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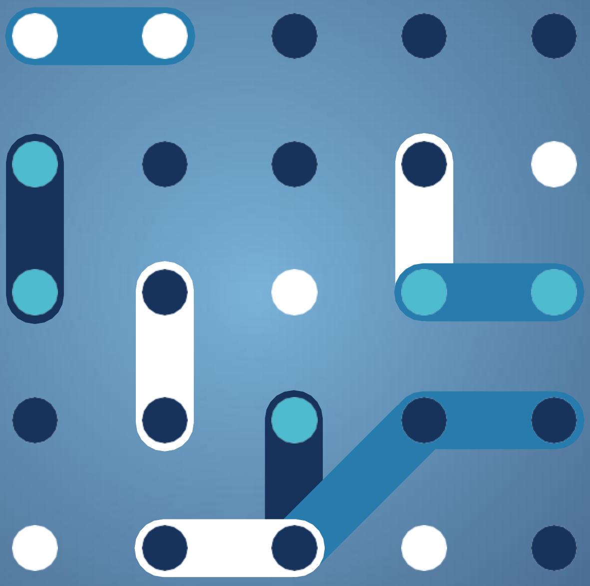
Digital tools and technologies for smart grids

Case Study #9



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0. INTRODUCTION

This paper sets out to develop a series of case studies over the course of the contract period (2024-2026), each incorporating the results of projects that will be part of the BRIDGE[1] programme during the period. The aim is to complete two case studies annually (with case studies #9 and #10 being the focus of this year's analysis), with each addressing a specific thematic area. These studies aim to go beyond the scope of individual project results, providing a broad and an integrated overview of the research landscape.

Case Study #9 focuses on the topic of *Digital Tools and Technologies for Smart Grids.* Specifically, it focuses on analysing how advances in this area are contributing to the modernisation and optimisation of energy networks. This thematic focus allows us to examine in detail how digital innovations are being exploited to create more resilient, efficient and adaptive smart grids (Chapter 2).

In pursuing this goal, the case studies will not only highlight the different outcomes in BRIDGE projects, but will also demonstrate how these outcomes align with and respond to real market demands. This approach ensures that the knowledge gained is not merely theoretical, but has practical applicability and potential for exploitation in reality. By focusing on market needs, these case studies aim to “bridge” the gap between research and application, showing how BRIDGE projects can contribute to solving current industry challenges.

Furthermore, the integration and interaction of the different projects and their outcomes will enable a more comprehensive understanding of the collective impact of the BRIDGE initiative. Each case study will provide detailed insights into specific topics, ranging from technological innovations to market adaptations, thus offering stakeholders valuable insights into the practical benefits and potential applications of the research. This structured analysis will support the effective dissemination and exploitation of BRIDGE project results, ultimately promoting innovation and growth in the relevant sectors.

In light of the above, this paper is structured as follows:

- Chapter 1 provides an overview of the methodological approach employed;
- Chapter 2 presents the digital tools and technologies for smart grids under analysis;
- Chapter 3 discusses on the potential opportunities and strategies for scaling up the project results;
- Chapter 4 provides the case study conclusions;
- The Annex section presents the tables with the single project’s analysis.

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[1] BRIDGE Website: https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/

1. METHODOLOGICAL APPROACH

This chapter outlines the methodological approach employed by the project team for data collection and analysis, while also detailing the criteria used to select projects for inclusion in the case studies.

1.1 DATA COLLECTION AND ANALYSIS

The data collection activities began with an extensive data extraction from the CORDIS[2] database, which encompasses detailed records of EU-funded research and innovation projects (the project types currently included are from the Horizon 2020[3] and Horizon Europe[4] programmes). This initial step was crucial for identifying key data of BRIDGE projects (e.g. start date, end date, budget, etc.). By applying specific search criteria and filters, a list of active projects was obtained, which served as a basis for further analysis.

Following the data extraction, the project team developed a detailed survey[5] to establish a unified database. The survey was designed to capture a comprehensive range of information about each project, including keywords/macro topic, types of technologies, demonstrations, pilots, and other relevant details. This structured approach ensured the collection of consistent and thorough data directly from project coordinators.

Upon receipt of the completed survey for all project involved, a thorough analysis of the responses was conducted. This involved systematically reviewing and categorising the data to extract pertinent information about each project's status and achievements.

