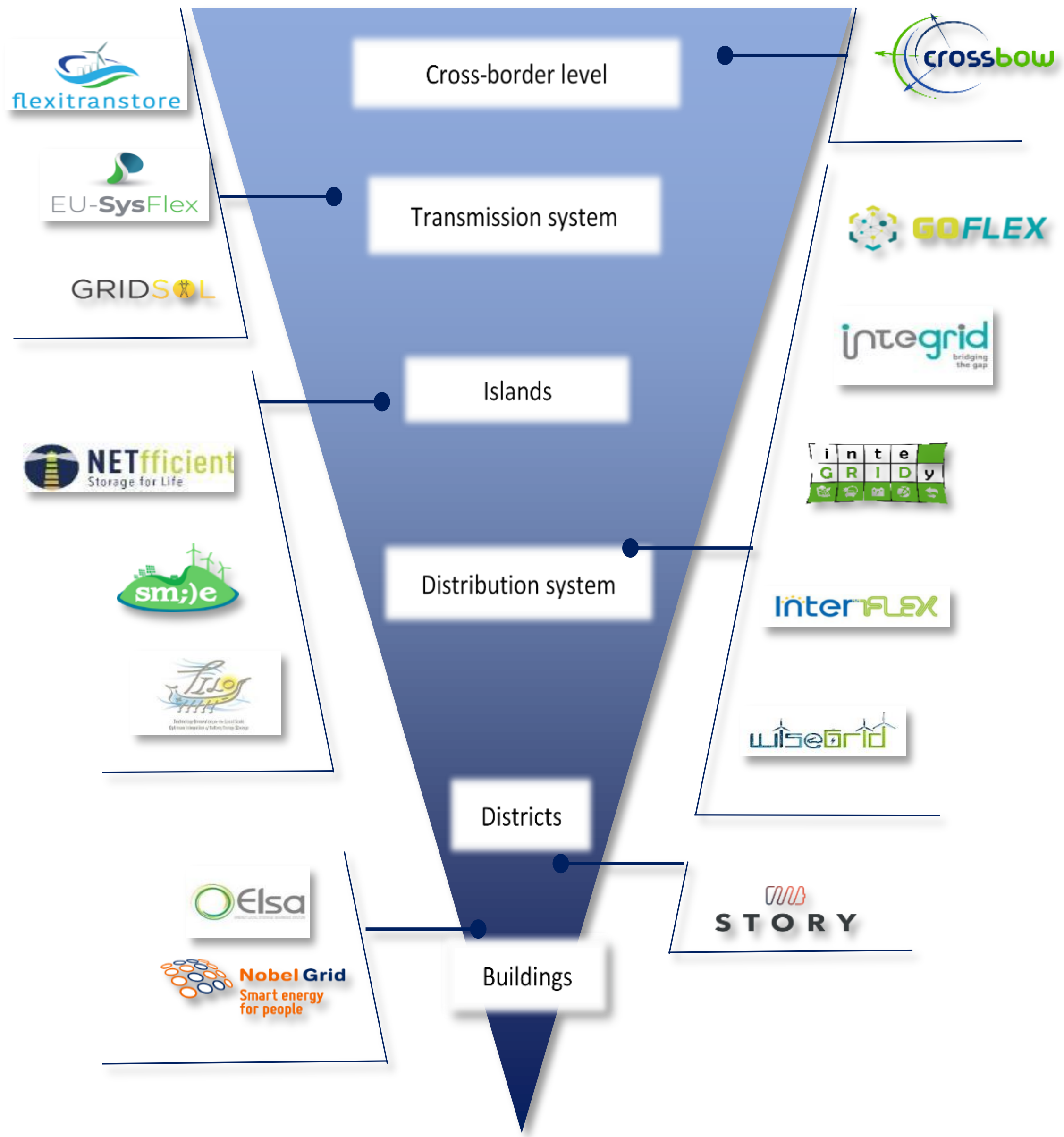
[1] More information at https://www.h2020-bridge.eu/.

Other battery technologies have been chosen by a few projects, for instance because of their lower cost or for specific applications. Notably a number of projects use long-established lead technology (1/5 of demos). And then there is at least one project using Molten Salt technology (Sodium Nickel Chloride) – TILOS project, Redox flow (GRIDOL project) and Nickel Iron technology (one of technologies used in STORY project).

Valuable feedback from H2020 projects is being provided with regards to possible improvements suggested to battery manufacturers. Some projects are using on purpose a variety of battery technologies in order to conduct a comparative assessment.

One project (NAIADES) is developing **Sodium-ion** technology which could be an alternative in case of shortage or excessive prices of lithium.

Analysed projects cover all energy system levels



Box 1. The 16 Horizon 2020 projects contributing to the present report

Cross-border aspects 	**CROSSBOW** (2017-2021) - CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market - http://crossbowproject.eu/ - **Involves co-ordinated use of a large number of small battery systems in different countries through Virtual Storage Plant(s) run by aggregators.**

Transmission level: Interactions with distribution level and generation 	**EU-SYSFLEX** (2017-2021) - Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES - http://eu-sysflex.com/ - **Involves batteries connected at low or medium voltage level to deliver services to the energy system; strong communication interface between TSO, retailer and battery system.**
	FLEXITRANSTORE (2017-2021) - An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources - http://flexitranstore.eu/ - **Involves big battery system(s) in conventional power plant to increase flexibility, in a substation at the TSO/DSO interface and in a wind plant.**
	GRIDSOL (2016-2019) - Smart Renewable Hubs for flexible generation: Solar Grid Stability - http://www.gridsolproject.eu - **Involves big battery systems integrated in renewable power plants (high voltage level, use of different battery chemistries, etc).**

Island cases 	**NETfficient** (2015-2018) - Energy and economic efficiency for today's smart communities through integrated multi storage technologies - http://netfficient-project.eu/ (Island of Borkum) **– Involves many small-scale batteries - incl. battery systems using 2nd life EV batteries - for self-consumption of sun energy by households and reaping benefits from ancillary markets. Street lighting based on PVs+batteries. Combined use of batteries and super –capacitors, etc.**
	SMILE (2017-2021) - SMart IsLand Energy systems - http://www.h2020smile.eu (Samso and Madeira Islands) - **The Li-ion batteries will be installed at the transformation cabin level or close to the demo PV plants. Also - Installation of batteries at household district level & smart charging EVs/boats. Project at early stage.**
	TILOS (2015-2019) - **Development and operation of a prototype multifunctional battery storage system integrated with RES generation** (system that will be provided with a smart grid control tools). - http://www.tiloshorizon.eu/ (Tilos island) - **Proud winner of 2 EUSEW awards(!)** for hybrid power plant combining the use of sun and wind together with big battery systems and introducing smart energy management system on the island.

Distribution level: Grid services 	**GOFLEX** (2016-2019) - Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid - http://www.goflex-project.eu/ - **Active use of distributed sources of flexibility (including electric vehicles) to provide grid services and optimize energy consumption and production at the local level.**
	INTEGRID (2017-2020) - Demonstration of INTElligent grid technologies for renewables INTEgration and INTEractive consumer participation enabling INTEroperable market solutions and INTErconnected stakeholders - http://integrid-h2020.eu/ - **Batteries at utility and domestic scale and e-mobility.** Project at initial stage.
	inteGRIDy (2017-2020) - integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization Storage Technologies - http://www.integridy.eu/ - **Some special features: dynamic charging schedules will be demonstrated for a forklift using RES and batteries. EVs will support the grid in case of need (vehicle-to-grid).**
	InterFlex (2017-2019) - Interactions between automated energy systems and Flexibilities brought by energy market players - http://interflex-h2020.com/ - **Main features of the demos: individual residential energy storage systems (PV with smart inverters + battery); shared batteries storage for collective self-consumption of sun energy; use of batteries for congestion management and EV integration (including in the fast charging context)**
	WiseGRID (2016-2020) - Wide scale demonstration of Integrated Solutions and business models for European smartGRID - http://www.wisegrid.eu/ - **Use of batteries, including EV batteries, by aggregators through special tools and platforms to enable prosumers to participate in the balancing market.**

Distribution level: From grid to building & household level 	**ELSA** (2015-2018) - Energy Local Storage Advanced system - http://www.elsa-h2020.eu - **Project is concentrated on development of scalable storage system using 2nd life EV batteries and related ICT and energy management systems to deliver services to buildings, districts and grid.**
	NOBEL GRID (2015-2018) - New cost-effective business models for flexible Smart Grids - http://nobelgrid.eu/ - **Small batteries have been used in the project for demand response tests.**
	STORY (2015-2020) - Added value of STORage in distribution sYstems - http://horizon2020-story.eu/ - **Different battery chemistries tested. Context: development, testing, improving & demonstrating of residential and industrial (hybrid) storage systems that can smoothly (without interruption) go from on-grid operation to off-grid operation, inject on demand and consume on demand. Peak-shaving services for manufacturing plant. Medium scale batteries connected to low voltage substation in a residential grid and to industrial energy infrastructure.**

Technological development 	**NAIADES** (2015-2018) - Na-Ion bAttery Demonstration for Electric Storage - http://www.naiades.eu/ - **Develops and demonstrates the ambient Na-ion battery under realistic conditions as an effective alternative to the Li-ion battery for stationary Electric Energy Storage.**

Link with electric vehicles

Batteries from Electric Vehicles are involved in two main frameworks:

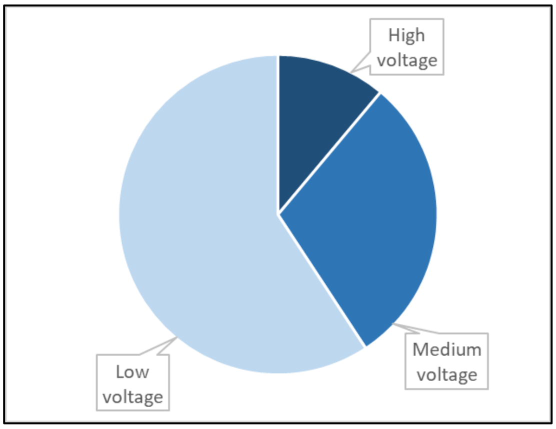
- **Second-life batteries from EVs** are gathered into stationary storage units to provide a range of services to network operators down to buildings (ELSA, NETFFICIENT);
- **Smart charging and Vehicle-to-grid (V2G) applications** are tested within a few demonstrations (INTEGRID, INTERFLEX, SMILE, WISEGRID, etc).
-

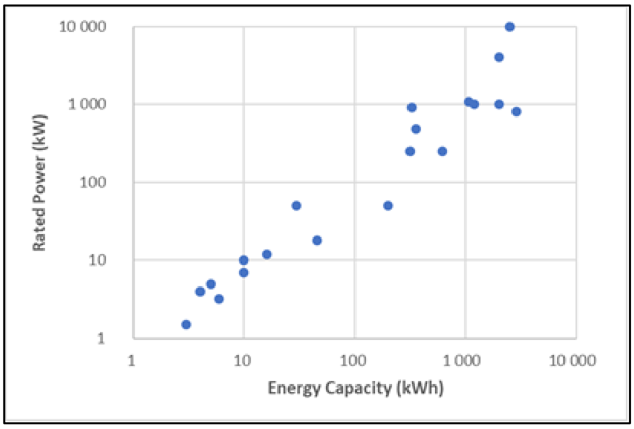
Battery size and voltage level

Batteries, as any energy generation or consumption devices, can be connected at three different levels:

- **Low voltage** (lower than 400 V): this covers residential cases as well as district level installations;
- **Medium voltage** (between 1 kV and 50 kV): in this case, batteries are connected to distribution grid or are part of medium-size generation facilities;
- **High voltage** (higher than 110 kV): in this case, batteries are connected to transmission network or operated together with big generation capacities.

Most of the batteries in H2020 projects are connected to the low voltage level.
Furthermore, a wide range of battery sizes (both in terms of energy and of capacity) are tested by H2020 projects.





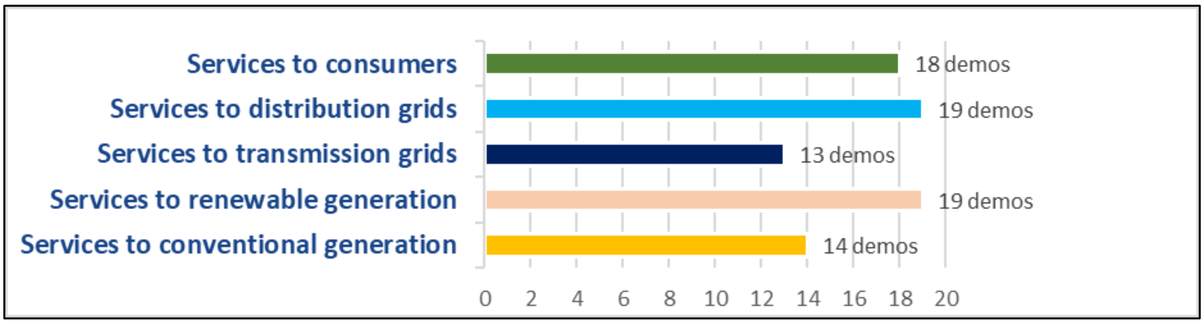
Services provided by the batteries

Energy storage in general, and batteries in particular, can provide services to all energy system stakeholders, namely:

- Conventional generation,
- Renewable generation,
- Transmission grids,
- Distribution grids,
- Customer services.

All types of services are demonstrated within the H2020 projects considered in the present report. Most projects actually demonstrate several types of services, which reflects the reality of the storage business model: a battery must provide a range of services in order to be profitable enough.

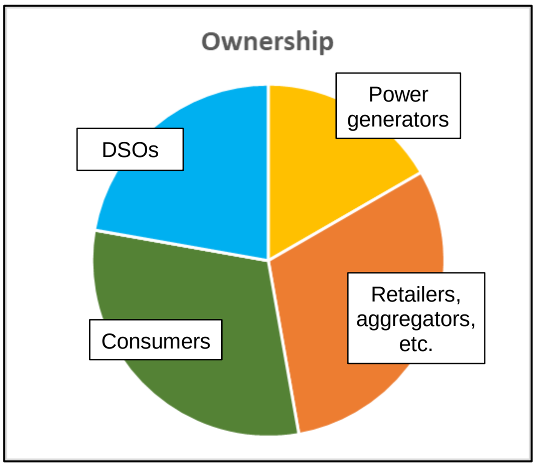
The allocation of the projects' demonstrations within the different services are illustrated below:

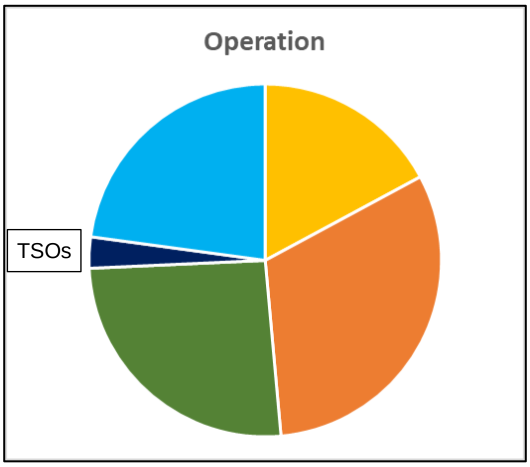


Ownership and operation of the batteries

In terms of ownership of the batteries and of who should operate them, H2020 projects have diverse views. **Ownership by prosumers** (possibly aggregated) is favoured to support self-consumption and to provide services to the DSOs. Batteries might also be integrated in **a production site** (CCGT or RES): in that case ownership and operation by power generators make sense. Nevertheless, network operators are still pleading for the right to own or operate batteries especially when batteries are used to relieve grid constraints.

