European Commission

# bridge

## Unleash the potential and value of power system flexibilities

Case study #1

# Unleash the potential and value of power system flexibilities

Case study #1

# DOCUMENT INFORMATION

## Editors


- Clémentine Coujard, Dowel Innovation
- Athanase Vafeas, Dowel Innovation


## Support from BRIDGE secretariat


- Shenja Ruthenberg, *CLERENS, BRIDGE Secretariat*
- Marcos Jareño*, ZABALA, BRIDGE Secretariat Coordinator*


## Acknowledgements

The editors would like to acknowledge the valuable inputs from the communication managers involved in the different BRIDGE projects, who participated and contributed to the regular meetings of the task force and the consultation rounds as well as members of the SPRING team, all contributing to this BRIDGE Annual Report of TF Joint Communication.

## European Commission

- *European Commission – Energy Directorate-General, Unit B5 "Innovation, research, digitalisation, competitiveness"*
- *European Climate, Infrastructure and Environment Executive Agency - Unit C.C2 "Horizon Europe Energy"*

# INDEX

# 1. Power system flexibility, a strong asset and requirement

## 1.1 Context

In reaching the great ambition of a Climate-neutral Europe by 2050, renewable energy sources (RES) and the electrification of end uses have major roles to play. But they also constitute a key challenge for our historical electricity networks, designed in a time of centralised generation, single-way power flows and rotating machines:

- on the generation side, the intermittent nature of RES, their low predictability, their absence of physical inertia and their power electronics trigger instability issues on the network,
- on the demand side, new types of loads such as e-V charging put additional stress on local power systems

On the other hand, some recent technologies and regulations provide new opportunities to mitigate the effects of massive RES integration and end-user electrification:

- Storage solutions provide a direct source of flexibility to balance and operate the system in a safer way
- The Clean energy for all Europeans legislative package will enable consumers and prosumers participate in new markets and be remunerated to adapt their behaviours to the grid needs
- Digital technologies enable a deeper and faster coordination of all power system components and participants creating the conditions of all types of flexibility.

## 1.2 Benefits

These elements combined can deliver new sources of flexibilities for the electricity networks, that can help:

- Limit and/or defer grid reinforcement investments, and therefore enable the further integration of RES at an acceptable cost for society
- Improve network operation via new types of services, provided by new types of stakeholders
- Increase consumer engagement toward energy and overall power system efficiency.

## 1.3 Pending challenges

Implementing new sources of flexibilities in the power system implies to answer, among others, the following questions:

- What are precisely the flexibility services needed by network operators, considering the evolutions generation and demand required by the energy transition?
- Which solutions can meet these needs in a profitable manner?
- How can the value of flexibity be distributed among the different stakeholders?

The next pages illustrate how some of the BRIDGE projects contribute to answering these questions.

**In a spirit of synthesis and conciseness, only a limited selection of illustrative project results is presented, as of September 2021.**

# 2. How to capture and value power flexibilities?

In order to identify and capture the sources of flexibility within the system, turn them into valuable services to the grid, and remunerate these services in a stimulating manner, three main building blocks are investigated by H2020 projects:

- **HARMONISED DIGITALISATION** to implement flexibilities. This refers to the development and integration of controls, automation and real-time communication solutions through an interoperable approach, allowing responsive behaviours of network assets and market participants to market/grid requests
- **BUSINESS MODELS & MARKET DESIGNS** to reach the profitability of flexibility services. This means assessing the flexiblity services required, and how such services can be provided in a profitable manner through combinations of technical solutions, market players and market conditions
- **INVOLVEMENT OF FLEXIBILITY PROVIDERS:** to maximise the volume of flexibilities consisting in the real-life implementation and testing of RES and demand-side flexibilities to evaluate their potential for scale-up and replication.