The next analysis phase centred on selecting mature projects, defined as those within twelve months of their scheduled completion. This criterion was designed to ensure that the selected projects had reached a sufficient stage of development to yield substantial and meaningful results for analysis. From the initial dataset, nineteen projects were identified as meeting the maturity criterion.

To further refine the selection process, a thorough keyword-based filtering method was applied. This approach aimed to ensure that the projects chosen for the case studies were not only in advanced stages of development but also closely aligned with the specific thematic focus – Smart Grids and Digital Tools. After identifying nineteen mature projects, the selection was further narrowed by focusing on those that aligned with the primary macro topic of the analysis. Subsequently, the filtering process delved into the *Sub-topics* covered by each project. These were used to match project descriptions, deliverables, and outcomes, ensuring a detailed alignment with the targeted research areas.

Through this rigorous selection process, five projects were ultimately identified.

After having selected the projects for the case study analysis, a specialised survey[6] focusing on key exploitable results (KERs) was developed and distributed. The purpose of this questionnaire was to collect detailed information regarding the unique contributions and insights of each project. A thorough comparative analysis of the responses was conducted on the selected five projects.

The comparative approach allowed us to understand not only the unique contributions of each project, but also how these contributions could be integrated to address broader challenges and opportunities in the sector. This method of analysis provided a more comprehensive view, highlighting areas where collective efforts could lead to

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[2] CORDIS database: https://cordis.europa.eu/it
[3] European Commission: https://cinea.ec.europa.eu/programmes/horizon-europe/h2020-programme_en
[4] European Commission: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
[5] Survey #1: https://ec.europa.eu/euSurvey/runner/bridgeSurvey2023
[6] Survey #2: https://ec.europa.eu/eusurvey/runner/7a874f25-a4bf-a3ce-8c2c-1083d9151f77

significant progress and innovation. Additionally, this comparative process was instrumental in drawing comprehensive and well-founded conclusions, which can be found in Chapter 3.

Following this data analysis phase, we held an online meeting with the projects to discuss the case study and to share experience and insights in a roundtable format. This allowed us to identify common themes and challenges and to refine our analysis.

1.2 SELECTION OF PROJECTS

This section briefly outlines rigorous criteria applied to identify the most promising projects to include in our case studies. These criteria included:

1. the level of maturity of the projects (projects with less than 12 months to closure),
2. alignment with the macro-topic covered (these are macro topics that were used in the Bridge Brochure[7])
3. relevance of the sub-topics to ensure a comprehensive analysis of innovation and market adoption.

The following table provides an overview of the outcomes from the selection process, highlighting the projects that were identified based on the established criteria.

Please refer to the attached document (Annex) for further details regarding the selection criteria specifications.

Table 1: Projects and subtopics selected for the analysis

N. Project	Logo	Project
1		ELECTRON
2	Hestia	HESTIA
3	HYPERRIDE THE FUTURE OF POWER DISTRIBUTION	HYPERRIDE
4	IANOS	IANOS
5	LocalRES	LocalRES

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[7] Bridge Brochure 2024: https://op.europa.eu/en/publication-detail/-/publication/79e30192-4a3f-11ef-acbc-01aa75ed71a1/language-en/format-PDF/source-337202064

2. CASE STUDY #9: DIGITAL TOOLS AND TECHNOLOGIES FOR SMART GRIDS

This chapter presents Case Study #9, which focuses on the application of digital tools and technologies within smart grid systems. It explores the advancements and innovations in this field, highlighting how these technologies contribute to the efficiency, reliability, and intelligence of modern grid infrastructures. The analysis encompasses a detailed examination of various digital solutions, including their integration and impact on the overall functionality of smart grids.

2.1 CONTEXT AND CHALLENGES ADDRESSED

Smart grids incorporate cutting-edge digital solutions and technologies to create a more efficient, reliable, and sustainable energy grid. Recent research & development efforts in the energy sector have focused on optimising the operation of these grids through a combination of hardware and software innovations. More specifically, we will explore the key components that make smart grids transformative, including advanced metering infrastructure (AMI), the integration of distributed energy resources (DERs) with energy storage systems, the role of microgrids, demand-response programmes, and the vital importance of communication technologies like 5G and Internet of Things (IoT). Additionally, this text discusses emerging technologies such as blockchain, artificial intelligence (AI), machine learning and digital twins, all of which contribute to the optimisation and resilience of modern energy grids.

