Ref. Ares(2023)1447972 - 28/02/2023

Horizon 2020 Programme
Research and Innovation Action

This project has received funding from the European Union's
Horizon 2020 Research and Innovation Programme,
under Grant Agreement **No°101096946.**

Flexibility services based on Connected and Interoperable Hybrid Energy Storage Systems

FlexCHESS

Start date of project:

Duration: 36 months

T1.1 Needs and flexibility requirements

D1.1 A report on needs and flexibility requirements

Deliverable details	
Deliverable Number	**D1.1**
Revision Number	**1**
Deliverable leader	**Toshiba**
Author(s)	**Toshiba, RDIUP**
Due Date	**28/02/2023**
Delivered Date	**28/02/2023**
Reviewed by	**LaSolar, EL**
Dissemination level	**PU**
Contact person EC	**Antonios MARINOPOULOS**

Contributing partners	
1.	AIX MARSEILLE UNIVERSITY – France (Coordinator)
2.	ALGOWATT SPA – Italy
3.	RDIUP – France
4.	ARCELIK A.S. – Turkey
5.	ELEKTRO LJUBLJANA PODJETJE ZADISTRIBUCIJO – Slovenia
6.	C.I.P. CITIZENS IN POWER – Cyprus
7.	LA SOLAR ENERGIA SOCIEDAD COOPERATIVA – Spain
8.	My Energia ONER, S.L. – Spain
9.	IREN SPA – Italy
10.	IREN ENERGIA SPA – Italy
11.	UNIVERSITA DEGLI STUDI DI GENOVA – Italy
12.	ULUDAG ELEKTRIK DAGITIM ANONIM SIRKKETI – Turkey

Associated partners	
1.	TOSHIBA EUROPE LIMITED – UK
2.	CARDIFF UNIVERSITY – UK

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Glossary

Abbreviation	Description
CHP	Combined Heat and Power
DER	Distributed Energy Resource
DLT	Distributed Ledger Technology
DNO	Distribution Network Operator
DR	Demand Response
DT	Digital Twin
ESO	Energy System Operator
EV	Electric Vehicle
FCR	Frequency Containment Reserve
FRR	Frequency Restoration Reserve
GDP	Gross Domestic Product
HESS	Hybrid Energy Storage System
IEC	International Electrotechnical Commission
PV	Photovoltaics
RES	Renewable Energy System
SCADA	Supervisory control and data acquisition
TNO	Transmission Network Operator
VESS	Virtual Energy Storage System
VPP	Virtual Power Plant
VRE	Variable Renewable Energy

Executive Summary

In this deliverable, a "State-of-the Art" will identify key initiatives at National, European and international level, ongoing research, promising innovations and suggested regulatory frameworks for HESS. This analysis will be carried out and evaluate the expectations and trends on flexibility services and innovative tools. Therefore, an initial market analysis for the pilot sites will be realised to better understand their current situation, assess needs and possible expectations for flexibility services at different time scales in selected countries, in which use cases are selected, will be studied through literature review and consultation with key stakeholders including the system operators and other market participants. This assessment will be elaborated and refined in future project deliverables (D1.2 and D1.3), starting from the existing flexibility services such as Frequency Response, Fast Reserve, etc. before developing a more general representation of flexibility products/services in the power system.

Also, specific fences and barriers that could slow down the progress of the FlexCHESS demonstrations will be highlighted. In this deliverable, we will pay attention to security aspects and we will define protection instructions to be followed during experimentations. Finally, analysis of feedback about energy stakeholders' needs for the use-cases relating to the specific optimisation goals.

1 Introduction

Flexibility refers to the ability of an energy system to adjust, with an acceptable ramp rate, and maintain its electricity generation/consumption inside a specified range within a given period in order to support the operation of the power grid.

A flexible system also needs to be capable of dealing with uncertainties caused by intermittent renewable energy power generation and consumption behaviors. Regulation in power systems requires at each moment some amount of reserved capacity to be procured by the system operator to deal with uncertainty. Such reserved capacity is controlled by the system operator and traditionally has been used in conventional power systems for one of two purposes:

- The first is to help the system recover in case of a contingency (e. g., loss of generation) through a fast-acting frequency containment reserve (FCR) and to restore the frequency to its nominal value following the contingency (through slower frequency restoration reserve, FRR).
- The second is to compensate for demand or generation forecast errors during normal operation (also called regulating reserve).

A flexibility provider is an entity who provides flexibility services by making temporary changes to the way they consume, generate, or store electricity when requested, to support a more efficient use of the energy network. (Definition of flexibility from project LEO - https://project-leo.co.uk/the-context/flexibility-services/). This can be an enabler for supporting more flexible energy markets, by offering consumers the possibility to actively participate and providing market signals for investments in distributed generation and storage and the efficient use of available resources - building missing infrastructure and better using existing infrastructure (see [16][17]]). The findings in these previous studies is that congestion management at the local level/network is identified as the main priority for platform developers. However, the same DER would become active participants in existing electricity markets, namely, wholesale and balancing markets. Consequently, these markets should be adapted to incorporate the ever-growing number of resources and associated aggregators. Finally, the so-called P2P trading in local and limited scope platforms may have an opportunistic interest, but their continuity and sustainability in the long term are still to be proven.

1.1 Variable Renewable Energy Impact

Increased levels of VRE deployment are leading to a transformation of the power sector, with VRE sources gradually becoming the new backbone of power systems. As the share of VRE sources in a power system increases, the operations of the power system increase in complexity. More specifically, gradual integration of VRE introduces additional levels of variability and uncertainty into the so-called net load. The net load is the electricity demand minus generation from VRE. The net load needs to be balanced by the remaining group of dispatchable generators – such as thermal generators and hydropower units – as well as by storage units.

At low VRE deployment levels, very little difference exists between the net load and the demand. As VRE integration increases, the shape of the net load changes until increasingly noticeable differences appear between the two.