It is to be noted that currently there are no common EU rules as to storage ownership. The rules which are proposed in the recast of the Electricity Market Directive are constructed around the basic principle that normally storage services should be provided by free market operators rather than network operators. However, ownership possibilities by network operators are possible in market failure situations.





Future deployment of the innovative solutions demonstrated within H2020 projects

Expected impacts

Altogether, the R&I projects considered in this report plan to deliver **practical solutions** contributing to the deployment of services provided by batteries to energy system stakeholders:

- Batteries connected at distribution level will support the system operators, locally up to cross-border level, to ensure the **security and quality of electricity supply** and to support the **system balancing**, while keeping **operation costs under control**.
- Batteries integrated into **renewable power plants** will help **limiting the intermittency** of renewable power generation.
- Batteries integrated into **conventional power plants** will allow those to be **even more flexible**. This is a must with increase in renewables generation.
- Batteries will support both **individual and collective self-consumption** of renewable production.
- Batteries installed in **hybrid power plants** will support the smooth functioning of **geographical islands'** energy systems and help limiting the use of CO_2-intensive power generation. Use of batteries in **boats** will contribute to cleaner connectivity of islands; smart charging envisaged.
- Solutions will be provided in order to manage the impact on the grid of the increasing number of **electric vehicles** ("smart charging"), and even to use such storage capacity in order to provide grid services ("vehicle-to-grid"). At the same time, increasingly available **second-life batteries** will be reused for stationary storage to serve building, district or grid needs.

New market designs and business models are being elaborated by the H2020 projects in order to make these new services economically viable.

Need for regulatory adaptation

Several projects mention regulatory aspects that deserve to be considered in order to facilitate the deployment of battery services. For instance:

- **Lack of regulation for the development of hybrid plants in most EU countries.** Notably variable renewable power plants integrated with Battery Energy Storage Systems should be able to sell they output as a single product. Renewable energy support schemes should take into account *pros* and *cons* of storage integration. This is especially needed in island systems.
- **Lack of regulation to drive demand for flexibility services provided by storage systems:** in some Member States, self-consumption regulatory framework allows only charging the energy storage systems from the renewable energy generated on-site, and energy excess cannot be fed into the grid. This is detrimental to the cost-effectiveness of the solution. In other Member States, if prosumers equipped with rooftop PV panels subsequently install batteries, they usually lose their PV-related support. This makes batteries combined with a rooftop PV at household level economically unattractive.
- **Barriers to the participation of distributed resources in wholesale energy markets and ancillary markets services**: participation in wholesale market should be possible with low amounts of generation/storage (in aggregation).

When the Clean Energy Package is adopted and enforced, the regulatory environment for storage (including batteries) will substantially improve.

Contents

Introduction

Context

Officially launched in October 2017, the EU Battery Alliance is an initiative of the European Commission which aims at addressing the lack of a domestic, European cell manufacturing base which jeopardises the position of EU industrial customers because of the security of the supply chain, increased costs due to transportation, time delays, weaker quality control or limitations on the design. The ambition is to act fast and collectively to overcome this competitive disadvantage and capitalise on the European leadership in many sectors of the battery value chain, from materials to system integration and recycling.

In this context, the European Commission asked the INTENSYS4EU project to analyse how the BRIDGE projects, i.e. R&I projects in the field of smart grids and energy storage selected under different H2020 calls from 2014 to 2017, are addressing the battery topic. Amongst the 36 projects participating in BRIDGE, around the half indeed address battery applications or battery technology developments.

Methodology

The INTENSYS4EU support team conducted a survey amongst BRIDGE projects to assess:

- The type of batteries involved in the projects,
- The services which are tested,
- The owner and the operator of the batteries in the projects' models,
- The challenges addressed,
- The results of the demonstrations,
- The exploitation prospects of the solutions and estimated impacts,
- The regulatory barriers faced to deploy these solutions.

Results from this survey are presented within the present document:

- First, some analytics based on projects' responses to the first three above items are provided and are illustrated by projects' statements.
- Then, each project's specificities are presented on a "project fiche".

Projects in the scope of the present document

16 projects responded to the survey. As illustrated by Figure 1 on page 3, those projects cover the whole range of scales from cross-border level down to building level:

- Transmission level
    - Cross-border aspects: **CROSSBOW**;
    - Interactions with distribution level and generation: **EU-SYSFLEX**, **FLEXITRANSTORE**, **GRIDSOL**;
- Island cases: **NETFFICIENT**, **SMILE**, **TILOS**;
- Distribution level
    - Grid services: **GOFLEX**, **INTEGRID**, **INTEGRIDY**, **INTERFLEX**, **WISEGRID;**
    - From grid to building & household level: **STORY**, **ELSA**, **NOBEL GRID**.

The **NAIADES** project has also participated in the survey but could not be represented on Figure 1. The project consists in the development and demonstration of ambient Na-ion batteries under realistic conditions as an alternative to Li-ion batteries for stationary applications.

Some projects have provided several answers to the questionnaire because they gather several demonstrations which address different battery technologies or services.

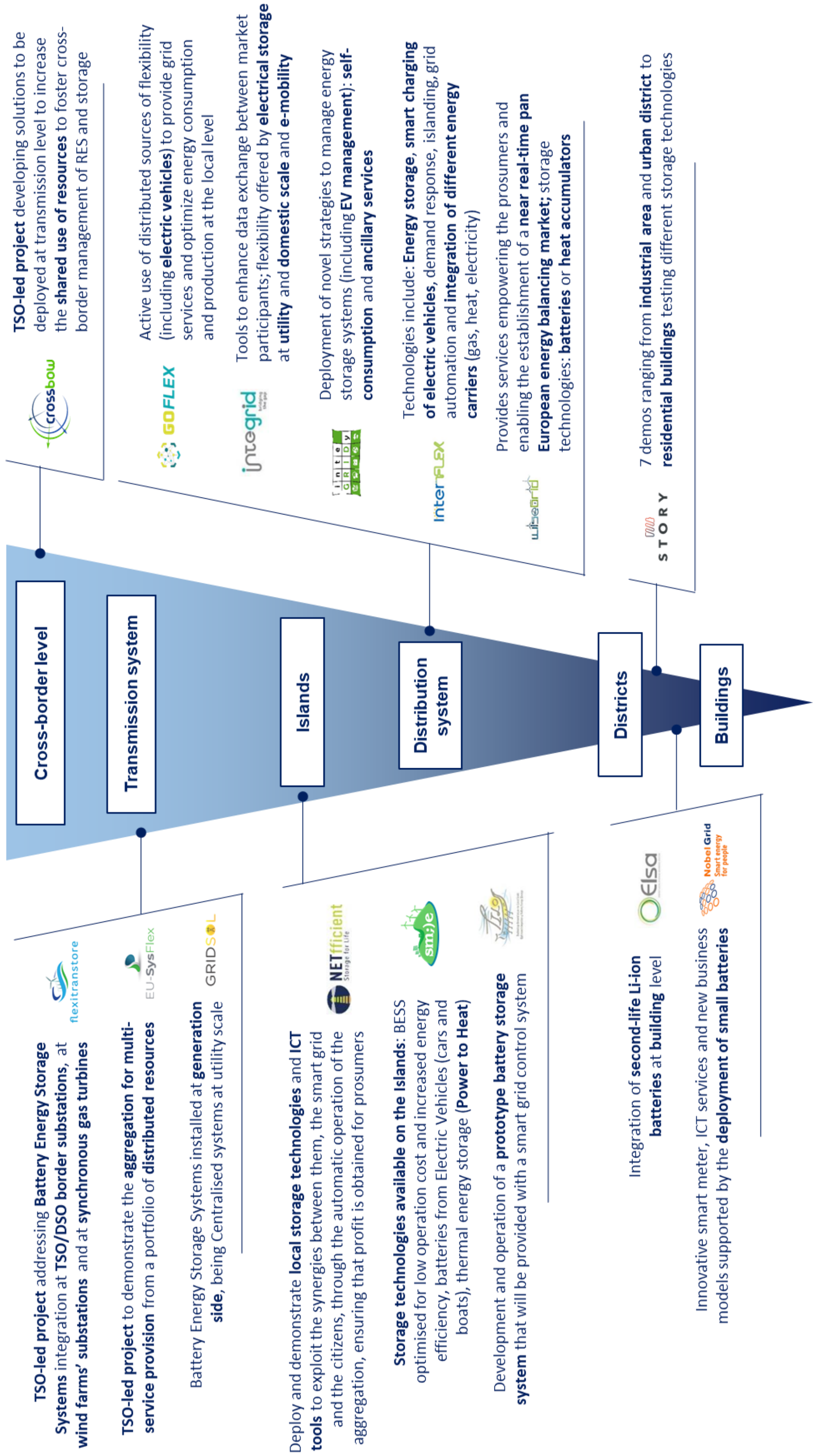
In the following, those different demos are distinguished where relevant with the country between brackets. This applies to:

- **FLEXITRANSTORE**: demos in Belgium, Cyprus, France and Greece;
- **INTEGRIDY**: demos in Greece and Spain;
- **INTERFLEX**: demos in Czech Republic, France, Germany, Netherlands and Sweden;
- **STORY**: demos in Belgium, Slovenia and Spain.

Therefore in total, 24 responses were received to the survey.[2]

[2] Two demos, namely **INTERFLEX** (Germany) and **STORY** (Slovenia) have provided late answers to the survey. They are therefore considered only in the project fiche part. They will be included in the general statistics for the next update of the report.

Figure 1. The BRIDGE projects responding the survey



Countries were the BRIDGE battery demos take place

The 16 projects considered in the present report are demonstrating batteries in 20 countries, as indicated in Table 1 and represented on the EU map in Figure 2. It shows that Southern European countries are hosting most of the demos – which tends to confirm that this is where batteries make the highest economic sense, in particular to store excess of solar power. Islands (not only Southern) are also very attractive for deployment of batteries in combination with RES given high cost of diesel-based electricity generation.

Table 1. Countries where the battery demonstrations take place

Project	Countries
crossbow	Bulgaria, Greece, Romania, Montenegro, Macedonia, Bosnia
Elsa	France, Germany, Italy, UK
EU-SysFlex	Finland, France, Italy
flexitranstore	Belgium, Cyprus, France, Greece
GOFLEX	Cyprus, Switzerland
GRIDSOL	Cyprus, France, Greece, Italy, Portugal, Spain, Other EU Islands
integrid	Portugal
inteGRIDy	Greece, Spain

Project	Countries
InterFLEX	Czech Republic, France, Netherlands, Sweden, Germany
NAIADES	France, Germany, Spain
NETfficient	Germany
NobelGrid	Greece, UK
smile	Denmark, Portugal, UK
STORY	Belgium, Spain, Slovenia
TILOS	Greece
WiseGrid	Belgium, Greece, Italy, Spain

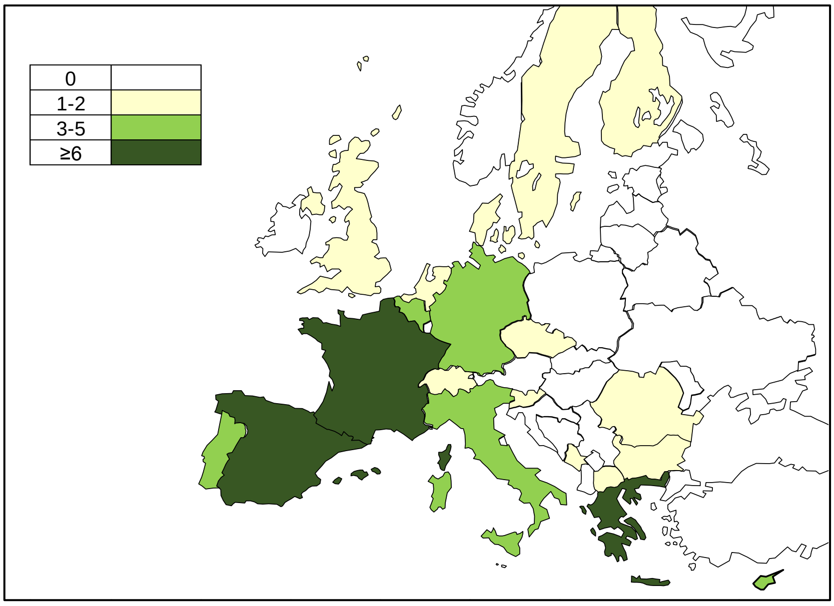


Figure 2. Countries where the battery demonstrations take place

Types of batteries addressed by BRIDGE projects

Technologies

The different battery technologies addressed by BRIDGE projects are presented in Table 2. Lithium-ion batteries are the most widely used – roughly two thirds of cases (including Lithium Iron Phosphate sub-type and Lithium Nickel Manganese Cobalt Oxide sub-type of Li-ion chemistry[3]). Other battery technologies are:

- Sodium technologies (Sodium-ion and Sodium Nickel Chloride),
- Lead technologies,
- Redox flow technologies,
- Nickel-Iron technologies (NiFe).

Table 2. Types of battery technologies addressed by BRIDGE projects

Type of battery technology	Number of responses	Projects / Demonstrations	
Lithium technologies, including:	**19**		
Lithium-ion (Li-ion), without sub-type of Li-ion chemistry specified	*14*	**ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTEGRID** **INTEGRIDY** (Greece) **INTEGRIDY** (Spain)	**INTERFLEX** (France) **INTERFLEX** (Sweden) **NOBEL GRID** **SMILE** **STORY** (Belgium) **STORY** (Spain) **WISEGRID**
⇨ *Sub-category: Lithium Iron Phosphate ($LiFEPO_4$)*	*3*	**GOFLEX**	**NETFFICIENT** **INTERFLEX** (Czech Republic)
⇨ *Sub-category: Lithium Nickel Manganese Cobalt Oxide (NMC)*	*2*	**INTERFLEX** (Netherlands) **FLEXITRANSTORE** (Belgium, France)	
Sodium technologies, including:	**2**		
Sodium-ion (Na-ion)	*1*	**NAIADES**	
Sodium Nickel Chloride ($NaNiCl_2$)	*1*	**TILOS**	
Lead technologies	**5**	**FLEXITRANSTORE** (Belgium & France) **GRIDSOL**	**INTEGRIDY** (Greece) **INTEGRIDY** (Spain) **STORY** (Belgium)
Redox flow technologies	**1**	**GRIDSOL**	
Nickel-Iron technologies (NiFe)	**1**	**STORY** (Belgium)	

[3] Most projects didn't specify which type of Li-ion batteries they were using.

Figure 3 displays the same information graphically. Three first categories belong to Li-ion family; LiFePO4 and NMC batteries are popular sub-types of Li-ion batteries.