One key aspect of smart grids is the **advanced metering infrastructure (AMI)**, which enables the collection and analysis of real-time data on energy usage. AMI systems typically consist of smart meters and data management systems interconnected by a data transmission network that allows detailed monitoring of energy use patterns and supports the implementation of a demand-response strategy. This is not the subject of the present case study but is a prerequisite for the operation of smart grids and specifically for the provision of reliable energy consumption data to the digital tools subject of the case study.

Another important goal of smart grids, enabled by **digital solutions**, is the integration of distributed energy resources – mainly from renewable sources like solar and wind – with various types of energy storage systems. To successfully integrate these resources into the electricity grid, robust energy management systems are necessary to dynamically balance supply and demand. Predictive analytics and machine learning algorithms play a critical role in forecasting energy production and usage, ensuring the grid performs optimally.

Energy storage technologies – especially batteries – are central to addressing the intermittency of renewable energy sources. Recent advancements in battery technology have focused on increasing energy density, improving charge-discharge cycles, and enhancing efficiency while reducing costs. Smart inverters further enhance battery storage systems by providing grid services such as frequency regulation and voltage support, leading to improved grid stability. **Microgrids**, which can operate independently or in coordination with the national grid, are another key component of smart grids. They incorporate DERs and energy storage systems managed by complex control systems, to ensure seamless integration and optimal performance. Microgrids offer significant benefits, including improved energy security and resilience, particularly for isolated areas or regions with weak infrastructure that are vulnerable to extreme events.

Communication technologies, including high-speed and secure networks, play a crucial role in smart grids. Technologies like 5G and IoT are transforming grid-related communication services by offering low-latency, high-bandwidth connections that support real-time data exchange and control of grid assets. Efficient and fast communication is essential for coordinating grid components — such as sensors, actuators, and controllers — enabling decentralised decision-making and automated responses to specific grid conditions.

Moreover, **blockchain technology** is emerging as a powerful tool for enhancing security and transparency in energy grid management. By providing a decentralised ledger, blockchain can securely track transactions and asset management actions across the grid, facilitating peer-to-peer energy trading while reducing cyber-related risks. Blockchain-based energy contracts can also simplify and automate processes like billing, compliance, and grid operation, further streamlining energy management.

Artificial intelligence and machine learning represent the latest advancements in grid analytics. AI-driven algorithms can analyse vast amounts of data from sensors and smart meters across the grid, detecting anomalies, predicting failures, and optimising maintenance schedules. The adoption of predictive maintenance strategies can reduce downtime and extend the lifespan of grid components. Additionally, machine-learning models support the dynamic optimisation of grid stability by adjusting operations based on fluctuations in energy supply and demand, enhancing resilience against disruptions.

Another significant development is the use of **digital twins** in power grids. These virtual models of physical grid infrastructure allow operators to run simulations and scenario analyses, enabling predictive analysis and proactive grid management. Digital twins help reduce risks and improve decision-making, contributing to the overall efficiency and reliability of the grid. This is connected to the concept of **Virtual Power Plant (VPP)**, which integrates through digital solutions differently distributed energy production plants (solar, wind, other RES or cogeneration plants) to collectively monitor, optimise and trade electricity, achieving a more stable electricity production, grid stabilisation and flexibility to participate in energy markets.

To conclude, **demand-response programmes** are gaining traction thanks for digital platforms that engage end users in grid management activities. These platforms use real-time data to incentivise consumers to adjust their energy usage during peak demand periods, helping to balance the grid. Advanced digital customer engagement tools, like mobile apps and smart devices, provide users with detailed information on their energy consumption and opportunities to participate in demand-response initiatives. Again, this is not a subject of the present case study, but the digital tools are a key enabler of demand-response programmes.

While significant potential from these innovations exists to enhance grid efficiency, reliability, and sustainability, some challenges hinder their deployment. The main regulatory and economic barriers identified are related to complex approval processes and high initial costs, but also to the need for standardised frameworks that help interoperability and data sharing among grid components. The present case study focuses on **how to facilitate the deployment of digital tools and technologies for smart grids** through overcoming the identified barriers and exploiting key enabling factors.