Three main characteristics of the net load profile that affect system flexibility are:

- the rate of change of net load (or ramp rate),
- the range between the maximum and minimum net load within a day (also called ramping range) and
- the uncertainty related to forecast error (the combination of demand, solar and wind forecast errors).
- Higher VRE penetration increases one or more of the above.

Large-scale VRE integration makes the process of balancing supply and demand more challenging due to the higher frequency of occurrence and magnitude of forecast errors on net load and has been associated with increased requirements for cycling of thermal generation, over generation and fluctuating electricity prices. A power system with flexibility gaps might experience VRE curtailment and, in extreme situations, loss of load.

When more electricity than is needed is being supplied due to technical constraints on the ability of thermal generators to further reduce their output a situation of over generation can trigger the need to disconnect (curtail) generation from VRE to maintain frequency at its nominal value.

There are two periods with increased risk of over generation:

- The first is during early morning hours when thermal units get commissioned in partial loading mode, being standby to accommodate the forthcoming typical morning increase of demand.
- The second period is during peak solar production, when online thermal units are pushed down to their minimum operating point to accommodate PV generation.

Over generation also can be a side effect of wind generation during late night hours when wind production is at the highest level while demand is at its lowest. In a market environment, energy oversupply causes a reduction in electricity prices, even reaching negative levels. Negative pricing is a market mechanism to restore balance in the system, however, it is also a symptom of lack of flexibility in the power system.

1.2 Stakeholder Perspectives

One of the **main tasks of a power system operator** is to balance electricity supply and demand at all times. Continuously balancing supply and demand is crucial for a system's reliable operation since even a small mismatch can disturb power system frequency and possibly affect the reliability of system operations.

Additional core system operator tasks are:

- maintain voltage levels within acceptable limits throughout the power system,
- avoid overloading transmission lines and other system elements and
- restart the system if it collapses due to a contingency that causes failing in one or more of the above.

Power systems are designed to operate under nearly constant frequency. Frequency deviations beyond acceptable limits and time periods can damage generators and electromechanical equipment and thus create a chain reaction of loss of load and/or generation that can lead to a blackout.

Balancing supply and demand is challenging. The main source of variability in conventional power systems is electricity demand, including both intra-day, weekend, inter-year variability and seasonal variability. The shape of electricity demand depends on a mix of climatic and socio-economic parameters such as local weather, season of the year, level of industrialisation, a country's energy intensity, social awareness and culture towards best energy uses, and gross domestic product (GDP).

In addition, power system operators have defined and procured ancillary services to deal with uncertainty related to unexpected loss of a generator (or a load) and real-time imbalances due to demand forecast errors. To date, in most power systems the main source of uncertainty is the loss of one or more of the largest in-feeds (i. e., generators or transmission lines). Solar and wind variability and uncertainty affect system operations across various time scales that vary from seconds (i. e., due to the passage of a cloud over a PV farm) to months (i. e., seasonal variability of VRE). Consequently, system-wide impacts of solar and wind variability have a related temporal dependency; for example, very short-term variability affects a system's ability for frequency regulation, while variability at time scales of 15 to 30 minutes affects load following and sizing of operational reserves. Seasonal variability, on the other hand, might affect medium-term hydro storage planning and a system's long-term capacity planning.

Distribution Network Operators (DNOs) and **Distribution System Operators (DSOs)** support a shift to flexible markets that enable a range of new energy technologies that generate, consume and manage electricity through Distributed Energy Resources (DERs).

Understanding the flexibility needs and requirement from DNO/DSO are possible by examining the Picloflex and similar marketplace platforms (e.g. LevelTen) and ongoing trials in Europe (see [16][17]). This prior research and trials have identified future investigation is needed within:

- Mechanisms for procuring grid services: The DSOs have different mechanisms to procure flexibility, both market- and non-market-based alternatives
- Flexibility markets structure: The organisational structure of the flexibility markets requires a series of functions divided into five main phases; the preparation phase, forecasting phase, market operation/bid selection phase, monitoring and activation phase, and measurement and settlement phase.
- Services and products characteristics: This study identified services and products of the selected new flexibility market models, where products can be grouped into standard products and specific products, which can be described by a set of technical attributes.
- Additional implementation considerations: On a wider level, research is also needed to examine additional implementation aspects in flexibility markets, such as metering requirements, baseline methodologies, and TSO/DSO coordination principles.

2 State of the Art

A survey, created by RDIUP, was dedicated to state of the art review of FlexCHESS to find sister funded projects or similar solutions to better understand the European and international market situation.

The Questionnaire answers

1-Please provide scientific research in the field of storage hybridisation linked to FlexCHESS

Relevant research into virtual energy storage systems, and techno-economic analysis of energy storage for providing a range of flexibility services are contained in [4], [5], [6], [7],[8] and [9].

The VPP4ISLANDS project provides relevant VESS background for FlexCHESS and are contained in papers; [10],[11],[12],[13] and [14].

Levenmouth Community Energy Project (LCEP) – Developed a Community energy system in Fife Scotland that provides a blueprint to decarbonise specific sites in both the energy and transport sectors, using a smart microgrid. This has been achieved through the installation of world-leading technologies and first-time integrated designs including 17 hydrogen powered vehicles, 7 buildings, 2 hydrogen refuellers and fuel cell as well as an energy management system and digital twins. The research combines high resolution telemetry and digital twins to optimize distributed energy resources through IoT platform and an energy management system [1].

Island Hydrogen - Demonstrates the use of hydrogen technology to integrate renewable generation, hydrogen production, and storage, supported by communication technologies, to provide a zero-carbon alternative to power road and maritime vehicles. During the project, two hydrogen refueling platforms were designed, built, and operated [2]. Tools were developed for evaluation of optimal placement strategies for refuelling stations.