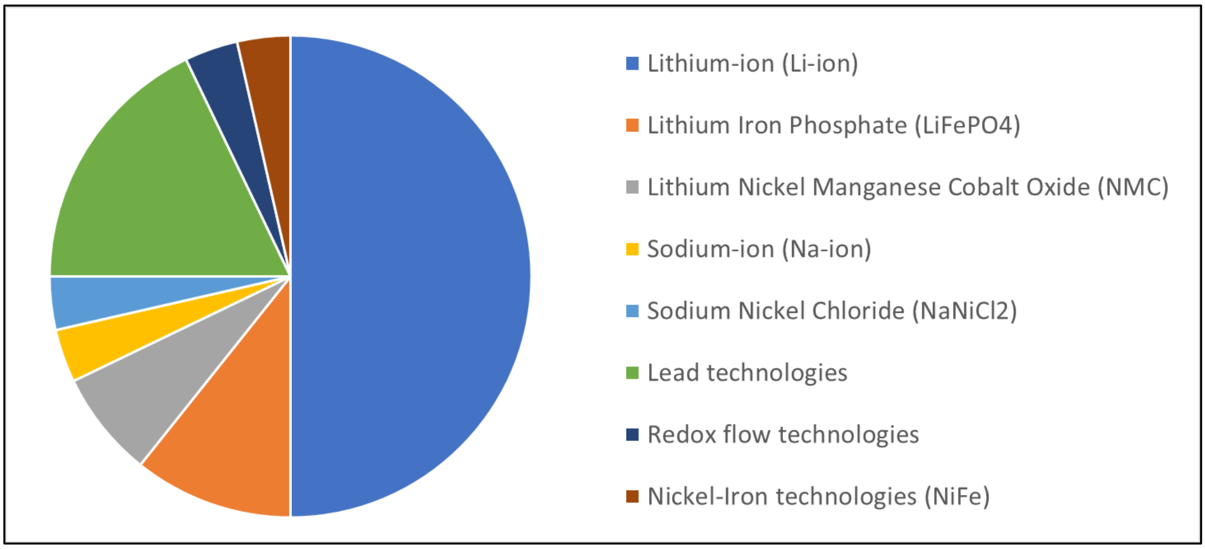


Figure 3. Types of battery technologies addressed by BRIDGE projects

The justification of the choice of the lead technology is provided by the different projects below:

- **FLEXITRANSTORE** (France / Belgium): the technology is not fully defined and will depend on application, reversibility criteria and potentially the cost.
- **INTEGRIDY** (Greece, Spain): the pilot involves different kind of storage and production units. Storage units that are used are batteries and fuel cells. The objective is to optimally combine different types of storage and production units. Lead batteries was the most convenient choice.
- **GRIDSOL**: Lead-acid is tested due to its low cost. However, it is not selected as a promising solution for power or energy services. Li-ion (power service) and Flow batteries (energy services) are considered better.
- **STORY**: Lead acid technologies can be bought easily on the market. Concerning the price-quality, these batteries come out really well. They are safe and reliable. They do not have an own BMS, which allows to optimally combine with different types of inverters and not having to bother about interoperability. In static applications energy density is less of an issue, hence that drawback becomes less relevant. Finally, they are nearly fully recyclable.

The choice of Lithium-ion technology had been motivated by the following advantages:

- High number of cycles (depending on the battery selected),
- Capacity of being designed for high power or high energy applications,
- Energy density,
- Mature technology with competitive prices and multiple experience feedbacks,
- Safety of operation,
- Safeguarding of cell temperature ranges is really important,
- Efficiency,
- Fast responsiveness,
- Durability.

Still, Lithium-ion batteries could be improved according to the projects:

- **INTEGRID** suggests more standardization for power applications, as considerable customization was required although most project use cases are common. Less thermal management consumption, more energy density / gravimetric density, life cycle assessment data available would be welcome.

- **SMILE** is facing recyclability and permitting issues. In particular, the regulatory framework is duly taken into account as far as the batteries for EVs are concerned. For instance, in Madeira (Portugal) the Decree-Law nº 90/2014, of June 11, established the legal regime of electric mobility, applicable to the organization, access and exercise of activities related to electric mobility, likewise the rules for the creation of a pilot electric mobility grid. The Decree-Law introduced the adoption of rules permitting the existence of a national grid of charging points for batteries of electric vehicles. In the pilot in Samso (Denmark), a BESS will be installed to store excess power from the PV plant during daytime and deliver power during the evening and nights when no energy is produced. Among the regulatory constraints, it has to be considered that selling from the BESS to the grid is forbidden under the current legislative framework in Denmark.
- **STORY** (Spain) had some troubles regarding the operation of the battery due to unusual configuration of strings and BMS design that were overcome but improvements are always desirable to minimise the time of commissioning.
- **STORY** (Belgium) mentions that a Li-ion home battery showed severe shortcomings in service of the company, software updates unavailability, interoperability blocks and fast drop-out in case of demands above 2 kW (physical restart needed).
- **FLEXITRANSTORE** (Cyprus, France and Belgium) considers that delivery times and prices could be more competitive.
- **INTERFLEX** (Sweden) mentions the lack of isolation built into the battery system (contactors only) necessitating additional external isolators and adding cost. Furthermore, there have been a few spurious trips and the battery balancing between racks seems to drift by up to 15%, which is causing issues.
- **INTERFLEX** (France), being the follow up of the NICE GRID project (French demo of the FP7 project Grid4EU), states that after 4 years return of experience on the field, the only issue is transportation which remains complex for safety regulation reason.

In one case (project **ELSA**), the choice of Lithium-ion batteries was imposed because the purpose of the project was to test second-life batteries coming from EV cars. The objective of the project is indeed to use these batteries in stationary storage after a first life in the cars. Bigger capacity, longer life, standardization of the BMS would need to be improved to facilitate such use.

NAIADES chose Sodium-ion technology because in case of lithium shortage or excessive prices for lithium, it is important to develop alternative technologies, with elements that will not be missing such as sodium.

Lithium Iron Phosphate technology (lithium-ion battery, which is using LiFePO as a cathode material) has been preferred by **INTERFLEX** (Czech Republic) because of the compatibility with PV inverters which are used in the project.

Lithium Iron Phosphate technology (lithium-ion battery, which is using LiFePO as a cathode material) has been preferred by **NETFFICIENT** for its high level of safety, high lifespan (thousands of cycles), absence of memory effect, low self-discharge, deep discharge possible, and energy efficiency of 96%. The energy density of such batteries, which is lower than that of Lithium Ion NMC (Nickel Manganese Cobalt) technology, has limited importance for stationary energy storage systems. This technology is available in Asia (China and Japan) and also in Europe (France).

TILOS opted for Sodium Nickel Chloride technology because at the time it was a mature energy management battery, suitable also for island applications. Afterwards, the technology has proven robust while at the same time it offers the advantage of remaining unaffected from weather conditions. This is a special advantage for the sunny island of Tilos, where temperatures could increase considerably during the summer period and where A/C needs for another technology could be quite demanding.

The intention of **STORY** and **INTEGRIDY** is to test and to compare a variety of battery technologies, including Lithium-ion and Lead technologies.

In **STORY** Belgian demo's experience, the NiFe battery is too maintenance intensive. The chosen Li-ion battery (from EVs) completely failed in all aspects because of interoperability issues between the invertor and the BMS.

GRIDSOL opted for three different technologies (Lithium-ion, Lead and Redox flow) because those technologies seemed the most promising to be implemented at Smart Renewable Hubs in order to provide flexible generation and grid stability. In **GRIDSOL** views, a combination of Li-ion batteries for power purposes and flow batteries for energy purposes provide a wide range of capabilities. The major improvements needed are a cost reduction of components, an increase of the round-trip efficiency, a longer life-cycle and a greater number of cycles at a reasonable cost.

Technology Readiness Level (TRL)

Most of the batteries used in the projects are mature technologies (usually TRL 9 solutions available off the shelf).

At the same time, System Readiness Level, including innovative integration of batteries, is much lower which justifies H2020 funding. Typically, BRIDGE projects make it possible for different smart energy system solutions involving batteries to evolve from TRL 5-6 to TRL 7-8. Usually BRIDGE projects are not involved in optimisation of battery technology/chemistry as such.

The only exception is **NAIADES** which is developing a prototype Sodium-ion battery, with a TRL brought from TRL 3 to TRL 5-6 (module demonstration in a realistic application environment).

Link with electric vehicles

Batteries from Electric Vehicles are involved in 5 BRIDGE projects out of 16:

- **ELSA, WISEGRID** and **NETFFICIENT** are using second-life batteries from EVs for other usages;
- **EU-SYSFLEX**, **INTERFLEX** (Czech Republic, the Netherlands) and **WISEGRID** are using EVs with smart charging; **WISEGRID** is also testing Vehicle-to-grid (V2G)[4] applications;
- **INTEGRIDY** (Greece, Spain) is using batteries for forklifts.

[4] INTEGRIDY: It is indicated that the Xanthi's pilot concerns an isolated system, with no connections to the grid and as a consequence there is no V2G applications.

Voltage level at which the batteries are connected

Batteries, as any energy generation or consumption devices, can be connected at three different levels:

- **Low voltage** (lower than 400 V): this covers residential cases as well as district level installations;
- **Medium voltage** (between 1 kV and 50 kV): in this case, batteries are connected to distribution grid or are part of medium-size generation facilities;
- **High voltage** (higher than 110 kV): in this case, batteries are connected to transmission network or operated together with big generation capacities.

Most of the batteries in BRIDGE projects are connected to the low voltage level as illustrated by Figure 4 and Table 3.

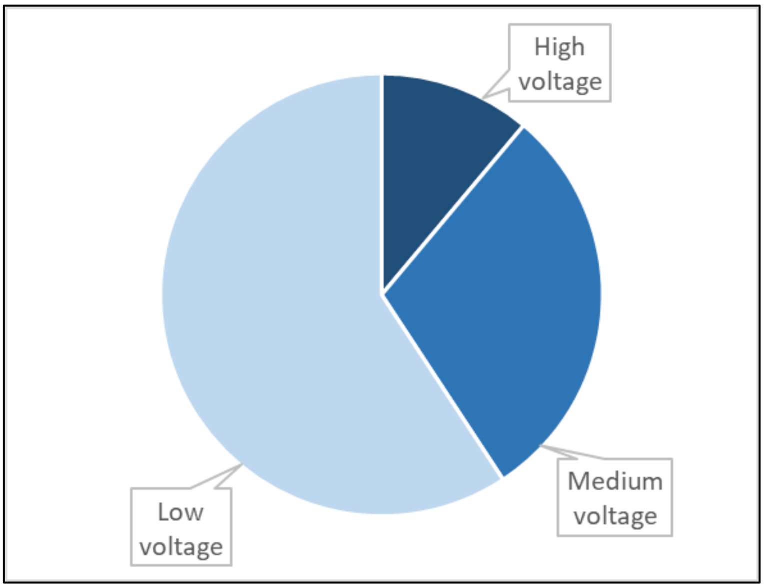


Figure 4. Voltage level at which the batteries are connected

Table 3. Voltage level at which batteries used in BRIDGE projects are connected

Voltage level	Number of responses	Projects / Demonstrations	
High voltage	3	**CROSSBOW** **FLEXITRANSTORE** (Cyprus)	**GRIDSOL**
Medium voltage	7	**FLEXITRANSTORE** (Belgium) **INTEGRID** **INTERFLEX** (Sweden) **NETFFICIENT**	**NOBEL GRID** **SMILE** **TILOS**
Low voltage	16	**EU-SYSFLEX** **ELSA** **FLEXITRANSTORE** (Greece) **GOFLEX** **INTEGRID** **INTEGRIDY** (Greece, Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Czech Republic)	**INTERFLEX** (Netherlands) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **STORY** (Belgium) **STORY** (Spain) **WISEGRID**

Batteries in transmission projects **CROSSBOW** and **FLEXITRANSTORE** are naturally connected at high voltage; furthermore, **FLEXITRANSTORE** tackles several demonstrations with batteries also connected at medium and low voltage levels. Within **GRIDSOL**, connection at high voltage is considered but this is for simulation purposes only.

Energy and power

Projects have been questioned about:

- The energy capacity of their batteries (in kWh),
- The rated power of their batteries (in kW).

As a result, the energy capacity and rated power of the different batteries tested within the BRIDGE project are graphically represented on Figure 5 (logarithmic scale).

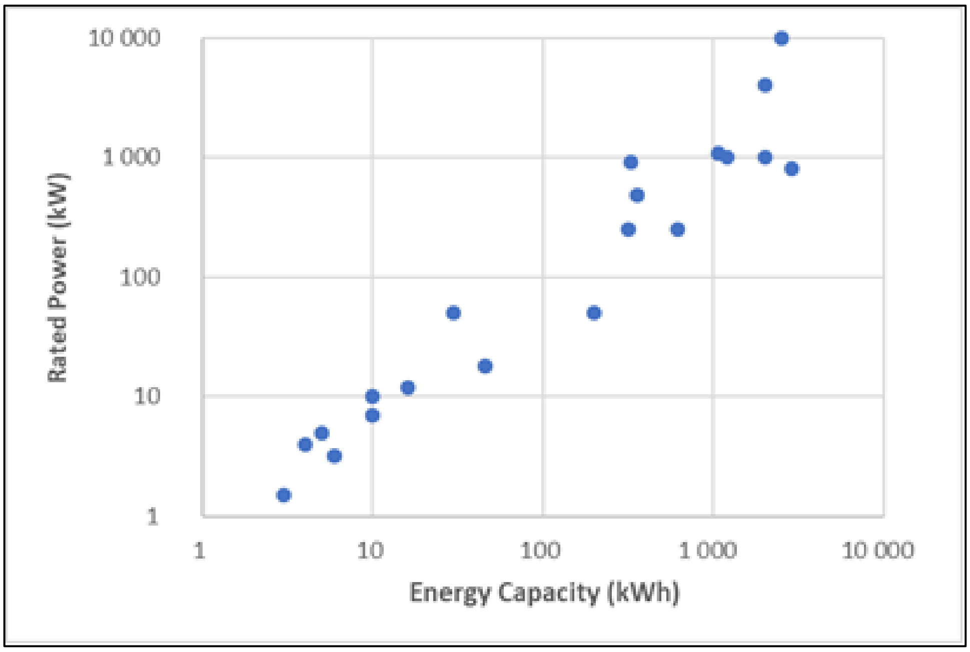


Figure 5. Energy Capacity and Rated Power of the batteries

*NB. **GRIDSOL**'s very high figures (up to 600 MWh / 100 MW) have been excluded from the graph because they are for simulation purposes; similarly, **NAIADES** very small figures (0,7 kWh / 1 kW) have been excluded.*

Battery applications in BRIDGE projects

Ownership and operation of the batteries

In terms of ownership of the batteries and of who should operate them, BRIDGE projects have diverse views represented on Figure 6 and detailed in Table 4 and Table 5.

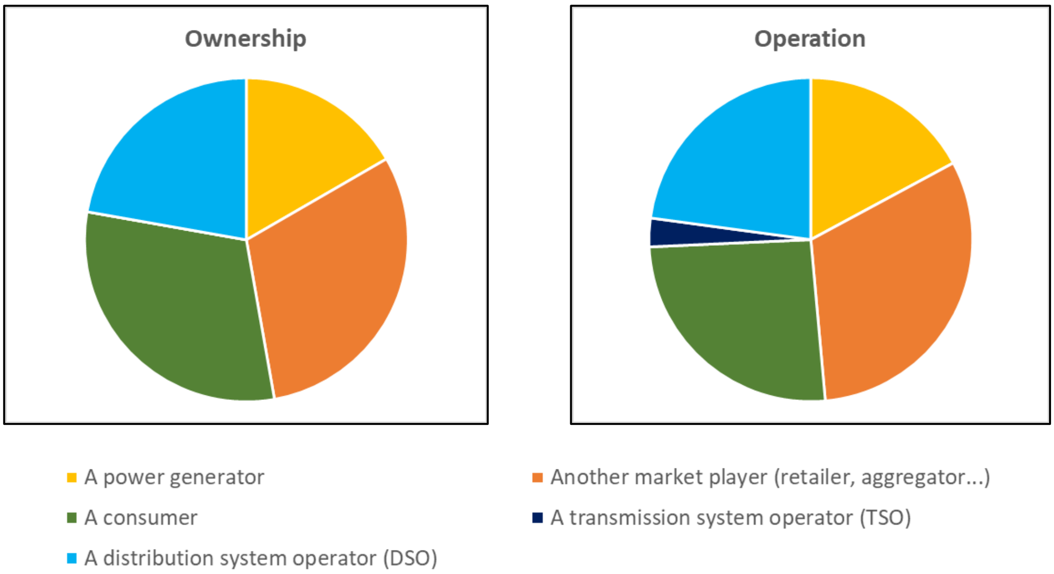


Figure 6. Ownership and operation of batteries within the projects' perspective

Arguments in favour of **ownership by consumers** (possibly aggregated) are the following:

- Consumers or intermediate entities such as aggregators, should have the capacity to manage their own capacity and offer it to the DSO.
- Batteries are supporting prosumers' self-consumption and possibly to operate off-grid in case of black out.
- Such ownership regime is compatible with existing regulations.