2.2 KEY FINDINGS

Based on the analysis of the project results, four research topics in the field of digital tools and technologies for smart grids were identified, namely:

- Platforms and forecasting tools: R&I efforts are focused on developing digital platforms that integrate AI, IoT, and blockchain technologies. These platforms aim to improve grid operations, enhance cybersecurity, and facilitate real-time data exchange, making energy distribution smarter and more efficient. This includes forecasting tools enhancing the accuracy of energy production/consumption data to optimise resource planning;
- Grid technologies: Advancements in grid technologies include the development of hybrid AC-DC systems, smart grids, and enhanced renewable energy integration systems including advanced energy storage systems. These innovations aim to improve grid resilience, stability and autonomous energy management, supporting higher renewable energy penetration and improving cost effectiveness;
- Virtual Power Plants (VPP): The development of VPP technologies focuses on aggregating distributed energy resources into unified, efficient power plants. These VPPs help reduce grid congestion, improve energy efficiency, and facilitate the integration of renewable energy sources;

- Citizen Engagement: Promoting community energy initiatives and collective flexibility programmes, R&I projects are increasing energy efficiency and encouraging sustainable practices. Active consumer participation in the energy transition is a key focus to achieve these goals.

The contribution of the different projects to the above-presented R&I topics is summarised in Figure 1.

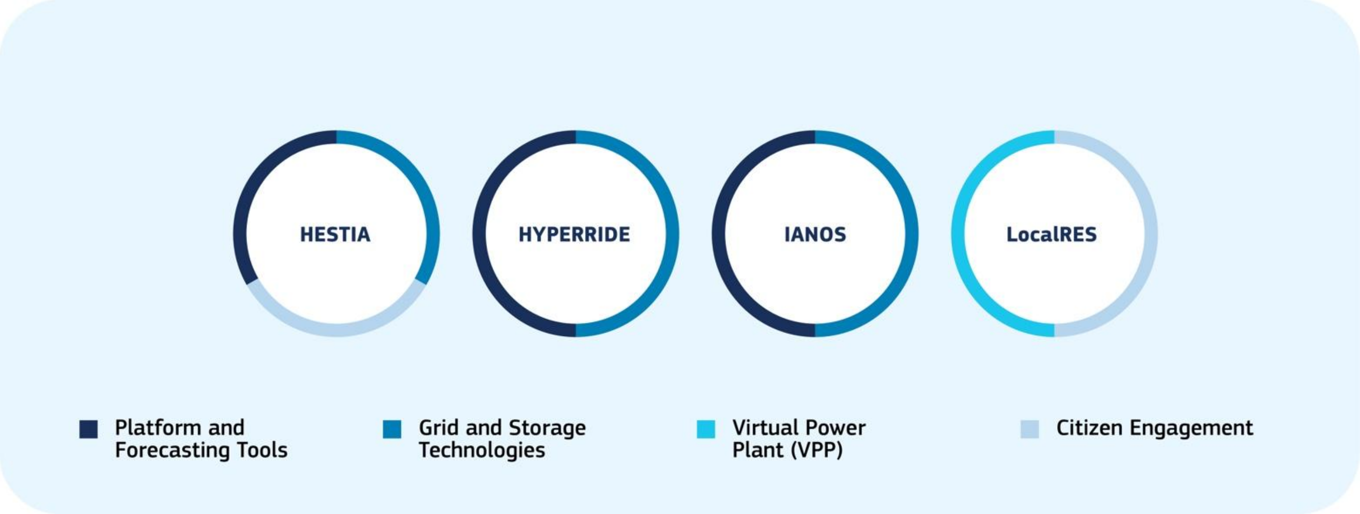


Figure 1: Projects Contribution to different R&I Topics

The following paragraph presents how the selected projects have covered the different topics. More generally, it presents the general trends in research activities for digital tools and technologies for smart grids.

2.2.1 Platforms and Forecasting Tools

These platforms focus on developing advanced digital tools incorporating state-of-the-art technologies with algorithms including AI, IoT, blockchain, with the core focus of improving the energy management and distribution. AI algorithms study vast amounts of data to optimise grid operations, predict possible issues before they happen, and improve the accuracy of energy demand and production forecasts. IoT devices offer real-time monitoring and control of consumption and generation to make the energy system responsive to real-time conditions. The transactions over blockchain are secure and transparent, offering protection against fraud and enabling peer-to-peer trust. These integrated platforms, apart from strengthening grid operations for making them smarter and efficient, allow accurate forecasting that supports effective resource planning, optimal dispatch of energy resources and integration of renewables. This, in turn, leads to a more reliable and resilient energy system that will be responsive to consumers' needs while minimising operational costs and environmental impacts.