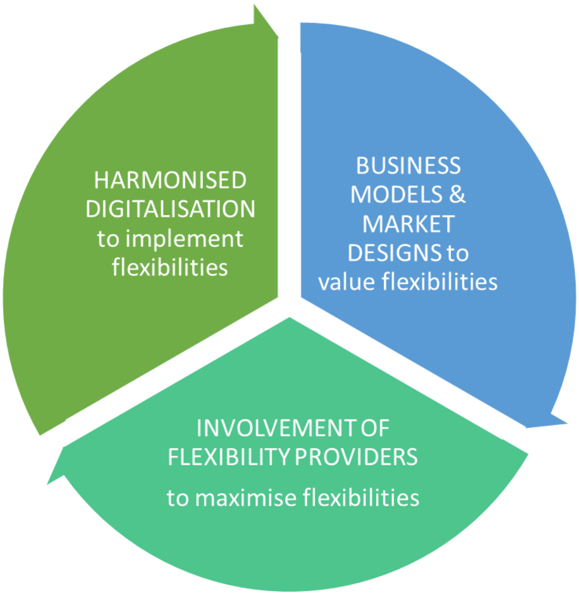



Figure 1: The three building blocks to explore power system flexibilities

This case study focuses on five H2020 projects that address those buildings blocks complementarily:

- OSMOSE investigates the optimal mix of flexibilities with a focus on the transmission grid, through four TSO-led demonstrations.
- FLEXIGRID develops interoperable hardware and software solutions for flexibility services at distribution level.
- INSULAE aims to demonstrate RES-based power systems in geographic islands with a full systems approach that augments synergies achieving lower operating costs with high RES penetration.
- SMILE focuses on demonstrating smart grid solutions in three islands with different policy, regulatory and market contexts.
- INVADE deals with the integration of eV and batteries to empower storage in distribution grids. The Norvegian demonstration explores eV user behaviours, while the Dutch demonstration tests different charge points (home, office, public space)

# 3. HARMONISED DIGITALISATION to implement flexibilities

Digital technologies offer opportunities to better coordinate 1) the different assets of the power systems, with controls on RES generation, storage, grid components and end-user loads to ensure grid stability; and 2) the different stakeholders in the electricity markets, with real-time data-exchange platforms accessible to all parties. However, some technical challenges remain, such interoperability issues, and data governance, or limited maturity of some technological solutions.

## 3.1 At distribution level, forecast and control algorithms are tested to handle jointly flexibility and system security

- **FLEXIGRID** project in its goal to enhance the grid hosting capacity of RES, through DR, P2X, electricity storage and variable generation has developed algorithms to improve distribution network operation considering jointly flexibility and system security. As of today the developed tools include a software module for demand and generation forecasting whose algorithms will be fine tuned in demonstration. The second tool consists in a platform for improved control technologies for smart operation of grid assets, which enabled the defintion of IoT devices for microgrid smart control (e.g. Energy Box integrated in distribution secondary substation) [source project coordinator contribution 'August 2021 achievements']

- **FLEXIGRID** project analysed also the RES hosting capacity and its effect on power system security: the identification of current **protection** devices in faulted phase and directionality declaration are both highly valuable for the defintion of new secured algorithms [source project coordinator contribution 'August 2021 achievements']

- **FLEXIGRID** project in its goal to mitigate (short and long term) congestions in the distributed grid has specifically developed a software module for congestion management which will be tested in a pilot in Greece [source project coordinator contribution 'August 2021 achievements']

- Within **SMILE**, an aggregator platform (Load controller) enables energy consumers and producers in the Orkney demonstrator to access the value of the latent flexibility in their energy consumption and production patterns. With intelligent control, flexible assets may be used to provide balancing or ancillary services to the power system, which in turn will facilitate the cost effective integration of renewable energy and electric vehicles into the power system [source project coordinator, September 2021]

## 3.2 5G and IoT solutions are explored as drivers for customer adoption

- **Unije island** in Croatia in its ambition to become a self-sufficient island has deployed a specific use case in **INSULAE** project combining digitalisation and customer adoption and aims at empowering islands' energy communities through 5G and IoT technologies for flexibility services. Inhabitants will be in position to monitor and manage all their consumption through a connection to the control centre. As of mid 2021, equipment is installed in several households in the islands and demonstration is ready to start (source website).