For **batteries integrated in a production site** (CCGT or RES), batteries should be owned and operated by power generators. For instance, in Greece, a regulatory framework exists for hybrid power stations under which there is a business case for storage in certain non-interconnected islands. TILOS considers that batteries could also be owned by an island's energy cooperative.

Several projects mention that most regulations do not allow DSOs to own storage systems. Nevertheless, arguments advanced by **DSOs owning or operating batteries** are:

- According to **INTEGRID**, investments in the distribution grid, either conventional or storage-based, must be targeted at concrete grid constraints/needs and, as such, are site specific – benefits are specific to a given location and network topology. Because storage investment opportunities for the distribution grid are site specific, the possibility of using pre-existing storage assets, originally developed for other applications, will be limited to the cases where local network needs happen to coincide with existing storage assets.

- According to **INTERFLEX**, the DSO is operating storage system for islanding and distribution grid constraints management, and the aggregator operates storage system for islanding support, grid constraint mitigation as well as market applications.

Table 4. Ownership of the batteries in BRIDGE projects perspective

Type of ownership	Number of responses	Projects / Demonstrations
A power generator	6	**CROSSBOW** **FLEXITRANSTORE** (Belgium & France) **FLEXITRANSTORE** (Greece) **GRIDSOL** **NAIADES** **TILOS**
Another market player (retailer, aggregator…)	11	**ELSA** **EU-SYSFLEX** **INTEGRID** **INTEGRIDY** (Greece, Spain) **INTEGRIDY** (Greece) **INTERFLEX** (France) **INTERFLEX** (Netherlands) **NAIADES** **NOBEL GRID** **STORY** (Belgium) **SMILE**
A consumer	11	**ELSA** **GOFLEX** **INTEGRID** **INTEGRIDY** (Greece, Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Czech Republic) **NETFFICIENT** **NOBEL GRID** **STORY** (Belgium) **STORY** (Spain) **WISEGRID**
A DSO	8	**ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Cyprus) **INTEGRID** **INTERFLEX** (France) **INTERFLEX** (Sweden) **NETFFICIENT** **WISEGRID**

Table 5. Responsible for the operation of the batteries in BRIDGE projects perspective

Responsible for the operation	Number of responses	Projects / Demonstrations
A power generator	6	**CROSSBOW** **FLEXITRANSTORE** (Belgium & France) **FLEXITRANSTORE** (Greece) **GRIDSOL** **NAIADES** **TILOS**
Another market player (retailer, aggregator…)	11	**ELSA** **EU-SYSFLEX** **INTEGRIDY** **INTERFLEX** (France) **INTERFLEX** (Netherlands) **NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **WISEGRID**
A consumer	9	**ELSA** **GOFLEX** **INTEGRID** **INTEGRIDY** **INTERFLEX** (Czech Republic) **NETFFICIENT** **STORY** (Belgium) **STORY** (Spain) **WISEGRID**
A TSO	1	**FLEXITRANSTORE** (Cyprus)
A DSO	8	**ELSA** **EU-SYSFLEX** **INTEGRID** **INTERFLEX** (France) **INTERFLEX** (Sweden) **NAIADES** **NETFFICIENT** **WISEGRID**

One of the **FLEXITRANSTORE** demos (Cyprus) features the TSO operating batteries as they are serving its needs. However, the owner is the DSO as the battery system will be installed in its facilities.

It is to be noted that currently there are no common EU rules as to storage ownership. The rules which are proposed in the recast of the Electricity Market Directive limit ownership possibilities by network operators to clear market failure situations.

Services provided by the batteries

The different types of services considered

According to the EASE-EERA European Energy Storage Technology Development Roadmap towards 2030[5], energy storage can provide services to all energy system stakeholders, namely:

- Conventional generation,
- Renewable generation,
- Transmission grids,
- Distribution grids,
- Customer services.

It appears that almost all BRIDGE projects are providing several types of services (Table 6), which is actually often requested within H2020 calls for projects. Actually, only in two cases, services to only one type of stakeholders are addressed:

- The **INTERFLEX** demo in the Netherlands is addressing services to the distribution and transmission grid;
- The **GOFLEX** project is addressing customer services and services to the distribution grid.

All types of services are equally addressed, except for services to the transmission grids which are less spread within BRIDGE projects, as illustrated by Figure 7. [6]

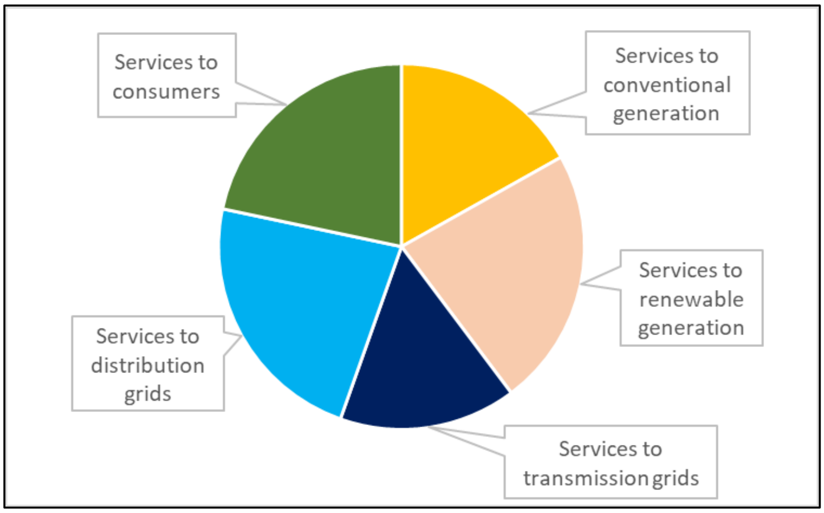


Figure 7. The different types of services provided by batteries in the BRIDGE projects

[5] See http://ease-storage.eu/wp-content/uploads/2015/10/EASE-EERA-recommendations-Roadmap-LR.pdf
[6] This might come from a bias in the survey. Two out of four of the new BRIDGE projects, all addressing transmission grids, have not participated in the survey because they are just starting.

Table 6. Types of services considered addressed by BRIDGE projects

Type of services considered	Number of responses	Projects / Demonstrations
Conventional generation (e.g. increase of its flexibility)	14	**CROSSBOW** **FLEXITRANSTORE** (Belgium & France) **FLEXITRANSTORE** (Cyprus) **GRIDSOL** **INTEGRIDY** (Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Czech Republic) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **SMILE** **STORY** (Belgium) **STORY** (Spain) **TILOS**
Renewable generation	19	**CROSSBOW** **ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTEGRIDY** (Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Sweden) **INTERFLEX** (Czech Republic) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **STORY** (Spain) **TILOS** **WISEGRID**
Transmission grid	13	**CROSSBOW** **EU-SYSFLEX** **FLEXITRANSTORE** (Belgium, France) **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTEGRIDY** (Greece) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **SMILE** **TILOS** **INTERFLEX** (Netherlands)
Distribution grid	19	**CROSSBOW** **ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Belgium, France) **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece) GOFLEX **INTEGRID** **INTEGRIDY** (Greece) **INTERFLEX** (Sweden) **INTERFLEX** (Netherlands) **INTERFLEX** (Czech Republic) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **TILOS** **WISEGRID**
Consumers	18	**ELSA** **FLEXITRANSTORE** (Belgium, France) **FLEXITRANSTORE** (Greece) **GOFLEX** **INTEGRID** **INTEGRIDY** (Greece, Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Sweden) **INTERFLEX** (Czech Republic) **INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **STORY** (Spain) **TILOS** **WISEGRID**

Services to conventional generation

According to the EASE-EERA Roadmap, services to conventional generation are:

- **Black start:** storage can help in the process of restoring a power plant to operation without relying on the transmission network
- **Arbitrage:** storage optimally selects the production/consumption moments according either to energy market prices (if operating under an electricity market environment) or to technical choices like, for instance, levelling the load (e.g.: in island systems)
- **Support to conventional generation:** storage optimises the operation of existing conventional generation assets:
    - *Generator bridging:* consists in the ability of EES to firm a generator's load while the generator is stopping and until a new generator starts up or the same generator is restarted
    - *Generator ramping:* consists in the ability of EES to pick up fast load variations giving enough time for a given generator to ramp-up/-down its production level according to technical limits.

14 BRIDGE demos do address services to conventional generation provided by batteries. As shown by Figure 8, within most of them batteries provide arbitrage services – charging when electricity is cheaper and discharging when it's more expensive (something which is in the interest of energy system as a whole). In addition to the other services above-listed (black-start and support to conventional generation), additional services have been mentioned. Examples are provided below:

- Electronics backup: the **NAIADES** prototype is meant for the backup of electronics (to reenergise the units' control command before reenergising the network);
- Grid Support in case of emergency (under frequency, under voltage): within the **INTERFLEX** demo in Czech Republic, batteries would support conventional generation units in providing such services to the grid.

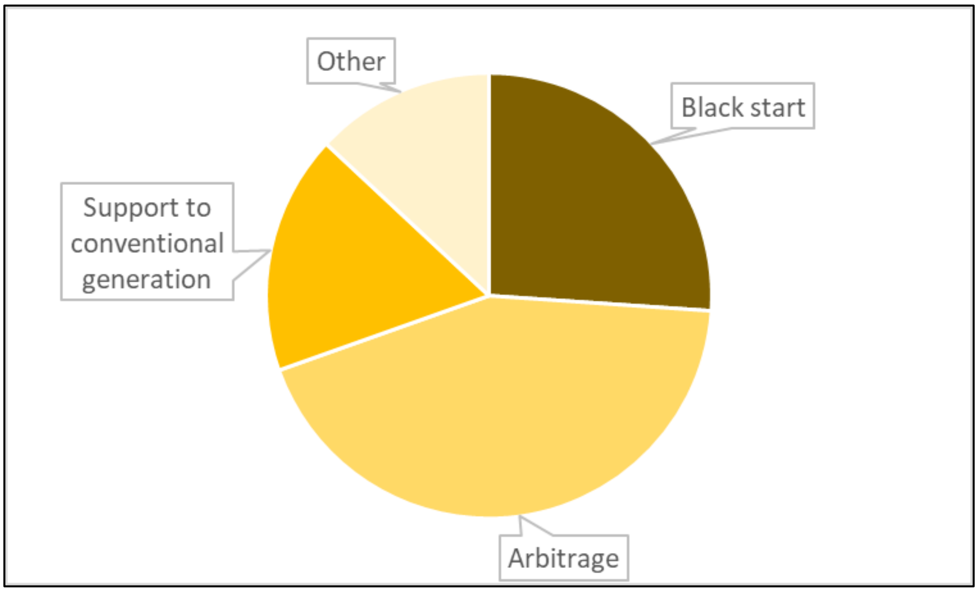


Figure 8. The different services to conventional generation provided BRIDGE projects

Table 7. Types of services to conventional generation addressed by BRIDGE projects

Type of services to conventional generation	Number of responses	Projects / Demonstrations	
Black start	6	**FLEXITRANSTORE** (Belgium, France) **NAIADES** **GRIDSOL**	**INTERFLEX** (France) **STORY** (Belgium) **TILOS**
Arbitrage	10	**CROSSBOW** **GRIDSOL** **INTEGRIDY** (Spain) **INTEGRIDY** (Greece) **NAIADES**	**NETFFICIENT** **SMILE** **STORY** (Belgium) **STORY** (Spain) **TILOS**
Support to conventional generation	4	**FLEXITRANSTORE** (Belgium, France) **FLEXITRANSTORE** (Cyprus)	**GRIDSOL** **TILOS**
Other	3	**INTERFLEX** (Czech Republic) **NAIADES**	**STORY** (Belgium)

Services to renewable generation

According to the EASE-EERA Roadmap, services to renewable generation are:

- **Distributed Generation (DG) Flexibility**: storage may help renewable generation to contribute to ancillary services
- **Capacity firming**: to support renewable integration, storage can help to increase the dispatchability of variable DG just like conventional generation assets
- **Limitation of upstream disturbances**: like users of distribution networks, decentralised generators must limit the disturbances they cause. Storage can help in this regard.
- **Curtailment minimisation**: when it is not possible to inject all the energy produced in networks, storage can be charged using this energy and replace the need for fossil fuels to provide this energy at a later time-period.

19 BRIDGE demos do address services to renewable generation provided by batteries. As shown by Figure 9, all types of services to renewable generation are addressed, the most commonly spread being minimizing curtailments. Two other services are mentioned:

- Maximizing own consumption, in the case of a prosumer (**STORY**, demo in Belgium);
- Support for islanding as demonstrated by the French demo of **INTERFLEX** (France, "Nice Smart Valley").

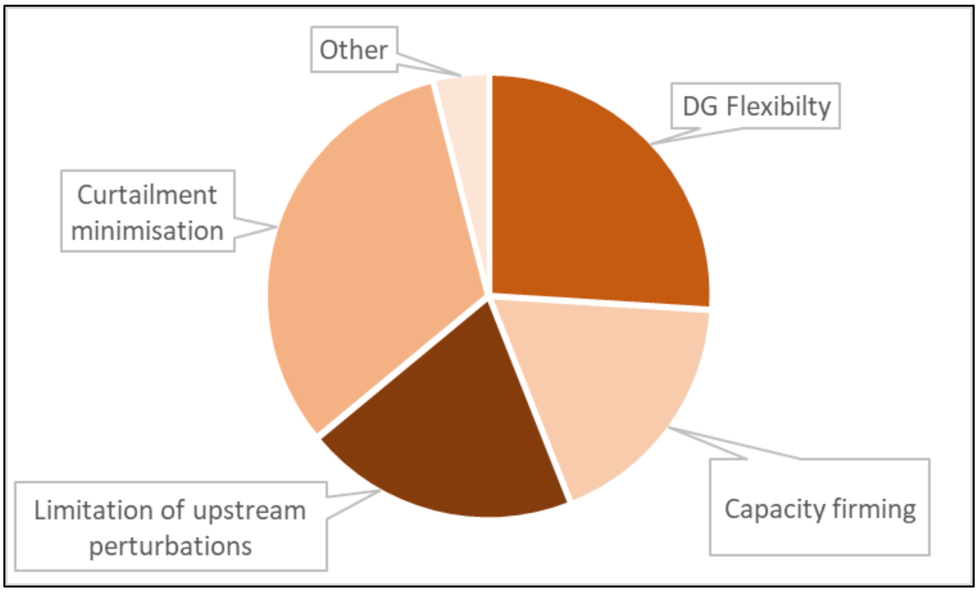


Figure 9. The different services to renewable generation provided BRIDGE projects

Table 8. Types of services to renewable generation addressed by BRIDGE projects

Type of services to renewable generation	Number of responses	Projects / Demonstrations	
DG Flexibility	13	**CROSSBOW** **ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Cyprus) **GRIDSOL** **INTERFLEX** (Sweden) **INTERFLEX** (France)	**NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **TILOS** **WISEGRID**
Capacity firming	9	**CROSSBOW** **ELSA** **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTERFLEX** (France)	**NAIADES** **NETFFICIENT** **NOBEL GRID** **TILOS**
Limitation of upstream perturbations	10	**ELSA** **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTERFLEX** (Sweden)	**INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **WISEGRID**
Curtailment minimisation	16	**ELSA** **FLEXITRANSTORE** (Greece) **GRIDSOL** **INTEGRIDY** (Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Sweden) **INTERFLEX** (Czech Republic) **INTERFLEX** (France)	**NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Belgium) **STORY** (Spain) **TILOS** **WISEGRID**
Other	2	**INTERFLEX** (France)	**STORY** (Belgium)

Services to transmission grids

According to the EASE-EERA Roadmap, services to transmission grids are:

- **Participation to the primary frequency control**: to help maintaining the instantaneous balance between generation and demand. In the ENTSO-E continental European grid, the reserves associated must be released within 30 seconds and maintained for at least 15 minutes
- **Participation to the secondary frequency control**: to adjust the active power production of the generating units to restore the frequency and the interchanges with other systems to their target values following an imbalance
- **Participation to the tertiary frequency control**: to restore the primary and secondary frequency control reserves, to manage congestions in the transmission network, and to bring the frequency and the interchanges back to their target value when the secondary control is unable to perform this last task
- **Improvement of the frequency stability of weak grids**: in island systems, to help avoiding load shedding
- **Investment deferral**: in case of congestion, the storage units with a capacity of discharge in few hours can be valorised by the resolution of congestions in HTB lines
- **Participation to angular stability**: when an accident occurs, to charge and discharge high levels of energy in short periods, thus reducing the acceleration of the groups to stop synchronism perturbations
- **Curtailment Reduction and Congestion management**: when strategically placed within the grid, to help defer energy production thus reducing the load on critical lines.