SUNSEED - Sustainable and robust networking for smart electricity distribution project - proposes an evolutionary approach to utilisation of already present communication networks from both energy and telecom operators. These can be suitably connected to form a converged communication infrastructure for future smart energy grids [3]. SUNSEED proposes a framework for estimating synchronized phasor measurements for a virtual node using the measurements from the other nodes in the network

2-Please name sister projects similar to FlexCHESS concepts (especially European funded projects)

PARMENIDES Plug&plAy eneRgy ManagEmeNt for hybrID Energy Storage

ID: 101096453

From: 1 January 2023 to: 31 December 2025

The ongoing transition of the energy system is accompanied by digitalisation activities, enabling new applications. This results in a fragmentation of existing platforms, protocols, and standards. Therefore, interoperability among various platforms as well as cross-domain.

PARMENIDES aims to develop a new ontology by extending existing ontologies to provide a knowledge base, with a focus on the electricity and heating domain for buildings, customers, and energy communities. It will support different use cases, focusing on the utilization of Hybrid Energy Storage Systems (HESS). Besides the representation of storage technologies, information about energy community customers, their behaviours, and components including their relation will be part of the ontology, providing a standardized vocabulary of the domain of energy communities.

INTERSTORE Interoperable opeN-source Tools to Enable hybRidisation, utiliSation, and moneTisation of stORage flExibility

ID: 101096511

From: 1 January 2023 to: 31 December 2025

Storage is becoming one of the most critical assets for modern energy systems. At the same time storage is a very diverse universe of solutions and technologies with very different characteristics. The middleware solution will be integrated both in open source and commercial platforms that will be incorporated in 4 large real-life demos to enhance the successfully flexibility platforms and check the user acceptance and economic value of the new solution.

VPP4ISLANDS

ID: 957852

From 1 October 2020 to 31 March 2024

VPP4ISLANDS project is revolutionising conventional VPPs by integrating virtual energy storage technology, digital twin and distributed ledger technology to enable enhanced VPPs and the creation of smart energy communities on islands. The outcomes will enhance the uptake of clean green energy on islands, reducing emissions and costs while creating new opportunities for businesses and job growth.

VPP4Islands is based on : Digital Twin (DT), Distributed Ledger Technology (DLT) and Virtual Energy Storage System (VESS)

VPP4ISLANDS

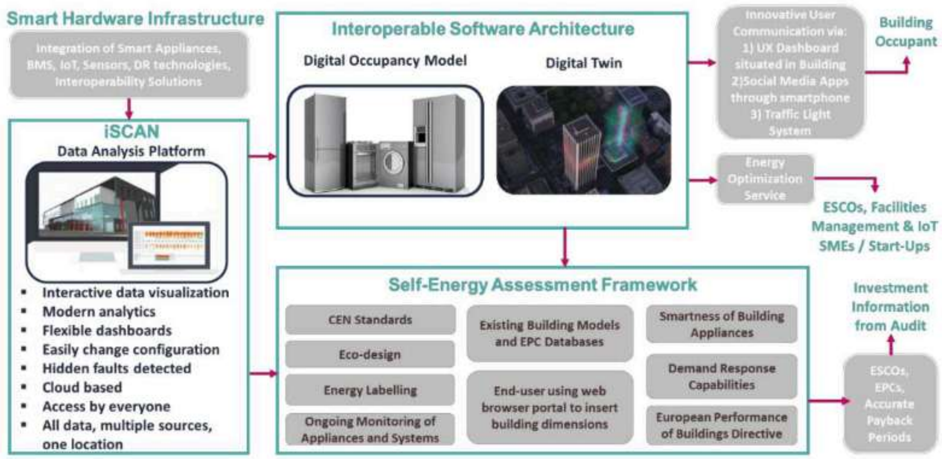
The project has developed a Virtual Energy Storage System (VESS) model for case studies in Turkey (Gökçeada), Balearic islands (Formentera) and replicated in other islands. The model of components in the VESS and the control algorithms developed in VPP4ISLANDS can potentially be used in FlexCHESS project too through common partners (UEDAS, Cardiff University, University of Marseille, AlgoWatt and RDIUP).

Auto-DAN project

ID : 101000169

From 1 October 2020 to 30 September 2024

The main aim of the project is to produce a technological solution that can self-assess and self-optimise buildings across the EU. The project team aim to successfully deliver a demonstration project that will validate a solution routed in augmented intelligence and showcase its replicability.



Focuses on accurately measuring and reducing energy consumption in buildings. Arçelik will use its smart products within the selected pilot regions. An energy management system that optimizes energy consumption will be established in these buildings. Arçelik's smart white goods will be designed to be connected to the energy gateway of the common system. The other project is the newly accepted

REFLEX

ID: 691685

From 1 May 2016 to 30 April 2019

REFLEX aims to analyse and evaluate the development towards a low-carbon energy system with a focus on flexibility options in the EU. The future energy system is challenged by the intermittent nature of renewable energy sources and requires therefore several flexibility options. Moreover, the interaction between different options, the optimal portfolio and the impact on environment and society are so far unknown.

REflex
Analysis of the European Energy System

REEFLEX

ID: 101096192

From 1 January 2023 to 31 December 2026

REEFLEX aims to generate niches of opportunities for new cross-sector energy services provided by SMEs and start-ups in demand side flexibility markets and to increase participation of energy consumers in demand side flexibility markets. The project develops a central interoperability platform and a catalogue of services with the capability of maximising distributed energy resources' flexibility while respecting the different end user profiles and needs along with the physical limitations of existing infrastructures. Additionally, the generation of a common operation market model together with AI-driven intelligence services and automation systems, enabled through the utilization of distributed ledger technologies for enhancing transparency and trust, will reduce market entry barriers and costs and achieve a higher participation from energy consumers.

REEFLEX Focuses on increasing the participation of energy consumers in demand-side flexibility markets Arçelik will be responsible for interoperability and provide device connectivity for data exchange with the project flexibility platform. Remotely controllable devices and Arcelik mobile application Homewhiz will be used to provide interaction with the customers and present to them a set of flexible usage options (such as on/off/shifting control of home appliances). Also, smart plugs will be used to include different brands of connected or non-controllable devices into a common smart home solution IoT platform. Communication protocols and interoperability studies which will be used for our connected products to communicate with energy management tools can be exploited. Also, smart plugs usage methods to control different brand products can be exploited from these projects.