## 3.3 Data storage services facilitate the integration of IT solutions

- In **SMILE**, the Energy Management System (EMS) consists of a flexible data storage and querying system, which integrates all the technological solutions tested in the Madeira demonstrator. The datastore and visualization aspect of the EMS provides a hardware agnostic approach for electricity monitoring and feedback. The datastore service can enable installations or equipment to be easily integrated (data wise) with third parties. This service can also be used to integrate data from equipment which belong to different vendors or installation, which cannot otherwise be integrated in the same service. The datastore services also allow services that use that data as an input. One of these services that is currently implemented is a set of control algorithms for Battery Storage Systems. This remote service has the advantage of being able to consider not only data from the household, but also external information such as weather forecast. This service maximizes the utilization of the Battery Storage System considering self consumption or cost factors [source project coordinator, September 2021].

## 3.4 At transmission level, a flexibility bidding platform is developed and tested in a cross-border area

- **OSMOSE** is testing a cross-border market platform (FlexEnergy) for close-to-real time optimisation of grid resources at the Italian-Slovenian border. Flexibility providers use a dedicated bidding tool while the TSOs integrate a full market optimisation software suite in their business environment. Tests are ongoing for the activations of flexibility units 15 minutes to real time. [Deliverable D6.3, 2020].

## 3.5 To support grid stability against RES deployment, grid forming controls have proven their feasibility

- **OSMOSE** demonstrated grid-forming algorithms in real environments. These inverter controls help mitigate grid disturbances at very short time scale, and are therefore particulary relevant for systems with high-RES penetration and low physical inertia. OSMOSE WP3 demonstrated that of-the-shelf converters equipped with grid forming controls can provide response to frequency variations of the power system in less than 5 milliseconds.

- **OSMOSE** WP3 also demonstrated that converters can perform grid forming on top of the conventional services they usually provide to the grid (e.g. peak shaving), and without oversizing the converter. Also the dedicated controls are robust against grid events such as voltage faults. These findings demonstrate that the grid forming capability can be added to existing devices at a limited cost to provide additional services, a significant step towards their economic viability.

- To enable manufacturers to integrate grid forming capabilities into their equipment, **OSMOSE** WP3 defined some precise technical specifications for grid forming devices, as well as a testing method to validate their related capability.

## 3.6 Interoperability is improving thanks to revised processes and protocols

- **OSMOSE** enhanced the IEC61850 standard for the interoperability of electronic devices in substations. The engineering process proposed eases the specification, configuration and installation of intelligent electronic devices, enabling users to create vendor independent system specifications and making electronic devices' capabilities transparent to users [D7.1, 2020]

- **FLEXIGRID** develops standardised communication protocols and ICT infrastructure over the whole chain connecting networks, devices and remote management platforms. The Cyber ICT layer on top of the hardware and software layers supports interoperability and compatibility of the developed solutions with the different platforms used by the European DSOs.

- In **FLEXIGRID** project, communication infrastructures and communication protocols for smart meter data in critical moments and areas in a context of close to real time monitoring are also developed and will be tested in four European distribution grids.

- **INSULAE** through the Investment Planning Tool (IPT) and a big data platform and island categorisation as well as demonstrator replication activities will look to standardise the metrics for demonstrator outcomes and energy system improvements, allowing comparisons with other energy systems to be made and helping in planning of future energy systems.

# 4. BUSINESS MODELS and MARKET DESIGNS to value flexibilities

While flexibility sources are quite well identified in the power system, the remaining challenge is to capture them in a way that is profitable for the different stakeholders involved. This implies to test the real implementation of flexibility services and identify the most suited business, market and regulatory conditions for the economic viability,

## 4.1 A quasi fossil-free business model is validated in insular real environment

- The Samsø island demonstration in **SMILE** is consistant with the vision to make it an island 'free of fossil fuel by 2030'. On the energy standpoint objective is to make a better use of the green electricity produced on the island through two technical objectives: testing a battery energy storage system and developing and testing a control system which allows for dynamic prices [Deliverable D3.1 SMILE and project demonstration]. The business model developed for the Samsø island demonstration in **SMILE** project proved its financial sustainability by reaching a viable payback period and exploring novel billing practices. BESS improved the annual utilisation of the PV plant to 89% instead of 45%.