13 BRIDGE demos do address services to transmission grids provided by batteries. As shown by Figure 10, all types of services to transmission grids are addressed, the most commonly spread being Primary frequency control and Frequency stability of weak grids. One other service is mentioned: voltage control and reactive power control as demonstrated by the **GRIDSOL** project (Cyprus, France, Greece, Italy, Portugal, Spain, Other EU Islands).

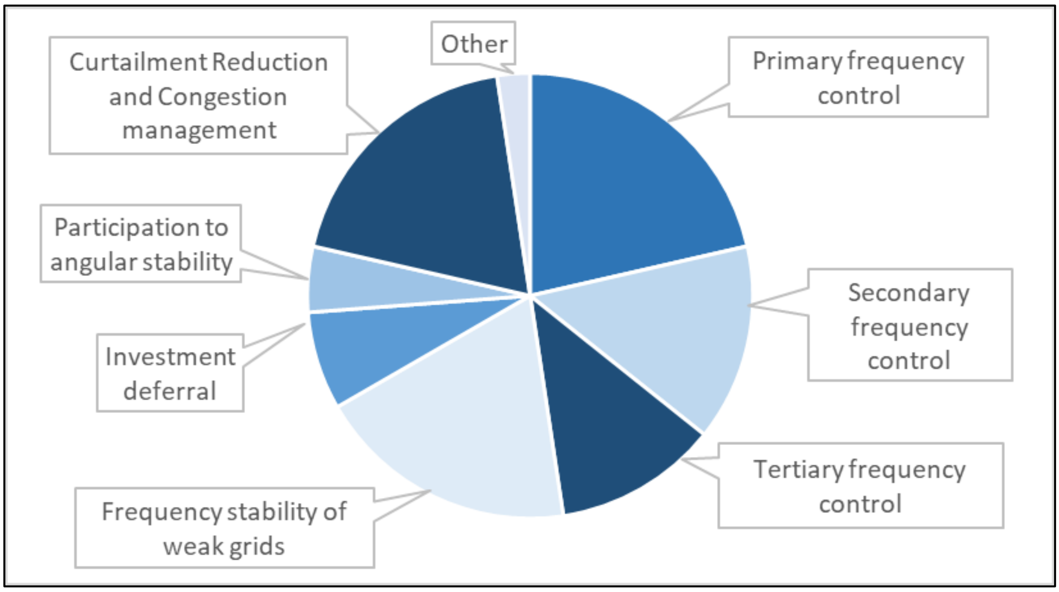


Figure 10. The different services to transmission grids provided BRIDGE projects

Table 9. Types of services to transmission grids addressed by BRIDGE projects

Type of services to transmission grids	Number of responses	Projects / Demonstrations	
Primary frequency control	9	**CROSSBOW** **EU-SYSFLEX** **FLEXITRANSTORE** (France, Belgium) **FLEXITRANSTORE** (Cyprus)	**FLEXITRANSTORE** (Greece) **GRIDSOL** **INTERFLEX** (France) **NAIADES** **TILOS**
Secondary frequency control	6	**EU-SYSFLEX** **FLEXITRANSTORE** (France, Belgium) **FLEXITRANSTORE** (Cyprus)	**GRIDSOL** **INTERFLEX** (France) **TILOS**
Tertiary frequency control	5	**EU-SYSFLEX** **GRIDSOL** **INTERFLEX** (France)	**NETFFICIENT** **TILOS**
Frequency stability of weak grids	8	**FLEXITRANSTORE** (France, Belgium) **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece) **GRIDSOL**	**NAIADES** **NETFFICIENT** **SMILE** **TILOS**
Investment deferral	3	**GRIDSOL** **INTEGRIDY**	**NETFFICIENT**
Participation to angular stability	2	**EU-SYSFLEX**	**GRIDSOL**
Curtailment Reduction and Congestion management	8	**EU-SYSFLEX** **CROSSBOW** **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (Greece)	**GRIDSOL** **NAIADES** **NETFFICIENT** **INTERFLEX** (Netherlands)
Other	1	**GRIDSOL**	

Services to distribution grids

According to the EASE-EERA Roadmap, services to distribution grids are:

- **Capacity support**: to shift load from peak to base load periods to reduce maximum currents flowing though constrained grid assets
- **Dynamic, local voltage control**: to help maintaining the voltage profile within admissible contractual/regulatory limits
- **Contingency grid support**: performing capacity/voltage support to reduce the impacts of the loss of a major grid component
- **Intentional islanding**: it consists in using Decentralised Energy Storage Systems (DESS) to energise a non-loopable feeder during an outage. Improving system reliability by energising a feeder during an outage (DESS used as a voltage source).
- **Reactive power compensation**: distribution power quality is made possible by power electronics as well but appears to be a niche application. Reducing the amount of reactive energy drawn from transmission and charged by the TSO to the DSO.
- **Distribution power quality**: to help the DSO maintain the voltage profile in acceptable limits, which increases the quality of supply (less probability of black out or interruptions)
- **Limitation of upstream disturbances**: DSOs have a network access contract with one or more TSO(s), and must therefore limit the disturbances they cause on upstream HV grids to contractual values. If these limits are exceeded, some types of advanced storage systems can help to comply with these commitments by performing active filtering.

19 BRIDGE demos do address services to distribution grids provided by batteries. As shown by Figure 11, all types of services to distribution grids are addressed, the most commonly spread being capacity support.

Table 10. Types of services to distribution grids addressed by BRIDGE projects

Type of services to distribution grids	Number of responses	Projects / Demonstrations	
Capacity support	12	**ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Greece) **FLEXITRANSTORE** (Cyprus) **INTEGRID** **INTEGRIDY** (Greece)	**INTERFLEX** (Netherlands) **INTERFLEX** (France) **NETFFICIENT** **NOBEL GRID** **STORY** (Belgium) **WISEGRID**
Dynamic, local voltage control	11	**CROSSBOW** **ELSA** **FLEXITRANSTORE** (Greece) **FLEXITRANSTORE** (Cyprus) **INTEGRID** **INTERFLEX** (France)	**NAIADES** **NOBEL GRID** **SMILE** **STORY** (Belgium) **WISEGRID**
Contingency grid support	3	**FLEXITRANSTORE** (Cyprus) **INTEGRID**	**NETFFICIENT**
Intentional islanding	8	**INTEGRID** **INTERFLEX** (Sweden) **INTERFLEX** (France) **NAIADES**	**NETFFICIENT** **SMILE** **STORY** (Belgium) **TILOS**
Reactive power compensation	7	**ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Cyprus) **FLEXITRANSTORE** (France, Belgium)	**INTEGRID** **NAIADES** **WISEGRID**
Distribution power quality	11	**ELSA** **EU-SYSFLEX** **FLEXITRANSTORE** (Cyprus) **INTERFLEX** (Netherlands) **NAIADES** **NETFFICIENT**	**INTERFLEX** (Czech Republic) **NOBEL GRID** **SMILE** **STORY** (Belgium) **WISEGRID**
Limitation of upstream disturbances	4	**ELSA** **EU-SYSFLEX**	**FLEXITRANSTORE** (Cyprus) **NOBEL GRID**

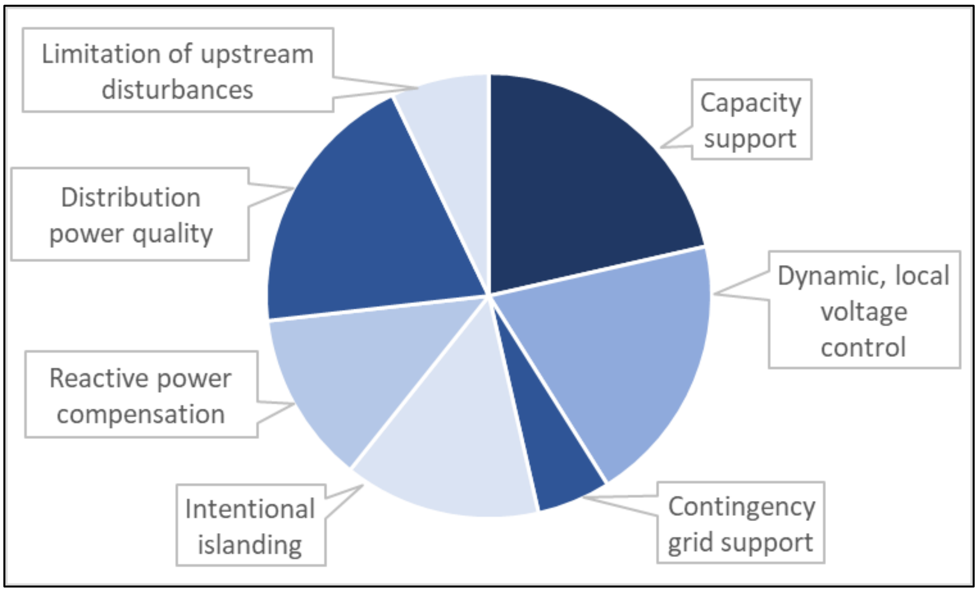


Figure 11. The different services to distribution grids provided BRIDGE projects

Customer services

According to the EASE-EERA Roadmap, customer services are:

- **End-user peak shaving**: to minimise the part of their invoice that varies according to their highest power demand (for industrial consumers)
- **Time-of-use energy cost management**: to enable a consumer to contract an Active Demand (AD) service with the DSO or a supplier
- **Continuity of energy supply**: to substitute the network in case of interruption
- **Limitation of upstream disturbances**: the customer's contract with a given DSO may account for the limitation of disturbances; the storage can help them to comply with their commitments
- **Compensation of the reactive power**: a storage unit, via the power electronics converter, is able to compensate in local the reactive power.

18 BRIDGE demos do address customer services provided by batteries. As shown by Figure 12, all types of customer services are addressed, the most commonly spread being time-of-use energy cost management.

It is worth mentioning that "**maximisation of self-consumption**" for prosumers is not included in this list of services. This is however an important type of services for behind-the meter installations. Such service is demonstrated by the **STORY** project, **WISEGRID**, **NETFFICIENT** and **SMILE**. Collective self-consumption is supported e.g. by **INTERFLEX**.

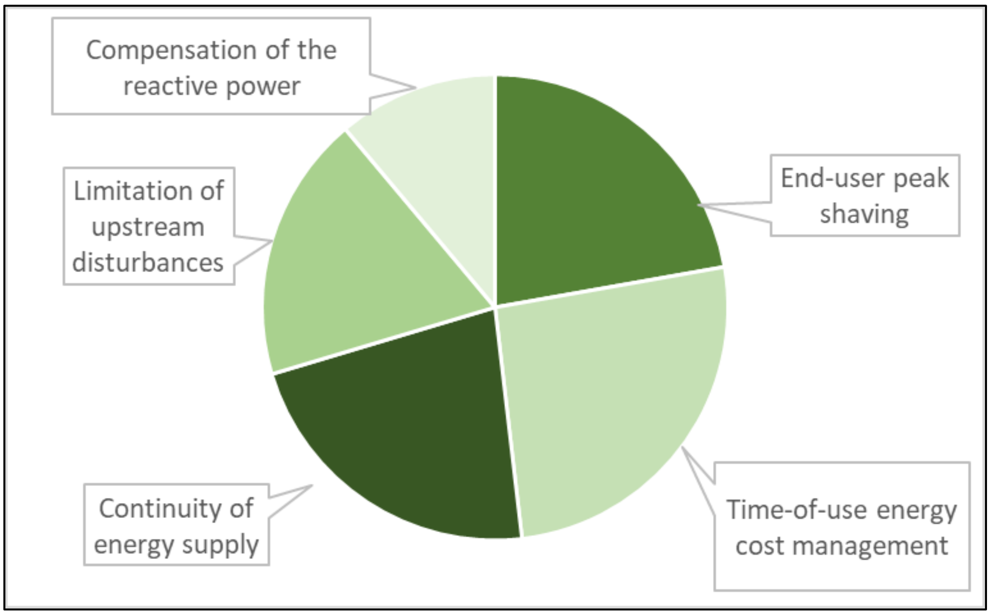


Figure 12. The different customer services provided BRIDGE projects

Table 11. Customer services addressed by BRIDGE projects

Customer services	Number of responses	Projects / Demonstrations	
End-user peak shaving	12	**ELSA** **GOFLEX** **INTEGRID** **INTEGRIDY** (Spain) **INTERFLEX** (Sweden) **INTERFLEX** (France)	**NAIADES** **NETFFICIENT** **NOBEL GRID** **STORY** (Belgium) **STORY** (Spain) **WISEGRID**
Time-of-use energy cost management	14	**ELSA** **FLEXITRANSTORE** (Greece) **GOFLEX** **INTEGRID** **INTEGRIDY** (Spain) **INTEGRIDY** (Greece) **INTERFLEX** (Sweden)	**INTERFLEX** (France) **NAIADES** **NETFFICIENT** **NOBEL GRID** **SMILE** **STORY** (Spain) **WISEGRID**
Continuity of energy supply	12	**FLEXITRANSTORE** (Greece) **GOFLEX** **INTEGRID** **INTEGRIDY** (Spain) **INTERFLEX** (Sweden) **INTERFLEX** (Czech Republic)	**NAIADES** **NETFFICIENT** **NOBEL GRID** **STORY** (Belgium) **TILOS** **WISEGRID**
Limitation of upstream disturbances	10	**ELSA** **FLEXITRANSTORE** (Greece) **GOFLEX** **INTERFLEX** (Czech Republic) **NAIADES**	**NETFFICIENT** **SMILE** **STORY** (Belgium) **TILOS** **WISEGRID**
Compensation of the reactive power	6	**ELSA** **FLEXITRANSTORE** (France, Belgium) **GOFLEX**	**NAIADES** **NOBEL GRID** **WISEGRID**

Project fiches

The current section describes each project participating in the BRIDGE initiative working with batteries.