CROSSBOW

ID: 773430

From 1 November 2017 to 30 April 2022

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.

CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market. CROSSBOW is a TSO driven project with two interrelated and equally important strategic goals: on the one hand, it aims at the successful deployment in the market, within a 24 months horizon after project completion, of a set of technological solutions which enable increasing the shared use of resources to foster transmission networks cross-border management of variable renewable energies and storage units, making possible a higher penetration of clean energies whilst reducing network operational costs and improving economic benefits of RES and storage units.

http://crossbowproject.eu/

INTERRFACE - TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system

ID: 824330

From 1 Jan 2019 to 31 December 2022

With the growth of renewables, the increased interconnection of European grids, the development of local energy initiatives, and the specific requirements on TSO – DSO cooperation as set forth in the different Network Codes and Guidelines, TSOs and DSOs face new challenges that will require greater coordination. The European Commission adopted legislative proposals on the energy market that promote cooperation among network operators as they procure balancing and other ancillary services and provide congestion management. Therefore, this creates the need for a project such as INTERRFACE having the greater coordination between TSOs and DSOs as its core objective.

INTERRFACE

INTERRFACE strategic objectives are:

S1. To create a common architecture that connects market platforms to establish a seamless pan-European electricity exchange linking wholesale and retail markets and allows all electricity market players to trade and procure energy services in a transparent, non-discriminatory way.

S2. To define and demonstrate standardised products, key parameters, and the activation and settlement process for energy services.

S3. To drive collaboration in the procurement of grid services by TSOs and DSOs, and to create strong incentives to connected customers, by improving market signals and allowing them to procure services based on specific locations and grid conditions.

S4. To integrate small scale and large scale assets to increase market liquidity for grid services and facilitate scaling up of new services which are compatible across Europe.

S5. To promote state-of-the-art digital technologies that consumers are familiar with in other everyday transactions (i.e. e-auctions, e-commerce, e-banking, social networks), into the electricity value chain, in order to engage end-users into next generation electricity market transactions, creating incomparable economic benefits by deferring conventional energy infrastructure investments.

http://www.interrface.eu/

Current Direct - Swappable Container Waterborne Transport Battery

ID: 963603

From 1 January 2021 to 31 December 2023

Is a new research and innovation project funded by the European Commission's Horizon 2020 program that will revolutionize the way we move goods and people by water with the use of swappable containerized batteries connected to an Energy as a Service Platform. It proposes to develop and demonstrate an innovative lithium-ion cell engineered for waterborne transport. It is based on novel manufacturing techniques that will enable significant cost reduction and fast adoption of methods supporting reduced greenhouse gas emission.

www.currentdirect.eu

E-LOBSTER - Electric LOsses Balancing through integrated STorage and power Electronics towards increased synergy between Railways and electricity distribution networks

ID: 774392

From 1 June 2018 to 31 August 2022

The project is proposing an innovative R+G (Railway to Grid) Management system which, combined with advanced power electronics, will be able to reduce electricity losses in both the power distribution network and the light railway network

https://www.e-lobster.eu/

DRIMPAC - Unified DR interoperability framework enabling market participation of active energy consumers

ID: 768559

From: 1 September 2018 to 31 August 2022

DRIMPAC offered a comprehensive solution to empower consumers to become active participants within a future electricity energy market. DRIMPAC developed a unified DR interoperability framework that enhanced building management intelligence and enabled closer ties amongst three key stakeholders of the electricity market (distribution system operators, aggregators and end users).

Their solution allowed closer relationships between these stakeholders and gave prosumers the opportunity to utilise their assets and modify their consumption. The hope is that this approach will help bring a 20 % reduction in energy cost savings and 15 % in energy consumption and stable energy prices in Europe.

https://www.drimpac-h2020.eu/

ACCEPT - ACtive Communities & Energy Prosumers for the energy Transition

ID: 957781

From 1 January 2021 to 30 June 2024

Grid integration of variable renewable energy sources poses major challenges with respect to system stability due to demand-supply imbalances. Energy communities are emerging as a promising element to promote citizen involvement in the energy transition. However, ICT tools are required to extract and optimise the flexibility of residential energy resources to create financially viable operations based on citizen needs. The EU-funded ACCEPT project intends to develop and deliver such a digital toolbox that allows energy communities to offer innovative digital services and access revenue streams that can financially support their functions and secure their sustainability and effectiveness. The ACCEPT framework will be demonstrated and validated in four pilot sites in Greece, the Netherlands, Spain and Switzerland involving more than 3 000 people and 750 residences.

https://www.accept-project.eu/

De-RISK

ID: 101075515

From 1 October 2022 to 30 September 2025

DE-RISK aims at supporting the market uptake of renewable energy systems by fostering the adoption of LFMs and unlocking up to 100GW of flexibility in 2030 which will allow a safe and reliable integration of RES in the grid. DE-RISK will achieve this ambitious objective by minimizing the investments and implementation risk through an innovative customer behavior change journey that will increase end users' trust and willingness to participate in the flexibility markets. DE-RISK integrates building, citizen and grids digital twins in its flexibility platform capable of reducing the gap between simulation and real implementation thus mitigating potential technical risks during deployment and operational phase. To maximize DE-RISK impact, innovative multi-sided business models will be developed ensuring multi-benefits, fairness and sustainability for all actors while disruptive financial schemes will be validated for democratizing the access to sustainable investments. Finally, a set of experts will develop regulatory recommendations to support a fair, clear and transparent adoption of LFMs.