## 4.2 Business models explore combined flexibility of different storage types

- In **INSULAE** in the Madeira demonstration, smart-charging technologies (V1G) have been deployed and will provide the background data required to formulate the potential flexibility benefits of this technology and the potential remuneration for market actors. In particular 25 users have been selected to participate in the V1G demonstration. In addition other charging types (V2G- vehicle to grid) are to be assessed in the coming months in Madeira and in Bornholm, along with BESS and photovoltaics in both Bornholm and Unije [project coordinator, September 2021].

- In order to provide flexibility services by using the thermal storage capacity of electric heating/cooling systems and electric water heaters, **FLEXIGRID** project developed a virtual thermal energy storage model for residential customers. This includes different models such as occupant behaviour model, including the occupancy profiling engine and the comfort profiling engine, building thermal model, DER models - for air-to-air inverter and non-inverter HVAC systems [source coordinator Aug 4th, 2021].

- **INSULAE** investigates business models over 7 use cases: 1 Joint Management of hybridised RES and storage; 2 Smart integration and control of water and energy systems; 3 Empowerment of islands energy communities through 5G and IoT technologies and flexibility services; 4 Transition to DC power grids; 5 Local bio-based economies supporting the electrical, thermal and transport systems integrated management; 6 Electrification of the islands' transport looking to grid frequency and voltage regulation; 7 Storage and power electronics for the stabilization of weak grids and microgrids. The delivery of services to the end user generally requires cooperation of government, DSOs/TSOs or other utilities, with the help of tehcnology providers and inermediaries [source deliverable D9.1, 2020].

- INVADE project analyzed methodologies and models to estimate the value of flexibility from mobile and stationary storages in distribution grids, with a focus on three types of consumer flexibility: DSO, Balancing Responsible Party (BRP), and Prosumer. The project proposed a method to evaluate the flexibilty potential of the mentioned solutions and a cost benefit analysis to compare different flexibility options. The most important factors determining the value of each flexibility service to the DSO are identified, with a method for estimating the combined value of two or more of these services [project deliverable D5.2, 2017].

- The Norwegian pilot in INVADE highlights the value of combining various use cases: the different use cases separately have limited savings compared with a combination of the different use cases. The most efficient and cost saving is to combine the different use cases in one solution). Total savings in average for all the pilots in Norway which could be combined in one solution amount to 580€ by using battery in combination with PV and eV-charging with a breakdown of savings per use case [Source INVADE project coordinator, Sept 2021]:
    - **Optimised own production, PV + Battery**: 44 € saved per year
    - **Power tariff/ peak shaving, eV + Battery:** respective daily savings amount to 0,93€ for eV and 0,49€ for batteries
    - **Time of Use, eV + Batteries:** respective daily savings amount to 0,04€ for eV and 0,02€ for batteries.

## 4.3 Awareness-raising and co-creation processes succeed in fostering citizen engagement

- **INSULAE** deploys a series of workshops for engaging local citizens to cleaner energy and the creation of energy communities, in particular exploring criticalities such as use of energy data for non-energy services, or the market organisation (tariffs, and regulation of the demand side organised in communities). They are supported by regulatory framework analyses in each islandic context. In **Unije** and **Madeira** where the highest levels of community engagement were required initial workshops[1] attracted 34 and 44 attendees respectively. In **Unije** this represents 40 % of the local permanent population, 85. Additional actions have reached many more local citizens and other stakeholders. The creation of visualisation tools and digital engagement tools to be used within the households (in **Unije**) or for vehcle charging (in **Madeira**) can leverage other included functionalities to increase engagement with energy usage. These take the form of applications with easy to use interfaces.
- **INSULAE** has designed its replication strategy around the motivation of local stakeholders to 7 new business models (see section 4.2). It relies upon the use of an investment planning tool combined with demonstrator replication actions, hence empowering local authorities mapping their future energy system scenarios. The created local market with higher acceptance for the future business models fully consistent with infrastructure changes constitutes, by construction, an authority and societal driver going alongside the market driver.
- In **SMILE**, social campaigns rose interest of hundreds of potential participants in the proposed demonstrations. In Madeira, for supporting the end-user engagement, the platform *EnergiasMaderia* was developed to be an interactive information source with independent and relevant content about energy, in particular photovoltaic energy for self-consumption which is one of the key topic of some local SMILE pilots.