The HESTIA project targets the development of a pan-energy platform to enhance demand-side energy management and consumer engagement. It includes next-generation demand response services integrated with advanced ICT that offers residential consumers real-time energy monitoring and management through user-friendly interfaces and mobile applications. Employing machine learning algorithms, HESTIA predicts energy demand and supply at community level by considering historical data and weather patterns, based on an iterative learning process: the HESTIA “measure-forecast-optimise-engage” loop. It gives real-time insights to the user on making informed decisions on energy, identifying peak demand periods and times of supply shortage to improve system reliability. HESTIA fosters a shift in energy use by consumers from peak to off-peak periods to reduce grid strain. It optimises local renewable energy sources efficiently, storing excess generation and using it when necessary. Besides that, HESTIA enables elastic energy market mechanisms for consumer-to-consumer trading of energy necessary for stability on the grid. Because of the scalable and modular nature of the solution, HESTIA can also be put to work with communities of variable sizes with variable energy requirements, hence proving to be a versatile solution for modern energy management.

The main encountered issues are related to:

- Difficulty engaging consumers in demand-side management: HESTIA uses personalised services, financial incentives and feedback on energy use, supported by a flexible ICT platform and a Consumer Digital Twin to simulate and optimise engagement strategies;
- Ensuring data privacy and autonomy while enabling decentralised smart grid operations: HESTIA employs an agent-based framework that allows for decentralised negotiation and local data handling, minimising large-scale data exchange and protecting user privacy in line with GDPR;
- Complexity in balancing supply and demand flexibility across multiple energy resources: HESTIA uses advanced energy dispatch optimisation techniques and Model Predictive Control (MPC) algorithms to dynamically adjust energy use, integrating real-time grid conditions, forecast demand, and renewable energy production;
- Challenges in accurately forecasting energy demand due to variable consumer behaviour and external factors: HESTIA is implementing machine learning-based Energy Demand Forecasters and Non-Intrusive Load Monitoring (NILM) to analyse historical data and predict energy needs with high precision;
- Low consumer adoption of smart grid technologies and practices: HESTIA is developing a user engagement methodology with participatory design processes and gamification strategies, such as reward systems, to make energy-saving measures more appealing and increase user acceptance.

In addition to the digital component of the research, HESTIA has also carried out an in-depth analysis of the end users' requirements for digital platforms for smart grids, highlighting the following main aspects:

- the target population must be involved in designing the devices so that these are both familiar and contextually relevant, and they need to be attractive, visible, safe and easy to use, in order to ensure long-term engagement by end users;
- Interoperability of various energy technologies within smart homes is important in terms of integration and synergy; a "one-size-fits-all" approach does not work within households and communities, but customisation needs to be allowed, accommodating different household habits, including overriding of the automated solution to maintain control when needed;
- platform design should consider various user profiles, considering variable digital and technical literacy and accessibility; learning opportunities and peer support to enhance users' understanding and interaction with energy technologies shall be provided, also relying on "warm experts" based in communities to provide accessible trust-based support and advice;
- testing of technologies in real-life settings, both at single energy use level and at integrated level is useful for building user trust and reducing technical problems.

HYPERRIDE aims at creating an advanced energy platform that embeds renewable energy sources into a storage solution working with the existing grid infrastructures while ensuring interoperability, including fluent communication and data interchange among the different parts of the energy system. Key enabling technologies studied in the project include DC circuit breakers, current and voltage sensors, and DC measurement units, targeting an increase of grid automation and an improvement of fault detection capabilities. To do so, the platform makes use of IoT devices and advanced sensors to monitor in real-time energy flows and enable performance-optimising control. HYPERRIDE improves the safety and transparency of energy trading, reducing the vulnerability to cyberattacks or frauds. The platform further integrates advanced analytics for predictive maintenance and fault detection in smart grids, reducing the possibility of downtimes, thus improving grid reliability, and supports distributed energy generation. To conclude, HYPERRIDE is designing business models for new products and services to support a wider rollout of smart grid technologies in Europe.