3-Please provide existing solutions/products/services commercialised on the market similar to FlexCHESS

Hybrid energy storage :

There are a number of energy storage providers, but relatively few existing hybrid energy storage solutions. HESStec is an example. https://hesstec.net/

- Hybrid Energy Storage Solutions Ltd. (HESStec) is a technological solution provider, pioneer in creating hybrid energy storage solutions (HESS), optimised in economic terms, thanks to the integration of several energy storage technologies, enhanced power electronics and patented energy management algorithms in exclusive, flexible hardware and software platforms.
- HESStec's portfolio is focused on three main activities:
    1. Control systems to optimize and monetize the energy storage technologies (EMS – Energy Management Systems and iNMS®)
    2. Hybrid technologies turnkey HESS solutions
    3. Turnkey consultancy services based on its sizing and optimising tools

Generation flexibility solutions (VPP) :

There are a number of VPP Company initiatives that have been commercially deployed globally and summarised here:

https://www.fortunebusinessinsights.com/blog/top-virtual-power-plant-companies-in-the-world-10629

- ABB - The company encompasses a developed system in power and utility solutions that optimises energy production.
- Siemens - The company engages in the distribution of resource-saving and energy-efficient technologies that include decentralized power generation, supply, and demand for energy resources for a plethora of use cases.
- GE - General Electric offers power assets and digital infrastructure for virtual power plants globally.
- Schneider Electric - The company specializes in energy-efficient technologies, digital solutions, and automation that emphasise sustainable efficiency.
- Enel X - A subsidiary company of the Enel Group is a pioneer in demand response globally.
- Cisco Systems Inc. - The company possesses expertise across utility and smart grids. It provides digital solutions in the energy industry, including system visibility, connectivity, security, and others.
- Bosch - The company majorly focuses on the objective to provide the connected living with solutions and products. It uses eco-friendly energy by managing power plants and building on several mobilities, energy, and connected city initiatives.
- Hitachi Ltd. - The company offers energy solutions in distributed energy resources, power generations, and storage batteries.
- Mitsubishi - Provides an assorted range of products in energy management, including DR systems, which utilize the self-generation facilities of consumers for balancing supply and demand in the electric power market.
- AGL Energy - Is one of the leading integrated energy business companies with the largest private electricity generation within the Australian National Electricity Market.

Demand flexibility :

The UK Demand Flexibility Service (DFS) has been developed to allow the ESO to access additional flexibility when the national demand is at its highest – during peak winter days – which is not currently accessible to the ESO in real time. The DFS has been developed to allow the ESO to access additional flexibility when the national demand is at its highest – during peak winter days – which is not currently accessible to the ESO in real time.

https://www.nationalgrideso.com/industry-information/balancing-services/demand-flexibility

There are also test and live open data sets available through the data portal :

ESO Data Portal: Home | National Grid Electricity System Operator (nationalgrideso.com)

EV charging management solutions offer flexible demand-side management such as the ampeco platform - www.ampeco.com/. With AMPECO's software, you can optimise charging and reduce maintenance and kWh costs. As a result, you can avoid having to upgrade site's electric power capacity. Offer dynamic smart tariffs as an incentive for charging during off-peak hours, reducing the risk of grid overload, even when numerous charges are used at the same time.

Flexibility service platforms

Bamboo Energy - offers a solution to manage the entire value chain of flexibility for retailers and aggregators, including forecasting and optimization of flexibility, day-ahead trading, and flexibility operation in real-time. Bamboo flexibility platform as a service - https://bambooenergy.tech/en/

Stemy Energy supports flexibility of energy demand and participation in electricity markets. It provides smart management of energy resources, ensuring consumption at the cheapest times of day without compromising on comfort using Flex Community App and Flex-ready devices - https://www.stemyenergy.com/

Picloflex – is a marketplace platform approach to flexibility services that permits trading between flexibility providers and DNO/DSO users through their needs published them on the platform and offers received from different providers - https://picloflex.com/.

3 Flexibility Use-case Needs and Requirements

Different use-cases present different needs and requirements for flexibility which are summarised for the FlexCHESS pilots in this section. An in-depth analysis of use-case details and requirements will be conducted for deliverable D1.5.

3.1 VESS for Industrial Buildings

Wales Pilot Site

Location Wales/ *UK*

Introduction

FLEXIS (Flexible Integrated Energy Systems) is a £24 million research operation designed to develop an energy systems research capability in Wales, UK.

The FLEXIS Demonstration Area is based in Neath Port Talbot, from the Tata Steel Port Talbot steelworks stretching around the coast to the proposed Swansea Bay Tidal Lagoon. The data of this pilot site will be used for supporting simulation study in this project, and no practical implementation would be possible for this pilot site.

Composition

The electrical generators within the demonstration site include two biomass power stations, a CCGT power station, a Solar farm, a wind farm and the proposed Tidal Lagoon, in addition to numerous behind-the-meter renewable generation and storage systems. In terms of consumers the demonstration site includes a steelwork (with onsite electrical generation from waste gases and heat), the Welsh Water Treatment plant (with onsite electrical generation), a cement works, a paper mill, an Amazon warehouse, BOC Industrial gases plant, schools, hospitals, council offices, the University of South Wales Hydrogen Centre, CU's Gas Turbine research center and Swansea University's Bay Campus.

Existing energy assets and infrastructures in the pilot site

Energy systems: Local electricity and gas networks in the pilot site.

Power Generation: Two biomass power stations, a CCGT power station, a Solar farm, a wind farm and the proposed Tidal Lagoon, in addition to numerous behind-the-meter renewable generation

Storage systems: Numerous behind-the-meter storage systems

Flexible loads: A steelworks (with onsite electrical generation from waste gases and heat), the Welsh Water Treatment plant (with onsite electrical generation), a cement works, a paper mill, an Amazon warehouse, BOC Industrial gases plant, schools, hospitals, council offices, the University of South Wales Hydrogen Centre, CU's Gas Turbine research center.

How FlexCHESS will help

Digital Functionality:

Provide the relevant data management and analysis functions.

Expected Energy Services to be adopted:

Responding to time-varying electricity prices, balancing services, voltage support, and constraint management.

3.2 EV Community based VESS

Elektro
Ljubljana

Pilot Site Slovenia

Location Slovenia

Introduction

EL LJ's OT, SCADA will be upgraded with a new feature, a tool which will in real time enable the functionality of Electrical energy Smart Storage, either to be developed and ready for exploitation as a part of new services for the needs of the DSO or even for other on the energy market present actors. Slovenian pilot will meet the requirements of a new generation of operational DSO ADMS-SCADA system, which comprises storage systems, as a result of combination or interaction between EV batteries-recharging process, local loads and production units, all connected directly on the distribution grid.