Projects are presented as they appear on Figure 1:

- Transmission level
  - Cross-border aspects: **CROSSBOW**;
  - Interactions with distribution level and generation: **EU-SYSFLEX**, **FLEXITRANSTORE**, **GRIDSOL**;
- Island cases: **NETFFICIENT**, **SMILE**, **TILOS**;
- Distribution level
  - Grid services: **GOFLEX**, **INTEGRID**, **INTEGRIDY**, **INTERFLEX**, **WISEGRID;**
  - From grid to building & household level: **STORY**, **ELSA**, **NOBEL GRID**;
- Technological development: **NAIADES**.

NB. Project fiches are not detailed in a homogeneous manner: this reflects the differences in project maturities, some being close to their end while some have just started.

Transmission level / Cross-border aspects

CROSSBOW (2017-2021)

CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market

http://crossbowproject.eu/

Main feature: co-ordinated use of a large number of small storage units in different countries through Virtual Storage Plant(s) run by aggregators. Context: transmission system coping with increasing volumes of intermittent RES.
The objective of CROSSBOW is to use the distributed storage units to operate the grid more efficiently and at lower costs. This project will utilize the existence of a market to access ancillary services enabling the trade of storage capability for energy quality control purposes.

FEATURES OF BATTERIES IN THE PROJECT	EVs	SERVICES TO:
Mostly small, normally Li-ion batteries (project recently started) providing services to TSOs (= high voltage)	☑ Yes ☐ No	☑ Conventional generation ☑ Renewable generation ☑ Transmission grids ☑ Distribution grids ☐ Customers

Description. CROSSBOW project is expected to demonstrate a number of different technologies offering TSOs increased grid flexibility and robustness including new storage solutions – distributed and centralized, offering ancillary services to operate **Virtual Storage Plants** (VSP).

When large storage is not available to support the excess of RES production in the same country or in a neighbouring one, the coordinated use of a set of smaller geographically dispersed storage units can be considered. In this case, a Virtual Storage Unit must overcome all the challenge regarding the intermittency of renewable generation, but also the challenge of coordinating a large number of distributed storage units and the need for close collaboration with DSOs.

Expected impacts. A set of distributed storage units (in the same country or not) can be managed by the TSO and DSO, where legislation currently permits it, or specialised aggregators on their behalf, in order to contribute to the quality of electricity supply (voltage level control through Q management) and to keep the grid balanced through strategies of distributed control whilst reducing operation costs for the entire energy system.

The project aggregates the storage/battery data obtained from 7 South-East European countries, which includes Romania, Greece, Bulgaria, Bosnia-Herzegovina, Croatia, Montenegro and Macedonia.

Transmission level / Interactions with distribution level and generation

EU-SYSFLEX (2017-2021)

Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES

http://eu-sysflex.com/

Main feature: batteries connected at low or medium voltage level to deliver services to the system; strong communication interface between TSO-retailer-battery storage system.
The objective is to ensure that an efficient level of system services is provided when meeting high levels of RES while maintaining the resilience expected for the European electricity system. The technical needs of the pan-European system will be defined for scenarios with over 50% RES and translated to services to be delivered by new actors. The electricity market and regulation will be designed to procure these services, with an in-depth understanding of all stakeholders' roles (Generation and flexibility providers, Transmission and Distribution System Operators, regulators) at various system levels.

FEATURES OF BATTERRIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	1,200	1,000[7]	Low & Med.

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☐ Customers

Description. The demonstrations aggregate and coordinate various flexibilities connected to the distribution network at low and medium voltage to manage active and reactive power and deliver services to the system. The demonstrations will improve network observability and tools for TSO-DSO interface, as well as optimisation and control signals and Tools between TSO-retailer-BESS communication interfaces.

Expected impacts. Market design options will be provided, as well as recommendations for regulatory options. Tools for coordination, optimization, forecasting will be developed.

[7] The total size of the battery used in will be 2.3 MW / 1 hour. The storage system will be composed of 2 containers and grid-connected.

FLEXITRANSTORE (2017-2021)

An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources

http://flexitranstore.eu/

FLEXITRANSTORE demo in Belgium or France

Main feature: Battery -based Storage System integrated in conventional power plant so that it can be more flexible in view of variable production volumes by RES production units. [8]
The objective of this demonstrator is to improve the full power plant operability and to integrate it in the best way for the customer (layout/electrical integration/increase services).

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion, Lead	**2,500**	**10,000**[9]	**Medium**

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☐ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. The PI-BESS (Plant Integrated Battery Storage System) used in the project is a unique Battery Energy Storage System developed and commercialized by GE GPS to:

- Help utilities optimise the operation of Combined Cycle Gas Turbines (CCGTs)[10] and increase revenues captured from the ancillary services markets by optimizing the management of the primary response or operate at a higher output power, or performing black start,
- Help reinforce grid stability on small/weak grids (islands and industrial grids).

The PI-BESS main features:

- Modular design, optimized and fully-integrated to the plant,
- Developed for both New Units and Retrofits, from smallest to biggest frames.
- The PI-BESS is a system composed of transformer / converter / battery and a control system. It is sized to compensate steam turbine behaviour in a combined cycle power plant.

Expected impacts. This system would allow the operation of the plant closer to base-load[11]. Services such as additional frequency response and black-start capacities are to be provided.

[8] The Combined Cycle Gas Turbines (CCGT) is composed of a Gas Turbine and a Steam Turbine. GT only can contribute to primary frequency response in considering its mechanical response time. ST will contribute later on. When the battery will contribute to primary response, response will be immediate and at full power.
[9] If we consider a demonstrator size of 12 MW / 2.5 MWh, the battery will be composed of 48 racks of batteries.
[10] A CCGT have is own capacity primary answer with the GT. But to be able to provide it, the CCGT is generally set lower than base load. With the participation of the Battery, the CCGT will be operated at base load or closer to base load, with a better efficiency, low emission, better revenue for the customer.
[11] Operating the CCGT closer to base load will allow to get more revenues for the customer from it CCGT during its standard operation. In term of cost of the hybrid battery compared to a standalone, it will be lower as the battery will be calculated to compensate the behaviour of the CCGT.

FLEXITRANSTORE demo in Cyprus

Main feature: Battery Energy Storage System in an advanced substation at the TSO/DSO interface to regulate frequency and voltage

The objective of this demo is to demonstrate the positive impact of providing several services at Transmission level and its contribution to a major penetration of renewables and other distributed energy resources, improving the efficiency and reliability of the grid. The major challenge identified is related to the monetization of the services in a harmonized way in order that they can be widely implemented within the European Union.

FEATURES OF BATTERRIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**2,000**	**1,000**	**High**

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☐ Customers

Description. Abengoa is going to develop a Battery Energy Storage System (BESS) of 1 MW during 2 hours. BESS will be installed in an advanced substation in Cyprus at the TSO/DSO interface, called Active Distribution Node (ADN) devoted to improving the TSO/DSO interaction by integrating energy storage, grid supporting power converters, automation and intelligent controllers focused on increasing grid stability.

The ADN utilizing the BESS will participate in the frequency regulation at the transmission level. Another advantage is the ability to manage energy at the distribution level to optimize its use and to increase the flexibility of the system. Voltage regulation and transient stability are additional services offered by the ADN. The ADN can also participate in energy markets since it can act as an aggregator with energy storage capacity, and in ancillary service markets by offering primary and secondary frequency control, spinning reserve, voltage control, and load regulation and shedding.

FLEXITRANSTORE demo in Greece

Main feature: Integration of 2MWh Battery Storage Energy System in an existing wind plant in order to regulate frequency, voltage and storage capacities.[12]

The objective of this project demo is to design a Battery Energy Storage System (BESS) for three control levels:

1) Comply with the grid code: Correct the frequency, voltage, etc.
2) Control the ramps to avoid grid fluctuations
3) Earn money with a prediction control saving the energy when is cheap and selling the energy when is expensive.

FEATURES OF BATTERRIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**2,000**	**4,000**	**Low**

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. The demonstration will consist of two[13] 40 ft containers with 2 MW converters and 2 MWh battery containers. The 2MW converter container consists of:

- 2 MW inverter/rectifier IGBT[14] technology 1000V converter
- Medium voltage transformer
- Switchgear protection.

[12] The container will be allocated in Aisimi substation at the North of Greece, close to the interconnection Greece-Turkey at the Nea Santa Substation, and the PCI new interconnection Greece- Bulgaria. The substation is owned by ANEMOS and is connected to its installed capacity 39,1MW wind park via a 150kV/20kV step up transformer.

[13] The solution is a 2MWh and is formed by two different containers. One of them contains the converters, LV/MV transformer and the switchgear protection whereas the second container contains the batteries.

[14] An insulated-gate bipolar transistor (IGBT) is a three-terminal power semiconductor device primarily used as an electronic switch which, as it was developed, came to combine high efficiency and fast switching

GRIDSOL (2016-2019)

Smart Renewable Hubs for flexible generation: Solar Grid Stability

GRIDSOL

http://www.gridsolproject.eu

Main feature: Batteries integrated at new or existing renewable power plant (high voltage level, different battery chemistries, etc). Virtual Power Plants (VPP) and Virtual Storage Plants (VSP) for distributed generation and storage units.

The main aims of the project are:

- To provide flexible generation and grid stability thanks to dispatchable RES units (Smart Renewable Hubs).
- To ensure security of supply, reduce costs and clean the energy system.

FEATURES OF BATTERIES IN THE PROJECT

Techno	kWh	kW	Voltage
Li-ion, Lead, Redox flow	>100	>1,000	High

EVs

☐ Yes
☑ No

SERVICES TO:

☑ Conventional generation ☑ Renewable generation
☑ Transmission grids ☐ Distribution grids ☐ Customers

Description. Battery Energy Storage Systems are installed at generation side, being Centralised systems at utility scale (High voltage network). Smart Renewable Hubs combines RES and storage technologies (Li-Ion, Flow and Lead-Acid batteries) to provide secure and clean electricity on a single output to the electric grid. Wholesale market and ancillary service market are analysed to better assess the cost-effectiveness of BESS.

Expected impacts. The main goal is to develop new Smart Renewable Hubs (hybrid plants) to provide flexible generation and grid stability based on the most promising results for EU Islands and EU continental cases. The main exploitations are:

- Building new hybrid power plants
- Retrofitting of existing plants.
- Virtual Power Plants (VPP) and Virtual Storage Plants (VSP) for distributed generation and storage units.

The main impact is the decarbonisation of the economy enabling the energy transition towards a 100% RE reliable and secure energy system, creating at the same time growth and jobs in Europe.

Regulatory barriers. There is a lack of regulation for the development of hybrid plants. Currently, it is not specifically encouraged or even allowed to install BESS coupled to power generators (PV, Wind, CSP, etc.) in a Point of Common Coupling (PCC) in many of EU countries that would facilitate high levels of renewable energy penetration. In addition, there are often market/legal barriers to dispatch the electricity of hybrid plants as a single output/bid. According to the project results, the installation of Smart Renewable Hubs (e.g. PV/Wind with BESS or CSP with PV, Biogas/Biomass and BESS) would provide cost-effective solutions for the EU power system.

Suggestions beyond the Clean Energy package? Possibilities for conventional plants to receiving incentives to provide security of supply should be reduced to absolute minimum. Long-term contracts should be established to install BESS (15-25 years), *inter alia* in the context of Member States tenders for new renewable generation.

Island cases

NETFFICIENT (2015-2018)

Energy and economic efficiency for today's smart communities through integrated multi storage technologies

http://netfficient-project.eu/

Main features: Wide-scale use of small-scale batteries including second-life EV batteries for self-consumption of sun energy by households and reaping benefits from ancillary markets. Street lighting based on PVs+batteries. Combined use of batteries and super-caps. The main objective of the project is to proof the technical feasibility of different energy storage technologies (Li-Ion, Supercaps, fuel cell, and second-life EV batteries), their ability to increase local RES use, and to provide tools to increase storage economic feasibility by maximizing the return on investment.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-Ion (Li Fe P04)	1,100[15]	1,075	Med. & Low

EVs
☑ Yes
☐ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. Within the project, a set of storage technologies have been deployed in LV and MV environments in the island of Borkum (Germany), tied to RES (PV):

- 40 houses combining PV, Li-ion, Li-Ion + supercaps, fuel cell, and 2nd life EV batteries
- 5 buildings combining PV, Li-ion, Li-Ion + supercaps
- Street lighting tied to PV and batteries
- Public facilities tied to PV and batteries
- 1 MV substation with 1MW Li-Ion + supercaps-based hybrid energy storage systems (HESS)

The storage is connected to smart inverters. Also, a cloud-based Energy Management Platform (EMP) has been developed: it is able to monitor and control all the distributed energy resources (e.g. energy flows, storage, provide services such peak shaving or frequency regulation through the MV HESS).

Expected impacts. Improvement of storage penetration, and RES use, because of the direct improvement of the ROI of storage + RES generation.

Regulatory barriers. Allow distributed energy resources (DER) behind the meter (RES+storage) to participate in wholesale energy markets with low regulatory barriers. Normally Clean Energy Package should push Member States in this direction, but already today Member States are free to roll out enabling solutions.

[15] Considering all batteries capacities.

SMILE (2017-2021)

SMart IsLand Energy systems

http://www.h2020smile.eu/

Main features: The Li-ion batteries will be installed at the transformation cabin level or close to the demo PV plants. Batteries will also be installed at household district level. Charging EVs and e-boats considered as a way of implementing demand side management strategies to avoid issues with the grid stability.
The project aims at using batteries to maximise local small-scale RES generators (SAMSO pilot) in order to peak shave in periods of high demand and utilise excess electricity from RES production facilities; maximise local houses PV self-consumption as well as better manage interaction between close local loads (MADEIRA), operate in parallel with thermal storage to reduce wind curtailment and guarantee an electricity driven thermal power production.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**30**	**50**	**Medium**

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. The generation means, loads and topology of the network developed in the two demonstration sites involving batteries are:

- Samso Island: wind and PV RES, CHP power plants and regarding the network, the island is connected to the mainland.
- Madeira Island: PV RES, Internal Combustion engines. The island is non-connected to the mainland and it involves MV distribution systems.

The Lithium batteries (stacks of 30 kWh) are to be installed at the transformation cabin level (district purposes for grid balancing and flexibility services) or close to the demo PV plants.

Business models for the BESS of the demos: installation at household district level to optimise self-consumption, promotion of battery for group of users.

The project is still at very early stage but prospects for BESS successful use so far are very promising.

Expected impacts. The Madeira electricity company **(**EEM) could support and promote the business case of installing batteries at district/cluster of users' level in Madeira Island. On the other hand, the boat battery concept could be further replicated in other marinas (SAMSO demo).

Regulatory barriers. Impossibility to interexchange power from storage on the DN (i.e. Denmark).

TILOS (2015-2019)

Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage

http://www.tiloshorizon.eu/

Main features: Development and operation of a prototype multifunctional battery storage system integrated with RES generation (system that will be provided with a smart grid control tools). The TILOS project aims at demonstrating the optimal integration of local scale energy storage in a fully-operated, smart microgrid on the island of Tilos currently supplied with oil-based generated electricity via an undersea cable from the island of Kos. The main objective is the development and operation of a prototype battery storage system, based on NaNiCl2 batteries, that will be provided with a smart grid control system and that will cope with the challenge of supporting multiple tasks.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
$NaNiCl_2$	2,880[16]	800	Medium

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. TILOS has developed a multifunctional, integrated battery storage to support:

- Island operation of Tilos island under high RES penetration (70-75% on annual basis);
- Switch to island mode or black-start at the island level, following a fault upstream of the interconnector that connects Tilos to Kos island;
- Provision of ancillary grid services (frequency control) at the overall Kos system;
- Minimization of power cuts on the island of Tilos;
- Collaboration with DSM aspects in the context of a smart microgrid;
- Grid-forming (stand-alone microgrid) and grid-following (microgrid coupled with the main grid) operation.