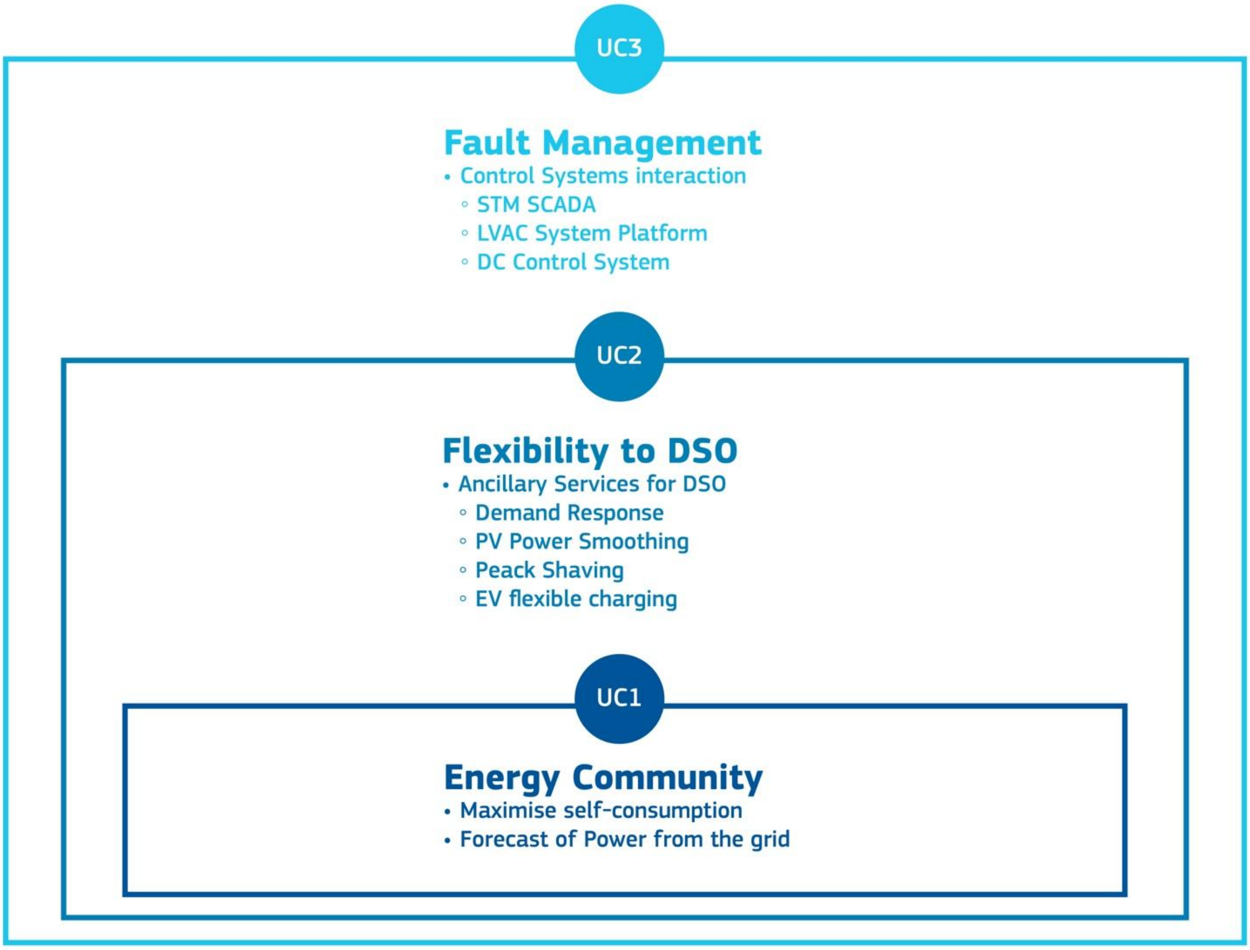