Composition

Residential buildings: we will select parts of the MV and LV grid with the highest possible, diversity of potential flexible units, which means that we will consider parts of network, where beside consumption, also the production is present.

Commercial buildings: We plan to involve at least two commercial buildings, connected at the MV grid level. These loads will be defined in our SCADA as loads, with flexibility. our selection of the buildings will be focused on the buildings where the recharging stations for Eves are implemented.

Industrial buildings: These kinds of the loads will be defined later, because the industrial grid users, are specific when considering their flexibility (individual approach) and are already participation on the market (aMFRR, mFRR...).

Existing energy assets and infrastructure in the pilot site

Electricity Distribution Power System: OT SCADA testing environment, network assets.

Distribution system secondary system: AMI with smart meters, sensors.

Aggregated power as a result of flexible units: Aggregated electricity producers and loads, recharging stations for EVs.

Other IT systems: recharging stations management system.

Flexible loads: EV recharging stations, heat pumps, RES (solar).

Challenges: activation of flexibility for the DSO services, upgrade of SCADA system

How FlexCHESS will help

Digital Functionality:

Aggregation of DERs is a core functionality of DERMS module in SCADA ADMS. It provides possibility to monitor real-time and forecast behavior of aggregated DER, get insight into their real-time and forecast capability (flexibility) and dispatch them in a most convenient way

Expected Energy Services to be adopted:
Flexibility services, based on a Smart storage.

3.3 Renewable Energy Community

Murcia Pilot Site

Location **Bullas/ *Murcia Spain***

Introduction

Bullas is a municipality of 11,553 inhabitants, nestled in the Northwest region that has an area of just over 8,200 hectares. It is in one of the most mountainous areas of the Region of Murcia. The town has a good cooperative willing and has been created an association to promote a REC (Renewable Energy Community).

La Solar has 31 contracts in Bullas, 6 of them with PV plants, at least one with batteries, mostly residential but including a municipal office building with its own 5kw PV plant.

Composition

The Bullas-Murcia pilot site will engage 15 homes, some of them own a PV installation for self-consumption, 2-3 of them with storage as batteries, one municipality facility, as well prosumer, and 1-2 commercial SMEs. will be utilized as a platform for validation of Flex-Chess solution.

Residential buildings: 15

Commercial buildings: 2 SME, 1 municipal office facilities.

Existing energy assets and infrastructure in the pilot site

6 residential and one municipal office building with PV plants.
Energy systems: 6 residential PV plants with 3-4 kW each. Annual consumption per dwelling: 3.500-4.000kWh/year
Municipal office building: 5 kW PV plant and annual consumption of 10.919,77kWh
Storage systems: 9,8 kW batteries in municipal building. At least a residential user with storage system with PV plant.
Flexible loads: mainly HVAC systems and electric DHW tanks

Challenges: creating a Local EC to maximize PV plants production and studying new business models, taking advantage of aggregation and DR schemes to obtain further benefits for the LEC members.
High capital costs, absence of financial incentives and lack of efficient remuneration schemes as well as no markets for provision of services to grid operators to medium/small consumers. Also, the absence of existing suitable business models.

How FlexCHESS will help

Digital Functionality:
Creating an IoT infrastructure to control the smart devices to be deployed in the pilot site.
Developing IoT solution and tools that are easy to use for end-users.
Testing use cases and developing new business models.

Expected Energy Services to be adopted:
VESS.
Implicit DR for individual users and the LEC.
Explicit DR for the LEC.
Testing Peer-to-peer energy sharing.

3.4 CHESS Node for Multi-buildings

Pilot Site Turin

Location Turin/Italy

Introduction

The Italian Pilot will be focused in an area of the city of Turin where Iren Group manages the electrical energy distribution grids through its DSO named Ireti. The Pilot will be structured around two primary assets that will be tested as sources of flexibility for the electrical grid.

Composition

The first asset is a multi-functional (residential and commercial) building owned by the municipality of Turin and with the HVAC system operated by Iren. The pilot wants to investigate the usage of a centralized heat pump as source of electrical power flexibility.
The second asset is a facility of the Iren Group with offices and a fleet multi-story parking, where Electric Vehicles (EVs) charging stations can be used to provide ancillary services. This facility is equipped with a rooftop PV system and actions for increasing self-consumption and not unbalancing the grid will also be investigated.

Existing energy assets and infrastructure in the pilot site

Building asset:
Energy systems: reversible heat pump that can be controlled with remotely supervised control algorithms capable of modulating loads.
Storage systems: no electrical storage systems are present; the HVAC configuration for heating/cooling includes a thermal storage.
Flexible loads: space heating and space cooling loads.

EV charging asset:
Energy systems: a set of AC and bidirectional DC recharging stations; a rooftop PV system is present.
Storage systems: currently not present.
Flexible loads: electric vehicles to be connected to the charging infrastructure.

Challenges:
The objective is to use existing Iren's assets to provide flexibility services to the network and that can be aggregated on a large scale to understand how to control and manage them with a central energy management system.

Barriers:

Possible barriers to be faced are: the provision of flexibility services through the identified existing assets should not interfere with end-users needs (guaranteeing adequate thermal comfort levels in buildings and allowing the normal usage of vehicles); it is fundamental to address the possible decoupling between flexibility grid requirements and loads; the use of widespread loads with lower power density requires a large-scale aggregation in order to have significant effects on power grids.

How FlexCHESS will help

The dialogue between system integrator and multi-utility can allow the exploitation and provision of flexibility services using the existing assets, allowing the integration of existing data with a central energy management system to manage loads.

3.5 Island Citizen Energy Community

UEDAŞ

Pilot Site Gökçeada

Location Gökçeada /Türkiye

Introduction

- UEDAS will install heat pump, which will have a thermal power of 17 KVA, will have an electrical consumption of 2-6 KW.
- 22 KW AC charging stations to be installed as our second variable load.
- UEDAŞ has 100 kWh electrical storage system in the island too. It will use during testing period.