## 4.4 Simulations of zonal vs. nodal market architectures show the importance of forecast errors

- **OSMOSE** is completing a large set of simulations about different market architectures, both zonal and nodal, that would allow an optimal flexibility mix. Preliminary results show that the load forecast errors at nodal scale are far higher than at zonal or country scale, and that such errors reduce significantly only a few hours before real time. Forecast uncertainties are therefore a key element to be reflected in market design studies, as they

[1] At current stage with demonstrator just starting, only data on number of locals reached are provided, but it is expected that the replication activities will greatly increase these numbers

impact how market opportunities are leveraged by market participants and how power system operators respond subsequently. Nodal market designs remain very challenging to model and simulate in practice. [OSMOSE Webinar on WP2 preliminary results, 2021]

## 4.5 Specific recommendations are issued about capacity planning and regulatory evolutions

- From the **SMILE** project**,** recommendations on electricity storage, smart charging of eV, isolated systems or energy communities have been formulated for replicability in isolated power systems. In particular, with respect to electric storage, specific recommendations regarding "double-charging" issue were provided in 2019 [source: BRIDGE questionnaire 2021]. Indeed, as storage facilities need to first consume electricity to replenish their capacity, before generating electricity in a second time when feeding it into the grid, they are submitted to the fees and taxes related to each of these two phases. Actually, the 2019 Electricity Directive provided a legal framework for electricity storage, with a definition, rules for ownership and operation, and indications (although only indirectly) on ending the current situation that results in double-charging. Regarding the ending of double-charging, SMILE, in its recommendations analysed three potential options for the Member States: 1) Member States can decide to impose taxes and fees only on the electricity injected by a storage equipment to the grid. 2) Member States can impose taxes and fees only on the electricity taken from the grid by the storage asset; 3) Member States can impose taxes and fees only on the difference between the electricity taken from the grid and the electricity injected into the grid by the storage asset: the energy losses. From the analysis, the second or the third option seem best suited to incentivise the deployment of the most efficient storage technologies available and limit energy losses. In both cases, the lower the conversion losses, the higher the benefits for the storage operator. Out of these two options, the last one would most incentivise the deployment of storage and more importantly reduce energy losses, although it might be the costlier for the state and the TSO (source: SMILE deliverable D7.1 "Regulating Electricity Storage" pag.49, "Recommendation 2" https://cordis.europa.eu/project/id/731249/results ).

- The investment planning tool developed in **INSULAE** will provide decision support to island planners to map future energy possibilities and their effects, helping make key decisions on the required future energy mix.

# 5. INVOLVEMENT OF FLEXIBILITY PROVIDERS to maximise the volume of flexibilities

This section deals with the real-life implementation and testing of RES and demand-side flexibilities to evaluate their potential for scale up and replication and their ability for effective integration.

## 5.1 Coupling flexibilities from transport, heating, storage and water to increase RES share proves technically viable in islands

All three demonstrators of the **SMILE project** in the Orkney island, Samsø[2] and Madeira deal with the integration of multiple types of demand-side flexibility. Special attention is paid to flexibility from sector coupling (heating and transport sectors) [source coordinator, September 2021].

- The **Madeira Regional demonstrator** included 5 different pilots: the first two pilots were related to the increase of self-consumption in micro-producers based on PV installation thanks to DSM services and the installation of BESS (8 kWh). More in details, pilot 1 targeted residential applications whereas pilot 2 devoted to commercial applications. 22 micro-producers (commercial and residential) were engaged in the project. Pilot 3 and 4 were related to smart charging of electric vehicles and pilot 5 deals with Voltage/Frequency control and Load Levelling and Peak Shaving at the Distribution Substation Level: a 80 kWh BESS was installed in the framework of pilot 5. With respect to pilot 1 and pilot 2, the control strategy allowing to pre-charge the BESS during off-peak periods proved to be the most profitable. Regarding pilot 5, the BESS installed at the Low Voltage distribution sub-station reduced the load peak by 70%.