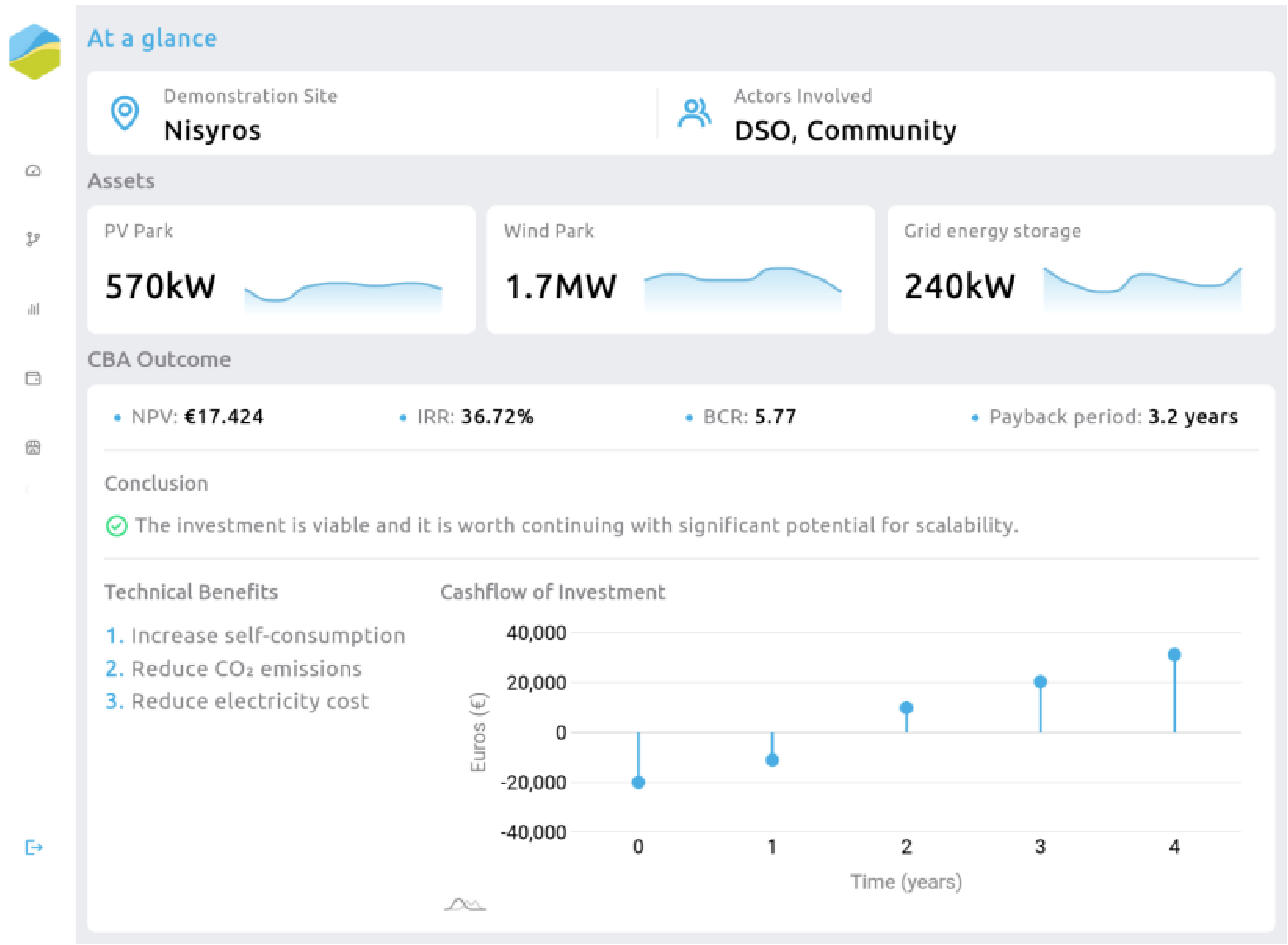