Composition

Gökçeada is the largest island of Turkey and the seat of Gökçeada District of Çanakkale Province. It is in the north-eastern of Aegean Sea, at the entrance of Saros Bay, and is the westernmost point of Turkey. The electrical connection to the mainland made by a submarine cable, and the power generation plant (green pentagon).

In the island are present three big-size renewable plant: two wind turbines of size 0.9 MW own by a company that has its core business in the textile sector and has decided to invest in the renewable sector, and a photovoltaic plant of size 0.21 MWp. In addition, there are 4x770 kVA diesel generators that are operated by the DSO, UEDAS, to provide power to the island when there are in faults in the submarine cable.

Residential buildings*: UEDAS* have 8000 residential customers

Commercial buildings: UEDAS have 1000 commercial customers.

Industrial buildings: UEDAS have 100 industrial customers.

In additional: There are approx. 70 transformers and 70km HV line length,100km LV line length.

Existing energy assets and infrastructure in the pilot site

In the island are present three big-size renewable plant:

Two wind turbines of size 0.9 MW and a photovoltaic plant of size 0.21 MWp. In addition, there are 4x770 kVA diesel generators that are operated by the DSO, UEDAS, to provide power to the island when there are in faults in the undersea cable.

100 kW electric storage system will be installed by us for other Horizon project (VPP4ISLANDS), and we can use this system for FlexCHESS.

Challenges: In the Turkish energy regulation, DSO must give the energy which indicate in power connection agreement of customers and flexibility regulation is not applied.

How FlexCHESS will help

We will install 100kW battery system (from VPP4ISLANDS project), 1 piece 22kW electric vehicle charging point and 6kW heat pump unit.

4 Flexibility Standards, Regulations and Security

4.1 Standards and regulations

The standards and regulations governing energy flexibility constrain and create barriers or incentives for deploying solutions in different regions. As the standards and regulations are constantly evolving this section provides a summary of the current situation and future directions.

European:

Energy Market: European Regulation (EU) 2019/943

The Industrial Digital Twin Association (IDTA) takes responsibility for the Asset Administration Shell (AAS) specification and repository. These are key aspects for interoperability between systems and their digital twin representations.

IEC 61360-4 - IEC/SC 3D - Common Data Dictionary (CDD - V2.0015.0003) defines the classes and properties of electrical products in a generic manner. This provides a common way to describe system components and their capabilities. IEC 61360 is evolving to support battery system lifecycle related parameters and Carbon Foot Print (CFP) determination in support of EU regulations on battery passports for second-use and recycling which are important considerations.

IEC 61850 substation integration models for SCADA Integration and control schemes.

IEC61970/61968 Common Information Model (CIM) mapping to / from other domain specific product ontologies can be automatically supported to facilitate inter-system / domain interoperability. For instance, in support of hybrid or multi-vector energy storage systems.

SGAM IEC/PAS 62559 methodology for developing requirements for energy systems

Italy:

Currently, in Italy, the remuneration of flexible loads is done by the TSO; a recent deliberation from ARERA (Autorità di Regiolazione per Energia Reti e Ambiente) has opened this role also to DSO.
The new business model of energy communities foresees the remuneration of self-consumption at local level, allowing to get incentives for energy sharing.

https://anienergia.anie.it/generazione/sistemi-di-accumulo/normativa-e-legislazione/
https://www.gse.it/normativa

UK:

The electricity market in the UK can provide diverse incentives for both energy and ancillary service markets. In the energy market, there are time-varying energy prices plus time-varying network charges. In the ancillary service market, the Electricity System Operator (ESO) procures many different types of balancing services. There are trial services procured by local electricity distribution network operators as well.
https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/electricity-system-operator-eso-regulation

https://www.gov.uk/guidance/electricity-network-delivery-and-access

Spain:

The figure of energy communities (EC) is defined in the Spanish legislation but not fully developed. EC needs to be founded as an association or Coop. Interactions with citizens: difficulties to understand a complex structure/low cooperative willing, lack of security in first stages. Interaction with DSO not easy. There is an unstable regulatory framework.

Spanish Law 24/2013 - regulates the electrical sector

Spanish RD 244/2019 (and updates: Orden TED/1247/2021; RD-Law 14/2022; RD-Law 18/2022; RD-Law 20/2022): legislation for self-consumption

Turkey:

DSO must give the energy needs of customers in Türkiye and flexibility regulation is not applied.

4.2 Security

Energy security is vitally important and various factors must be considered to ensure stable supply even in the event of unforeseen events, failures and attacks on the system components. Electricity security can be defined as the power system's capability to withstand disturbances - i.e. events or incidents producing abnormal system conditions -, or contingencies - i.e. failures or outages of system components - with minimum acceptable service disruption (see [15]]). Electricity security can be considered as a combination of several electricity security properties :

- Operational security is the ability of the power system to maintain or to regain an acceptable state of operational condition after disturbances. It covers dynamic issues and real-time network management issues.
- Flexibility is the capability of the power system to cope with the short/mid-term variability of generation (like renewable energy) and demand so that the system is kept in balance.
- Adequacy is the ability of the power system to supply the aggregate electrical demand at all times under normal operating conditions. It generally includes:a generation/storage adequacy component, a transmission network/import adequacy component, distribution network and end user adequacy components,a market adequacy component.
- Resilience is the mid-term capability of the power system to absorb the effects of a disruption and recover a certain performance level.
- Robustness is the long-term capability of the power system to cope with constraints/stresses originating outside the infrastructure dimension.