The project started at TRL 5 to reach today TRL 7 at system level. The TRL increase was challenged by the integration of the battery and PCS (power conditioning system) components in order to create a functional prototype.

Expected impacts. Issuance of the first PPA for a battery-based hybrid power station in Greece:

- Disruption of the local energy market
- Challenge of the regulatory framework by introducing special technological characteristics of batteries.

Consequences for the Greek Regulatory Authority for Energy (RAE):

- Commercial exploitation and replication of the TILOS system
- Establishment of a new energy model for the currently oil-dependent island regions.

Regulatory barriers. The Greek regulation on hybrid power stations was created for pumped hydro storage (PHS) and thus is not adapted to battery storage. TILOS wishes to introduce hourly dispatch scheduling in non-interconnected island regions and promote the creation of a proper remuneration scheme for battery-based ancillary services. Indeed, currently, hybrid power stations need to offer day-ahead guaranteed energy offers for the first and second 12h of the following day. The DSO can then draw the energy offered at any given time of the 12h period, given some upper and lower limits. The project suggests that this changes to hourly energy offers so that the producer can provide a realistic schedule that could also support RES smoothing through the batteries in an efficient way. If the current approach remains, only large-scale storage (PHS) can be used.

Suggestions beyond the Clean Energy package? Storage in small island regions should ideally benefit from a stronger support than currently exists under the "New operating aid scheme for the production of electricity from RES and high efficiency CHP" in the sense that small islands are otherwise affected by extremely high electricity production costs of oil-based power generation, which should be reflected in the remuneration of the storage component of new hybrid power stations replacing expensive thermal power units.[17]

[16] The figures refer to the sum of two identical BESS.

[17] New tariffs proposed for storage components of hybrid power stations under the aid-scheme are considered low (~150E/MWh; 50% higher than the RES reference tariff). In small island regions, production cost of oil-based power generation could even reach 1000E/MWh. Tilos believes that in small scale islands (<5000 people), storage should receive tariffs that reflect to the production cost of thermal units to be replaced.

Distribution level / Grid services

GOFLEX (2016-2019)

Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid

http://www.goflex-project.eu/

Main feature: Active use of distributed sources of flexibility (including electric vehicles) to provide grid services and optimize energy consumption and production at the local level.
The GOFLEX project innovates, integrates, and demonstrates a group of electricity smart-grid technologies for managing flexibility in energy production and consumption. GOFLEX focuses on active use of distributed sources of flexibility to provide services for grid operators, balance electricity demand and supply, and optimize energy consumption and production at the local level. Sources of load flexibility include thermal (heating/cooling) and energy storage in electric vehicles and residential batteries.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion (Li Fe P04)	3	1.5	Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☐ Renewable generation	
☐ Transmission grids	☐ Distribution grids	☑ Customers

Further information will be available once the project is more advanced.

INTEGRID (2017-2020)

Demonstration of INTElligent grid technologies for renewables INTEgration and INTEractive consumer participation enabling INTEroperable market solutions and INTErconnected stakeholders

http://integrid-h2020.eu/

Main feature: Tools to enhance data exchange between market participants; flexibility offered by electrical storage at utility and domestic scale and e-mobility. The general objective of the project is to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimisation services while ensuring sustainability, security and quality of supply.

FEATURES OF BATTERRIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	~230	~180	Low
Li-ion	360	480	Medium

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☐ Renewable generation	
☐ Transmission	☑ Distribution grids	☑ Customers

The project is still at an early stage in the project and more information will be available at a later stage.

In the Portuguese demonstrator, the grid-connected energy storage devices are owned and operated by the DSO. However, this model is only allowed for pilot projects; this regulatory constraint should be taken into account for a future roll out of the solutions developed within the project.

INTEGRIDY (2017-2020)

integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization Storage Technologies

http://www.integridy.eu/

inteGRIDy demo in Greece (Xanthi)

Main feature: Optimum Distributed Control of RES-enabled Islanded Grids Local Storage. Dynamic charging schedules will be demonstrated for a forklift using RES and batteries. EVs will support the grid in case of need (vehicle-to-grid). The pilot aims at utilizing flexible storage management algorithms for charging/discharging energy storage technologies. The pilot will employ hybrid storage options (batteries, hydrogen). Moreover, inteGRIDy demonstrates dynamic charging schedules for a forklift using RES and batteries or stored hydrogen options on demand via energy management methods. The pilot will offer balancing solutions by returning power to the grid at peak network demand with EVs. The pilot concerns isolated system.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Lead-acid	5.5	5	Low

EVs
☑ Yes
☐ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☐ Distribution grids	☑ Customers

Description. Lead-acid batteries and Polymer Electrolyte Membrane (PEM) electrolyser that produce and store hydrogen are to be used for energy storage in the demo site to be deployed at N. Olvio in Xanthi, Greece. It is to highlight that the experimental grid will be totally isolated.

Regulatory barriers. In Greece, there is no legislation for autonomous power supply of buildings.

inteGRIDy demo in Greece (Thessaloniki)

The pilot involves 100 residential households and one small basketball court to demonstrate demand response models, with storage support, likely to happen in the near future in Greece.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion & Lead	4	4	Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. inteGRIDy deploys a demand response approach for buildings in Greece, using storage devices (batteries). market model and the experience gained from the stakeholders in the demo would provide innovative schemes to support new market needs in Greece.

Regulatory barriers. Regulatory barriers have been identified related to mass storage for demand response in low voltage grids in Greece.

INTERFLEX (2017-2019)

Interactions between automated energy systems and Flexibilities brought by energy market players

http://interflex-h2020.com/

Main features of the demos:

- Shared large-scale batteries to both relieve grid constraints and enhance self-consumption (French and Swedish demos)
- Large-scale central storage unit *inter alia* to enhance electrical vehicles smart charging (Dutch demo)
- Home storage systems to increase the overall hosting capacity of distributed renewable generation units (Czech and German demos)

InterFlex demo Czech Republic

The use case aims at increasing distributed energy resource (DER) hosting capacity in LV grids thanks to the installation of smart PV inverters with batteries (capacity between 4,5kWh to 9kWh are expected) which allow increasing self-consumption levels and peak shaving of PV production and thus securing the power quality according to EN 50160 standard. Delivery of active power from batteries in case of under frequency, undervoltage or in case of receiving signal from DSO through narrow band simple one-way PLC communication (emergency functions).

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion (LiFEPO)	**6**	**3.2**	**Low**

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. CEZ Distribuce will test the influence of using the residential energy storage systems (PV + battery) on the PV peak shaving in one LV distribution network and assesses the potential of grid-connected energy storage systems (for increasing the flexibility by providing grid services). The smart energy storage functions which are going to be tested are: active power injection in case of DSO request (remote control) and active power injection in case of under frequency or under voltage in the distribution network (autonomous, local-only control). Customer participation is essential. Testing the influence of residential energy storage systems on solar peak shaving helps determining how these systems affect the power quality and how they contribute to avoiding congestions in the distribution network.

Expected impacts. PV and battery solution will be able to react on DSO commands and on under voltage or under frequency in distribution system:

a) in case voltage in the point of PV inverter + battery connection is lower than predefined value, thus the PV inverter + battery will discharge: this will help to increase the voltage in the point of connection
b) in case frequency in the point of PV inverter + battery connection is lower than predefined value, thus the PV inverter + battery will discharge: this will help to increase the frequency
c) in case of emergency, the DSO dispatcher will decide to discharge the battery and sends a command through narrow band simple one-way PLC communication, based on that signal, PV inverter + battery will discharge and this will help to reduce load in the selected area.

Further information will be available once the project is more advanced.

InterFlex demo in France ("Nice Smart Valley")

A **Medium Voltage Islanding storage**, wireless control architecture will be developed in order to enable the master converter to control the slave asset in islanding mode, innovative algorithm in order to optimise local consumption and production management in regard to historic data and real time measurements, master the grid stability with either inductive and/or capacitive grid configuration. The following services will be supplied in a multiservice approach: **collective self-consumption**, ancillary services, grid constraints mitigation, islanding, end user power subscription reduction. The DSO will use storage system for islanding and distribution grid constraints mitigation.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**620**	**250**	**Med. & Low**

EVs: ☐ Yes ☑ No

SERVICES TO: ☐ Conventional generation ☑ Renewable generation ☐ Transmission grids ☑ Distribution grids ☑ Customers

Description. The storage systems within Nice Smart Valley / INTERFLEX will be used for providing several services in a multiservice approach. Collective self-consumption will be done at secondary substation level, the customers using a single community energy storage to increase self-consumption rate at district level. **This will be the first self-consumption scheme with a shared storage system in France.** Islanding of two islands in the south East of France will be performed with two storage systems: a master asset operated by the DSO and a slave asset operated by an aggregator. Storage systems will also be used to mitigate grid constraints at distribution grid level (MV and LV), as a flexibility for the grid. The aggregator will also value the storage system on markets, such as ancillary services and balancing mechanism.

Expected impacts. The project will allow to deliver the following feedback:

- Technical feedback on an islanding at MV level with two storage systems (master/slave)
- Grid constraints mitigation capability of storage systems
- Collective self-consumption scheme with shared storage systems.

Issues of market design between DSO and aggregators will be raised and targets for market design could be proposed by the partners of the project.

InterFlex demo in Germany

In Germany InterFlex seeks to activate all types of flexibility owned and operated by household customers. Residential batteries, oftentimes operated in combination with a rooftop PV, can be an important part of the flex portfolio. Moving forward batteries can be used to charge and discharge in response to the DSOs. Due to regulatory and technological barriers the actual use of batteries in the German demo is currently being reevaluated.

FEATURES OF BATTERRIES IN THE PROJECT: Small batteries, normally Li-ion, owned by household customers

EVs: ☐ Yes ☑ No

SERVICES TO: ☐ Conventional generation ☑ Renewable generation ☐ Transmission grids ☑ Distribution grids ☐ Customers

Description. Focus is on activation of privately owned flexibility by the DSO in order to improve power quality, relieve grid congestion and increase the grids hosting capacity.

Regulatory barriers. Batteries operated by household customers in combination with a rooftop PV are not necessarily an attractive option: they are giving up PV-related support. This imposes a severe restriction on provision of services to wider energy system. Furthermore, the technical solution that is currently employed to control LV connected generators is not advanced enough to allow the DSO to leverage batteries for local flexibility.

InterFlex demo in the Netherlands

Experiments aim at validating the use of batteries for congestion management and EV integration (including in the fast charging context). There will be a technical aggregator who will manage the local battery and decides if and when the battery is used to solve congestion and power quality issues towards the DSO or TSO. This use case conceptualizes, implements the systems and interactions necessary to achieve a stable grid through flexibility using Smart Storage Unit and PV systems.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion (NMC)	315	250	Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☐ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☐ Customers

Description. Test and validation of the application of a smart storage unit for the following purposes:

- Congestion management;
- Energy trading / portfolio management through spot, imbalance market and/or ancillary service provision;
- Power quality improvement (voltage support) upon request from DSO.

Expected impacts. The exploitation of the battery is done by the LIMS operator in the project. This is a local party that can facilitated several DER equipment to deliver flexibility when needed. The LIMS operator can use the battery on the national TSO market or the local DSO market. A market mechanism is to be tested on the impact and the economic feasibility of the deployment of the battery.

InterFlex demo in Sweden

Another main focus of the project is the **power electronics control for a microgrid at MV**. Main aspects tackled:

- Demonstrate islanding and operation of a zero-inertia microgrid,
- Tuning the primary & secondary control systems to achieve the best balance of quality of supply & fast response
- Making the business case stack up for installing the battery systems in microgrids,
- Reducing the cost of installation (cabling, communication systems, logging etc), and
- Addressing the issues of what responsibility a local microgrid controller can have (rather than the dispatch centre)

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	330	800	Medium

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. Within the project:

- 500kW wind turbine and 440kW of solar installed on an existing site with 150 customers consuming up to 900kW of load across five substations.
- 800kW / 330kWh BESS system installed to demonstrate that the community could be taken off-grid and the BESS system can manage the power quality without any conventional rotating inertia (power electronics interfaces from the wind turbine and solar generation) while the load and generation vary.
- Backup generator on renewables fuel has been integrated into the microgrid and generates power when needed to extend island operation to demonstrate control of power electronics in parallel with conventional synchronous generation.
- Behaviour through an electrical short circuit at LV has been demonstrated.

The community has been taken off-grid >30 times with power quality when islanded being similar to being grid-connected, and seamlessly reconnected to the supply. TheAs a proof of concept, the BESS selected is high-power, capable of supplying full load for only 30 minutes with no generation. During times of surplus the BESS can support islanded operation indefinitely, and during deficit the backup generation is run. The tests are being extended and DSR (Demand Side Response) systems included to show the value of DSR in increasing autarchy.

Expected impacts. Planning on installing similar solutions at sites requiring off-grid capability, such as communities in Northern Sweden that suffer from regular outages, where the capability to operate off-grid could increase their security of supply. In areas of weak grid, the BESS will allow increased RES to be connected and reduce curtailment.

WISEGRID (2016-2020)

Wide scale demonstration of Integrated Solutions and business models for European smartGRID

http://www.wisegrid.eu/

Main features: promotion of self-consumption and use of batteries, including EV batteries, by aggregators through special tools and platforms. WIseGRID main challenges related to batteries are:

- Proving their capability to provide ancillary services to the DSOs
- Providing economic benefit to their owners (in addition to the already known benefits such as self-consumption)
- Thanks to their batteries, some EVs will be used as an extra source of flexibility while they are charging

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	6.5 66	2.5 72	Low

EVs
☑ Yes
☐ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. The WiseGRID project will develop a specific tool for storage systems (called WG STaaS VPP) that will be mainly used by aggregators and tested during the demonstration step of the project. The use of batteries will be also tested in the tools WiseCORP and WiseHOME (focused on facility managers, ESCOs and domestic consumers who own RES such as PV panels). All the batteries will be about 6.5 kWh energy capacity. These batteries, will be tested in households and small businesses in Ghent (Belgium) and Kythnos (Greece) and fulfill the green code requirements.

Moreover, the project will take advantage of 6 EV batteries (total capacity 96 kWh) to give support to the local DSO in Terni (Italy). These batteries are being deployed in the ELSA project in which Terni is also a pilot site.

Also it is noteworthy the EVs that will be used in WiseGRID for testing purposes. In WiseGRID, 14 EVs will be monitored and will profit their battery flexibility capacities (most of all for grid balancing) in Ghent, Crevillent (Spain) and Terni.

Expected impacts. WiseGRID will validate innovative storage services that will benefit both grid and consumer, empowering citizens and balancing the grid. The use of the innovative WiseGRID storage services would reduce the future costs of these products, promoting storage systems industry in Europe. This promotion of batteries will also help to spread Self-Consumption in Europe (this means that the penetration of DER will be fostered).

Regulatory barriers. The lack of demand response regulation in some EU countries.