- The **Orkney demonstrator** focused on demonstrating two different types of controllable demand over the region: domestic heat installs and electric vehicles charging. 45 homes were equipped with a variety of different technologies (Phase Change Material based Thermal Batteries, Air Source Heat Pumps, residential BESS (8kWh)) implemented in four different architectures to test combined flexibilities. Furthermore, more than 60 homes (equipped with storage heaters and/or hot water cylinders) were added as additional controllable loads. The overall scope was to demonstrate that the operation of a DSM system and energy storage can be used to increase electrical demand at times of high RES production, thereby safely reducing local network constraints, and increasing the renewable energy production capacity of existing RES infrastructure - specifically 2 x 900 kW wind turbines owned by local community energy organisations by reducing curtailment.

- The core of the **Samsø** Regional Demonstrator is the DSM system for the Ballen marina including a battery energy storage system (BESS). The Marina annual demand is around 105 000 kWh. The PV plant estimated annual yield is 56 000 kWh. A BESS (237 kWh) was developed, installed and tested on the field during SMILE. The BESS improved the annual utilisation of the PV plant to 89% instead of 45%. The overall measured degree of self-supply in the Ballen Marina is 43% thanks to the BESS (without the BESS the value drops at 26%). A heat pump covering 100% of the heating demand in the harbour master's office was installed. 340 boat connection points (sockets) equipped with a smart meter have been installed in the Marina. The overall energy control has been implemented including a deterministic control algorithm considering 24-hour ahead that forecasts electricity price and real time measurements of load.

2

- **INSULAE** demonstrations include in Unije a 1.4 MW PV (1MW grid connection) and 0.4MW/1 MWh BESS with power electronics for generation flexibility. This is also coupled with the desalination plant and entire water system to look at flexibilities that this synergy can provide to the interconnected island system. [project coordinator, September 2021]

- Still in INSULAE, In Bornholm a DC microgrid with a novel 288kWh BESS coupled to 61kW of PV production and 2 EV fast charging stations (combined 150kW) seeks to find efficiencies compared to more traditional PV connections and maximise local independence/self consumption. Additionally a virtual power plant centered on a combined electricity and heat biogas plant but with wind and PV generation in the local network also seeks to optimise the system components through simulation and testing. The biogas plant could be a valuable buffer during peak RES generation with the use of an electrolyser, or using the generated biogas as a dispatchable renewable energy source. [project coordinator, September 2021]

  - In Madeira the key objective of demonstration is the use of eV charging V2G and V1G; and BESS plus BMS systems as potential flexibility sources. Following a selection process, 25 eligible users were selected to participate in the V1G upcoming demonstration. One of the benefits for participants letting their eV batteries available for V2G, consisting in getting free energy for the charges of the vehicles[3] [project coordinator, September 2021]

## 5.2 Upgrading large industrial sites to provide load flexibility is challenging

- The Italian demonstration in **OSMOSE** involves 7 industrial load sites that will contribute to congestion management, voltage control and Automatic Frequency Restoration (aFRR). Upgrading the industrial sites to provide flexibility revealed to be seriously challenging due to the number, variety and complexity of plants involved, and the number of suppliers to be involved for each site. [OSMOSE website news, 2021]

## 5.3 Wind power generators are testing the provision of Automatic Voltage Control and synthetic inertia

- In **OSMOSE WP5**, two wind parks are also experimenting the provision of Automatic Voltage Control and synthetic inertia: the ongoing tests proved the static and dynamic capability of the plants in providing the requested reactive power. Regarding synthetic inertia, dedicated controls use the available mechanical inertia of wind turbines to instantaneously reduce or inject power. The experiment will be completed by end 2021. [OSMOSE website news, 2021]

[3] although this is still under analysis by the National regulator

# 6. KEY TAKE AWAYS: facts & figures

Regarding **harmonised digitalisation to implement flexibilities,** the OSMOSE, FLEXIGRID, INSULAE and SMILE projects brought the following:

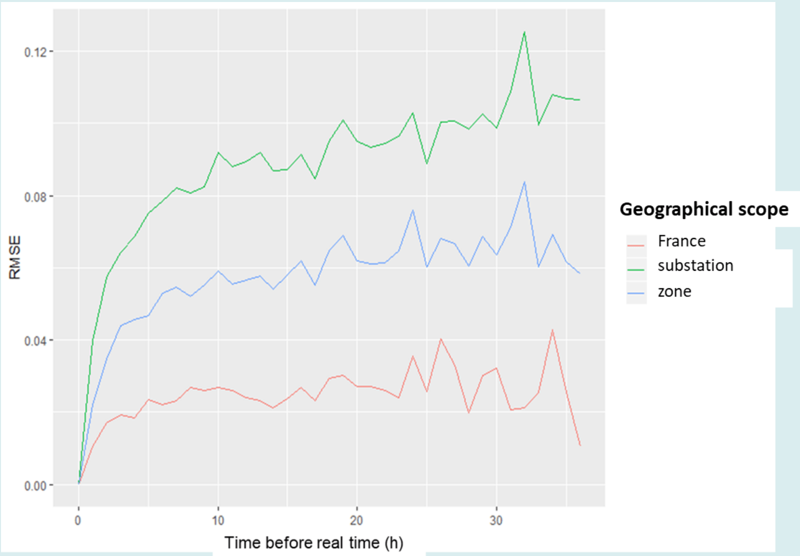
- At distribution level, forecast and control algorithms are tested to handle jointly flexibility and system security
- 5G and IoT solutions are explored as drivers for customer adoption
- Data storage services facilitate the integration of IT solutions
- At transmission level, a flexibility bidding platform is developed and tested in a cross-border area
- To support grid stability against RES deployment, grid forming controls have proven their feasibility
- Interoperability is improving thanks to revised processes and protocols.

| **HARMONISED DIGITALISATION** to implement flexibilities | |
|---|---|
| 4 | EU distribution grids in FLEXIGRID demonstrating **interoperable, reliable and replicable ICT solutions** |
| ☑ | Demonstration of **end-to-end interoperability** between intelligent electronic devices at electrical substations, using an enhanced version of the **IEC61850 standard** (OSMOSE WP7, 2020) |
| ☑ | Technical feasibility of **grid forming** and the provision of **synchronization services** with off-the-shelf voltage source converters in battery energy storage systems (OSMOSE WP3 demonstrator, 2021) |
| 5 ms | The **Factory Acceptance Tests** of OSMOSE WP3 demonstrated a transient response by grid forming controls below 5 ms (compared to 100 ms for frequency restoration reserves FRR), 2020 |

*See section 3 for context and references of the above facts and figures.*

Regarding **business models & market designs to reach profitability of flexibility services,** the OSMOSE, FLEXIGRID, INSULAE and SMILE projects brought the following:

- A quasi fossil-free business model is validated in insular real environment
- Business models explore combined flexibility of different storage types
- Awareness-raising and co-creation processes succeed in fostering citizen engagement
- Simulations of zonal vs. nodal market architectures show the importance of forecast errors
- Specific recommendations are issued about capacity planning and regulatory evolutions.

| **BUSINESS MODELS & MARKET DESIGNS** to reach profitability of flexibility services | |
|---|---|
| 70% | The level of ambition targeted in INSULAE project of 70% cost reduction for RES-based systems compared to diesel imports appears as sound and achievable at the current stage of progress based on the 7 use cases, each with a specific business model offering a wide replicability potential (source : project website, 2021) |
| 89% | Annual utilisation of the PV plant in SMILE with BESS is doubled (reaching 89% with BESS vs. 45% without). |
| 50% | Load forecasting errors are at least 50% higher at nodal scale than at zonal scale [OSMOSE WP2 webinar, May 2021], a key component to be taken into account in market design studies.   *Root Mean Square error on load forecasting at Substation/zonal/country levels in OSMOSE WP2 simulations* |
| 580€ | Total savings in average for all the pilots in INVADE demo in Norway, being combined in one solution by using battery in combination with PV and eV-charging [INVADE project coordinator, Sept 2021]. Breakdown of savings per use case:<br>- Optimised own production, PV + Battery: 44 € saved per year<br>- Power tariff/ peak shaving, eV + Battery: respective daily savings amount to 0,93€ for eV and 0,49€ for batteries<br>- Time of Use, eV + Batteries: respective daily savings amount to 0,04€ for eV and 0,02€ for batteries. |

*See section 4 for context and references of the above facts and figures.*

Regarding **the involvement of flexibility providers to maximize the volume of flexibilities**, the OSMOSE, FLEXIGRID, INSULAE and SMILE projects brought the following:

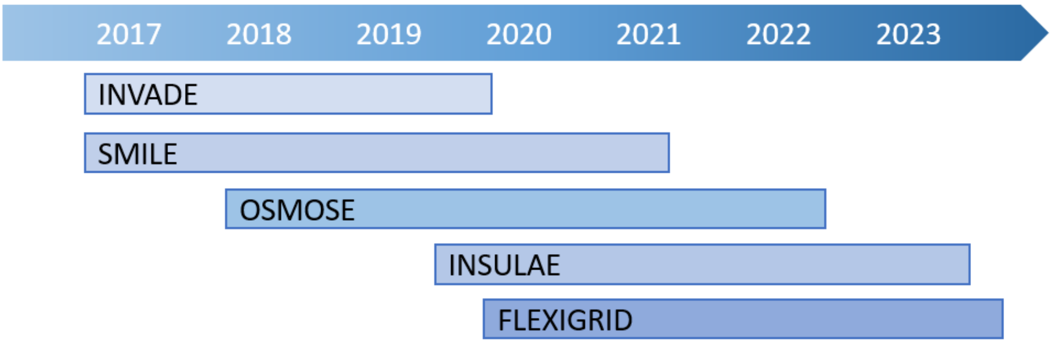
- Coupling flexibilities from transport, heating, storage and water to increase RES share proves technically viable in islands
- Upgrading large industrial sites to provide load flexibility is challenging
- Wind power generators are testing the provision of Automatic Voltage Control and synthetic inertia.

| **INVOLVEMENT OF GENERATORS & END-USERS** to maximise the volume of flexibilities | |
|---|---|
| 88 MW | Flexibility capacities of 88MW for congestion management, 5.5MVar for voltage control and 0.4MW for aFRR made available through 7 industrial loads in the Italian OSMOSE demonstration. [OSMOSE website news, 2021] |
| ☑ | The 3 lighthouse INSULAE demos constitute a proof of concept of an island operated in a 100% RES generation mode |
| 100 | More than 100 homes were involved in the DSM load feasibility demonstration in the Orkney Islands in SMILE. |

*See section 5 for context and references of the above facts and figures.*

# References

Timeline of the projects studied:




**Projects information**

| Bridge project | Call | Goal | Website | Coordinator / Contact |
|---|---|---|---|---|
| SMart IsLand Energy systems | LCE-02-2016 - Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system | 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. | http://www.h2020smile.eu/ | RINA CONSULTING SPA (I) |
| (864579) Interoperable solutions for implementing holistic FLEXIbility services in the distribution GRID | LC-SC3-ES-1-2019 - Flexibility and retail market options for the distribution grid | FLEXIGRID improves the distribution grid operation making it more flexible, reliable and cost-efficient through the development of 8 solutions interoperable with the IT systems used by the energy stakeholders | www.flexigrid-h2020.eu | FUNDACION CIRCE (E) |
| Maximising the impact of Innovative energy approaches in the EU Islands | LC-SC3-ES-4-2018-2020 - Decarbonising energy systems of geographical Islands | INSULAE aims at helping islands find locally produced, sustainable and low-cost energy sources. Through 7 replicable use cases at 3 Lighthouses, it aims to demonstrate their capability to evolve RES-based systems up to 70 % cheaper than diesel. The project also designs an investment planning tool to be displayed at four Follower Islands. | http://www.insulae-h2020.eu/ | FUNDACION CIRCE (E) |

| | | | | |
|---|---|---|---|---|
| OSMOSE<br>Optimal System-Mix Of flexibility Solutions for European electricity | LCE-04-2017 - Demonstration of system integration with smart transmission grid and storage technologies with increasing share of renewables | OSMOSE addresses flexibility for the integration of renewable energy sources, through a holistic approach to capture “silo-breaking” synergies across needs and sources flexibilities. | http://www.osmose-h2020.eu | RTE (F) |
| INVADE | LCE-02-2016 - Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system | Smart system of renewable energy storage based on integrated EVs and batteries to empower mobile, distributed and centralised energy storage in the distribution grid. | https://www.invadeh2020.eu/ | Smart Innovation Norway As (Norway) |

**Credits:**
This brochure is financed by the European Commission and developed by DOWEL Innovation

**bridge**