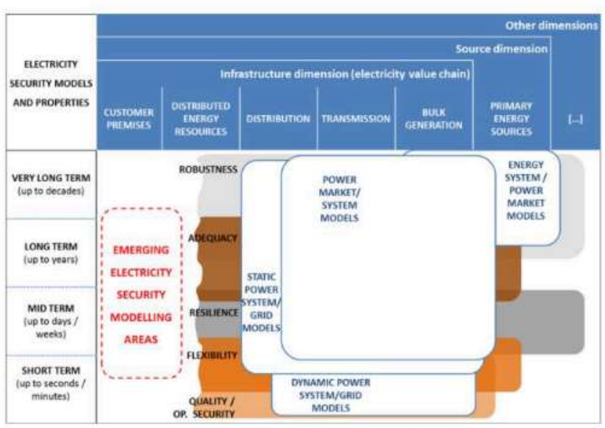


Figure 1 : A taxonomy between science and policy is derived for electricity security properties, and electricity security models and approaches are critically reviewed and contrasted (from [15]])

It is clear that there is a requirement to evaluate emerging security models for flexibility services with distributed energy resources to ensure the energy security (see Figure 1). This itself must be resilient, operate in different timescales and be robust to failure and attacks.

5 Analysis and Conclusions

The analysis and conclusions of the flexibility needs and requirements is conducted by answering the three following questions.

5.1 What are the key flexibility needs and benefits for stakeholders ?

The key flexibility needs and benefits derived from the FlexCHESS use-cases (see section 3) are:

- Responding to time-varying electricity prices, balancing services, voltage support, and constraint management.
- VESS to reduce storage costs and permit rapid deployment.
- Implicit DR for individual users and the LEC.
- Explicit DR for the LEC.
- Testing Peer-to-peer energy sharing approaches.
- Creating a dialogue between system integrator and multi-utility which would facilitate the exploitation and provision of flexibility services using the existing assets, allowing the integration of existing data with a central energy management system to manage loads.
- Creating a Local EC to maximize PV plants production and studying new business models, taking advantage of aggregation and DR schemes to obtain further benefits for the LEC members
- Providing the relevant data management and analysis functions and tools for supporting flexibility services.
- Creating a cost-effective IoT infrastructure to control the smart devices.
- Developing cost-effective IoT solution and tools that are easy to use for end-users.
- Testing use cases and developing new business models for flexibility services.

5.2 What are the fences and barriers for adoption ?

The main fences and barriers to adoption of flexibility service solutions derived from the FlexCHESS pilot use-cases (see section 3) are summarised as:

- High capital costs, absence of financial incentives and lack of efficient remuneration schemes as well as no markets (remuneration) for provision of services to grid operators to medium/small consumers. Also, the absence of existing suitable business models.
- The provision of flexibility services through the identified existing assets should not interfere with end-users needs (guaranteeing adequate thermal comfort levels in buildings and allowing the normal usage of vehicles).
- The possible decoupling between flexibility grid requirements and loads.
- The objective is to reuse as far as possible assets already present that can be exploited to provide flexibility services to the network and can be aggregated on a large scale. However, there may be limitations on what is possible due to this approach.
- For cost and practicality it is necessary to start from widespread loads (albeit with a lower power density) on existing assets to understand how to control /manage them with a central energy management system.
- DSO must guarantee the energy needs of customers in Türkiye and other regions, but flexibility service regulation is not well defined.

- There are difficulties to understand a complex structure, low willingness to cooperate, lack of security in the initial stages and interaction with DSO is not easy. Also, unstable regulatory frameworks hinder the adoption.

A thorough analysis will be conducted for each pilot use-case in D1.5.

5.3 What are the futures for flexibility services within the selected Countries ?

The urgency for support and deployment of flexibility services is increasing across Europe as a results of the recent energy crisis, which has had a major impact on energy security and prices throughout the region. Coordinating HESS, VESS and DER assets can be realised with lower investment in a distributed manner as compared to deployment of large scale centralised approaches, or new generation capacity. This is only possible if the necessary incentives are made possible by the appropriate and effective regulatory and market regimes.

In the short to mid term there are many initiatives for providing flexible markets and flexibility services in various countries. However, the approaches are currently fragmented and not interoperable and are limited by the different market regimes. For instance, in Turkey, Spain and many other countries there is still no provision for DSO/DNO or communities to allow incentives for the provision of flexibility services, but these can be tested to explore the best flexibility solution and market approaches to force regulatory change. Hence, the widespread commercial adoption of VPP, VESS, HESS and DER enabled flexibility services is still very low but increasing. To accelerate this process requires both movement from regulators and from stakeholders to adopt flexibility-enabling standards and IoT solutions that can support easy integration and low cost deployment of distributed HESS and VESS. We are beginning to see this shift in regulatory position within Italy, the UK and other countries that will permit DSO/DNO and communities to be able to participate in emerging flexibility services markets, but further research and evaluation is required for different use-cases.

The adoption of flexibility service, enabled by distributed connected HESS and VESS solutions, is expected to accelerate rapidly in most European countries due to reliance on unpredictable renewable generation and the impacts on energy security caused by the recent energy crisis. The mid to long term will see harmonisation of standards and flexibility market regimes permitting economies of scale, but optimal market and regional sizing considerations will depend on the response timescale and type of response required from the flexibility services, which are determined by local considerations such as local weather and energy demand conditions.

Finally, some products and services have been identified in the various regions, that provide some hybrid energy storage, VPP or VESS and demand side flexibility capabilities. However, there is generally a lack of interoperability and fragmentation in the local markets limiting widespread adoption or harmonised approaches. The scaling of solutions from small trials and pilots towards requires tackling the complexity and performance trade-offs which can be addressed by considering different optimisation and flexibility timescales in combination with the spatial dimension. The distributed platform to support this energy management optimisation and flexibility market approach will need to consider many factors and trade-offs. Within the future work of FlexCHESS the specific interoperability and harmonisation targets for optimising the trade-offs will be defined and addressed.

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Contact

contact@flexchess.eu

Aix-Marseille University

Jardin du Pharo, 58 Boulevard Charles Livon,

13007 Marseille, France

https://www.FlexCHESS.eu/

@FlexCHESSHorizonEU

www.linkedin.com/company/FlexCHESS/

https://twitter.com/ChessFlex

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement **No°101096946.**