Distribution system / From grid to building & household level

STORY (2015-2020)

Added value of STORage in distribution sYstems

http://horizon2020-story.eu/

STORY

STORY demo in Belgium

Main features: Development, testing, improving and demonstrating a residential and industrial hybrid storage system that can smoothly (without interruption) go from on-grid operation to off-grid operation, inject on demand and consume on demand. This system allows to increase self-consumption and avoid injecting PV energy during moments with a risk for curtailment. A similar system is installed in the industrial site where it is not connected to a PV set-up but to an ORC[18]. In both residential and industrial cases, continued supply in case of a black out on the grid side has shown to be relevant (several instances occurred so far). The control system is based on monitoring voltage levels. The residential set up is further equipped with a multi-energy model predictive control which can increase self consumption or reduce cost.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion, Lead-acid, NiFe	46	18	Low

EVs
☑ Yes
☐ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. Two cases deal with the technical features described above:

- Residential end-of-line case. 1 hybrid set up: can work on- and off grid
- Industrial case meant to improve power quality and reduce black outs (occurring because of high peak power demands)

Expected impacts. STORY has set up a separate company installing now commercially the developed systems[19]. The project is involved with the development of the subsidy scheme for batteries.

Regulatory barriers. Safety issues with regards to multiple phase buildings should be tackled. Remuneration schemes for services provided by batteries are missing.

[18] New wood fired boiler (1.6 MW) will be installed with a heath delivery of 150°C. This boiler is in connection with a ORC (Organic Rankine Cycle). The ORC produces electricity of +/- 90 kW/h.
[19] This has been done despite the net metering in Belgium.

STORY demo in Slovenia

Main features: demonstrate the flexible and robust use of medium scale storage unit in two contexts: connected to low voltage substation in a residential grid and to industrial energy infrastructure. The control of the plant is made for ensuring reliability in the event of blackouts, performing peak demand control within the daily load diagram, reducing line congestion, controlling the voltage control and participating in reserve market operation.

FEATURES OF BATTERRIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	330	170	Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. Medium scale storage unit (170kW, 330 kWh) for demonstrating the flexible and robust use in diverse applications is fabricated by ABB. This battery energy storage system BESS will first operate connected to 1x 400 kVA OLTC MV/LV transformer station of Elektro Gorenjska supplying Suha village residential grid. In the second demo case, storage unit will be connected to LV industrial grid in Elektro Gorenjska headquarters in Kranj.

In residential demonstration case, battery storage with power conversion unit will be situated near the transformer station. The residential district of the village of Suha has a 400-kVA transformer (20kV/0,4kV) and high penetration of (210 kW) of PV generation.

The EG headquarter, with the variety of installed power production and storage devices, will serve as a test bed for connection of medium scale storage unit in the industrial grid. It comprises the following equipment:

- 35 kW Photovoltaic power plant
- Cold storage (Ice bank) within the heating / cooling facility
- 27 kW combined heat and power unit
- 2x 630 kVA transformer station
- 80 kW diesel generator

The integrated management of battery and the equipment at each of the locations will focus on the following use cases:

- Increased RES use: Increase of distributed RES integration efficiency, reduction of RES curtailment.
- Peak demand control: Peak shaving & peak shifting, incl. smart supply scheduling based on model predictive control
- Reserve provision: Provided as ancillary service
- Voltage support: Activated locally (storage PLC) in case of under/over voltage detection
- Congestion management: Reduction of current congestion in LV network
- Fault Ride Through: Supports network in case voltage dip
- Zero load provision: Independence of energy consumption from the grid
- Reactive power compensation: Transformer losses reduction, coordinated with Voltage support.

Expected impacts. The investigated use cases focus on improvement of supply reliability, benefitting the DSO or possibly providing services that could be valorized by market actors. The SCADA software upgraded with STORY control algorithms will be a multiplier for other DSOs in Slovenia and EU, as the SCADA manufacturer is integrating them in their products.

Regulatory barriers. In future the ownership of storage will likely be restricted to free market actors. A cooperation model with market actors therefore will have to be investigated. In demonstration projects, a grid-charge exemption for pilot cases is already in place in some countries (e.g. Austria), but not in Slovenia. The STORY team is currently discussing with the Slovenian NRA an amendment in the new 2-year Grid tariff plan that is currently under public consultation.

STORY demo in Spain

Main features: demonstrate the feasibility of a pilot plant for peak-shaving services from the customer point of view (manufacturing plant). The control of the plant is made based on economics and the demonstrator deals with technical, market, business model and regulation challenges. Indeed, regulation has an important impact in the energy management strategies implemented in the control since limits very much the operation of the storage system at that point of making the system non-profitable depending on that.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**200**	**50**	**Low**

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☐ Distribution grids	☑ Customers

Description. The pilot plant is installed in the facilities of a refrigerated cabinets' manufacturer and comprises a PV plant of 113 kWp, a Li-ion battery (50 kW/200 kWh) and the power consumption of the factory including the manufacturing processes the loads of a factory (280 kW). The main stakeholder involved is the factory owner (consumer) since power exchange with the grid is not allowed yet by the Spanish regulation for self-consumption[20]. Nowadays, the plant is running with a basic strategy to reduce the power peaks as much as possible taking into account that battery can only charge from the PV plant- according to the current regulatory framework. It is expected to implement an advanced strategy to charge the battery from the grid in the next months which will allow to consider the tariffs and increase savings. Preliminary results obtained up to now point out savings of 8% in the electricity bill that could increase up to 20% with the advanced strategy and make the plant profitable.

Expected impacts. The peak-shaving can benefit the DSO since the network can be operated in a more efficient way, reducing congestions and deferring investments. If demonstration at the local level is successful, with a proper regulation in the future, DSOs could use these storage systems for improving the network operation and batteries could be exploited for grid support services.

Regulatory barriers. In this demo plant the main challenge is regulatory since storage of electricity not produced by renewable sources (and hence locally in the plant) is not allowed. Technically the plant is working well but the strategy to operate the plant is limited by the regulation making very difficult the cost-effectiveness of this solution. Current self-consumption regulatory framework allows only charging the energy storage systems (battery) from the renewable energy generated on-site and energy excess cannot be fed into the grid. Therefore, the energy management based on off/peak hour tariffs is difficult. Regulation to support and promote the flexibility services provided by storage systems are necessary. If electricity storage regardless of source would be legal in Spain, the business case of a battery optimizing the electricity flows to and from the grid would be much more favourable. Clean Energy package should help solving the above problems but it will also depend on how ambitious Member State(s) will be in transposing the relevant requirements.

[20] Self-consumption regulation in Spain comprises different types of plants depending on the renewable power installed, etc. In this demo, the regulation didn't allow charging the battery from the grid, only from the PV energy produced on-site, and the excess of PV energy cannot be fed into the grid so, renewable generation and factory loads are balanced internally to minimise the energy consumption from the grid or maximise the "self-consumption".

ELSA (2015-2018)

Energy Local Storage Advanced system

http://www.elsa-h2020.eu

Main feature: develop an industrialized scalable Storage system using 2nd life EV batteries and develop the ICTs and EMS to deliver services to customers including Buildings, Districts and Grid using this storage system. Within the project, business models will be tested such as: Sell storage as a service; Provide different services to several customers using the same storage system (for example: Building + DSO).

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	**22 to 88**	**24 to 96**	**Low**

EVs
☑ Yes
☐ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. Within the project, the second use EV batteries are used to build a storage with a specifically developed smart power converter. A storage system is composed of:

- 1 to 8 Second life EV batteries
- 1 to 8 DC/DC converter (one per Battery)
- 1 AC/DC power converter (power range from 24 kW to 96 kW)
- 1 Central controller to perform power allocation, safety functions and communication.

The services provided are: peak shaving, increased self-consumption, time shifting, arbitrage, reactive power compensation, ancillary services, harmonics filtering, frequency control, primary reserve... Business models are based on the possibility to deliver different services with the same storage

Expected impacts. Exploitation plans will be based either on selling the storage (linked with the increasing availability of the second use of EV batteries) or selling services to several customers through financing, installing and exploiting a storage system in their premises. Impact will be on integrating more REN, maximizing auto consumption and offer flexibility to the Grid. The challenges are due to the different legislation in each country and the difficulties to stack services sold to different customers with the same storage

Regulatory barriers. With the same storage device, not all the services are allowed in different countries. Regulatory barriers are linked to ownership of the storage, aggregation is not authorized in all countries, stacking of services not allowed in all countries, minimum size of storage involved.

NOBEL GRID (2015-2018)

New cost-effective business models for flexible Smart Grids

http://nobelgrid.eu/

Nobel Grid Smart energy for people

Main features: Innovative smart meter, ICT services and new business models supported by the deployment of small batteries.
The project has developed and demonstrated new tools and business models that allows all European citizens to benefit from a more secure and stable distribution network, promoting the integration of distributed renewable energy sources and greater participation of consumers and "prosumers" in the energy market.
As main ground-breaking objective of the project, NOBEL GRID provides solutions for all the actors, such as advanced Smart meters and final users Applications, in order to share the benefits of the Smart Grid in a fair, sustainable and efficient way. In this context, NOBEL GRID promotes, demand response schemes, supported by the deployment of batteries.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Li-ion	10	10	Med. & Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☐ Conventional generation	☑ Renewable generation	
☐ Transmission grids	☑ Distribution grids	☑ Customers

Description. Only small batteries are used as the use of batteries in NOBEL GRID demonstrators will be only based on the (additional) flexibility that these are able to offer to the grid, to the end user directly, or to the DSOs, managed by the aggregators or retailers. Batteries are not the main solution demonstrated in the project. They are more a support to the rest of the demonstration site. The batteries have been used in the project only for very limited tests on demand response.

Regulatory barriers. In some European countries (i.e. Spain), there are different (indirect) costs for using batteries in order to provide the user with flexibility. To foster the deployment of this type of services this barrier would need to be tackled. This is the case of the Sun Tax in Spain, the law adopted on October 9, 2015 aims at the group of solar system owners that produce their own electricity while being connected to the national power grid. With the passing of the law, those with self-consumptive photovoltaic systems have to pay the same grid fees as those without solar panels. They also have to pay a second “sun tax” which means solar panel owners pay for the electricity they generate and use from their PV systems, even though it doesn’t come into contact with the grid. Photovoltaic systems up to 100 kW are also not able to sell any excess electricity they produce. Instead, they must “donate” the extra to the grid free of charge. While this last aspect may to some extent encourage storage, this is clearly not the best way to do so. In view of massive opposition to the sun tax system, including from international organisations, it’s likely to be removed/adjusted.

Technological development

NAIADES (2015-2018)

Na-Ion bAttery Demonstration for Electric Storage

http://www.naiades.eu/

Main feature: The NAIADES project aims to develop and demonstrate the ambient Na-ion battery under realistic conditions as an effective alternative to the Li-ion battery for stationary Electric Energy Storage (EES) application. The overall purpose of this project is to develop a battery technology based on the sodium ion technology for sustainable EES that would bring a radical decrease in cost with respect to the lithium ion technology while ensuring sustainability and performance in terms of safety, cycle life, and energy density.

FEATURES OF BATTERIES IN THE PROJECT			
Techno	kWh	kW	Voltage
Na-ion	0.7	1	Low

EVs
☐ Yes
☑ No

SERVICES TO:		
☑ Conventional generation	☑ Renewable generation	
☑ Transmission grids	☑ Distribution grids	☑ Customers

Description. First objective: improve the understanding of the technology and develop materials at labscale: two positive electrode materials (Na3V2(PO4)2F3,120 mAh/g and Na2/3Fe1/2Mn1/2O2, 180mAh/g) and one negative electrode (Hard carbon, 250-400 mAh/g) were selected.

- Second objective: scale up of the materials synthesis to conduct a first module demonstrator (20-70 kg of active materials, module of 1kWh, 1kW) to be integrated in a secondary substation as a back-up battery.
- Third objective: develop solutions to answer environmental challenges by performing a first Life Cycle Analysis (LCA) on the Na-ion system and give recommendations into the future energy policy.

Expected impacts. Too early development stage of the battery to be able to tackle this section.

Suggestions beyond the Clean Energy package? Considering the importance of batteries storage for grid ancillary services or in all decentralized energy applications (in relation with renewable local implementations), their development and access to the market should be promoted through adapted public policies, including evolution of power markets rules in Europe, in order to ensure a convenient remuneration for the numerous services they are able to bring.

Annex: list of projects and corresponding calls

Project	General description of the project	Period
LCE-07-2014 - Distribution grid and retail market		
Nobel Grid	NOBEL GRID will provide advanced tools and ICT services to all actors in the Smart Grid and retail electricity market in order to ensure benefits from cheaper prices, more secure and stable grids and clean electricity.	2015-2018
LCE-08-2014 - Local / small-scale storage		
Elsa	ELSA will adapt, build upon, and integrate close-to-mature storage technologies and related ICT-based energy management systems for the management and control of local loads, generation and single or aggregated real or virtual storage resources, including demand response, in buildings, districts and distribution grids.	2015-2018
NETfficient	The NETfficient project will deploy and demonstrate local energy storage technologies and develop information and communication tools, to exploit the synergies between energy storage, the smart grid and the citizens.	2015-2018
STORY	STORY is a European project researching through 7 pilot plants new energy storage technologies and their benefits in distribution networks and involves 18 Partner Institutions in 8 different European countries.	2015-2020
TILOS	TILOS' main goal is to demonstrate the potential of local / small-scale battery storage to serve a multipurpose role within a smart island microgrid that features high shares of renewable energy and trades electricity with the main electricity network.	2015-2019
LCE-10-2014 - Next generation technologies for energy storage		
NAIADES	The NAIADES project aims to develop and demonstrate the ambient Na-ion battery under realistic conditions as an effective alternative to the Li-ion battery for stationary Electric Energy Storage (EES) application.	2015-2018
LCE-02-2016 - Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system		
GOFLEX	The GOFLEX project innovates, integrates, and demonstrates a group of electricity smart-grid technologies for managing flexibility in energy production and consumption.	2016-2019
integrid	InteGrid's vision is to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services	2017-2020
inteGRIDy	inteGRIDy pursues facilitating the optimal and dynamic operation of the Distribution Grid, fostering the stability of the electricity grid and coordination of distributed energy resources, Virtual Power Plants and innovative collaborative storage schemes within a continuously increased share of renewable energy	2017-2020

Project	General description of the project	Period
InterFLEX	InterFlex investigates during 36 months the INTERactions between FLEXibilities provided by energy market players and the distribution grid. This project focuses particularly on energy storage, smart charging of electric vehicles, demand response, islanding, grid automation and integration of different energy carriers (gas, heat, electricity).	2017-2019
sm;)e	The SMILE project aims at demonstrating different innovative technological and non-technological solutions in large-scale smart grid demonstration projects in islands, paving the way for their introduction in the market in the near future.	2017-2021
WiseGrid	WiseGRID will provide a set of solutions and technologies to increase the smartness, stability and security of an open, consumer-centric European energy grid.	2016-2020
LCE-07-2016-2017 - Developing the next generation technologies of renewable electricity and heating/cooling		
GRIDSOL	GRIDSOL aims to provide secure, clean and efficient electricity by combining primary renewable energy sources and technology under an advanced control system called Dynamic Output Manager of Energy (DOME) supplying secure electricity and contributing to grid stability through Smart Renewable Hubs.	2016-2019
LCE-04-2017 - Demonstration of system integration with smart transmission grid and storage technologies with increasing share of renewables		
crossbow	CROSSBOW will propose the shared use of resources to foster cross-border management of variable renewable energies and storage units, enabling a higher penetration of clean energies whilst reducing network operational costs and improving economic benefits of RES and storage units.	2017-2021
flexitranstore	FLEXITRANSTORE project will develop the next generation Flexible Energy Grid (FEG), which will provide the technical basis supporting the valorisation of flexibility services and enhancing the existing European Internal Energy Market (IEM).	2017-2021

Report developed by DOWEL MANAGEMENT
within the INTENSYS4EU Coordination and Support Action
(H2020 Grant Agreement n° 731220)

More information at http://www.h2020-bridge.eu/