Figure 2: HYPERRIDE Use Case Topics

The most significant difficulties faced are related to:

- Difficulty in coordinating protection for hybrid AC-DC grids, such as feeder selectivity for DC grid protection, addressed by HYPERRIDE by developing and demonstrating advanced protection coordination solutions involving MVDC breakers and integrated power electronics;
- Lack of standardisation for LVDC and MVDC components, mitigated by engaging with relevant standardisation authorities and initiatives to establish new standards and certifications for DC grid components;
- Cybersecurity risks due to multiple ICT access points; to this aim, HYPERRIDE is developing a secure ICT platform and extending the SUCCESS Toolbox for advanced threat detection and prevention;
- Complex grid automation and control in a hybrid AC-DC environment, overcome by HYPERRIDE by creating and validating automation algorithms, grid control methods, and sensor technologies to support automated fault detection and response;
- Difficulty in integrating and optimising renewable energy sources in hybrid grids, addressed by using advanced DC grid technologies, such as active front-end converters and power conversion units, to enhance flexibility and efficiency in renewable energy integration;
- Scalability and affordability of new technologies, addressed by investing in the development of business models and technology certification.

IANOS is developing an advanced energy platform that optimises the management, storage and distribution of renewable energy to support local energy communities. The iVPP Operative Orchestration Toolkit connects different building blocks to optimise grid management, i.e. the Centralised Dispatcher, Forecasting Engine, and Energy Routers. It also taps into tools such as the IEPT suite for energy planning and transition (screenshot shown in Figure 3) and the P2P Transactive Energy Trading Framework to enable the local communities to trade energy. By integrating real-time data analytics and control algorithms, the platform balances energy supply and demand, ensuring reliable distribution. It also enables peer-to-peer energy trading, promoting local sustainability through the integration of solar, wind, and wave power. The platform's forecasting techniques use machine learning to predict renewable energy generation and energy-use patterns, optimising the use of energy storage systems. This allows excess energy to be stored during high production and utilised during peak demand, enhancing grid reliability. IANOS also supports demand response and provides essential grid services like frequency regulation.



At a glance

Demonstration Site: **Nisyros**

Actors Involved: **DSO, Community**

Assets

PV Park: **570kW**

Wind Park: **1.7MW**

Grid energy storage: **240kW**

CBA Outcome

- NPV: **€17.424**
- IRR: **36.72%**
- BCR: **5.77**
- Payback period: **3.2 years**

Conclusion

✓ The investment is viable and it is worth continuing with significant potential for scalability.

Technical Benefits

1. Increase self-consumption
2. Reduce CO₂ emissions
3. Reduce electricity cost

Cashflow of Investment

Figure 3: IANOS Energy Planning and Transition Tool Screenshot

The principal challenges are associated with the following topics:

- Technical complexity of integrating multiple energy sources and technologies into existing island grids: this is addressed by IANOS by using the iVPP platform to provide real-time optimisation and management of energy assets;
- Variability of renewable energy sources like solar and wind makes forecasting difficult: IANOS employs advanced forecasting engines to improve accuracy by over 10%;
- Limited local energy storage capacity creates reliability issues: this is being mitigated by IANOS by implementing different storage technologies such as biobased batteries, heat batteries and flywheels;
- Ensuring community engagement and acceptance of new technologies: IANOS overcomes this through local

energy communities, involving over 900 participants in decision-making on energy management;

- Privacy: the Forecasting Engine collects energy consumption encrypted data, covering user preferences and energy generation and storage; such data only need to be accessed by authorised users and therefore platforms often require a Data Protection Impact Assessment in line with GDPR.

2.2.2 Grid Technologies

Advanced grid technologies are crucial in enhancing the resilience, stability, and efficiency of energy distribution networks. Most research initiatives have focused on hybrid AC-DC systems, which target more flexible and efficient grids, as well as on real-time data analysis to optimise energy flows, reduce losses and achieve a higher penetration of renewables. Energy storage technologies also play a key role, since they are needed to ensure grid stability, especially during peak periods and to compensate for the intermittent nature of some renewable energy sources. Advances in the energy density, charging speed and life expectancy of energy storage systems can make these solutions scalable, cost-effective and viable for both large-scale and residential applications. With the combined effect of these technologies, what R&D is targeting is more resiliency, reliability and sustainability while managing energy resources more efficiently to ensure the continuity of power supply.

HESTIA approaches the challenge of energy storage by integrating these systems into local grids to increase energy self-consumption and add flexibility. The energy storage system developed in HESTIA is specially designed to interact flawlessly with other smart grid technologies, such as demand-response services and renewable energy forecasting systems. It includes an all-in-one system housing both battery and inverter in one simple package, making the installation process easier and increasing connectivity at pilot sites. Energy storage solutions at both levels will enable prosumers to maximise locally produced energy, reduce their dependency on the main grid, and reduce energy costs.

The major barriers for the implementation include:

- Integration complexity of combining storage systems with demand-response services, which is mitigated through modular design and flexible ICT platforms;
- Ensuring grid stability while allowing for decentralised energy storage management, addressed with agent-based control systems;
- Consumer engagement with energy storage technology, overcome by involving local communities and stakeholders in the design and deployment phases, incorporating user-friendly dashboards and providing incentives to achieve flexibility;
- Unpredictable renewable energy generation affecting storage use, resolved through advanced energy forecasting tools;
- Interoperability issues between different energy systems and platforms, tackled by using standardised communication protocols and gateways.

HYPERRIDE is pioneering a route for grid optimisation and innovation by upgrading grid infrastructures in order to smooth a higher integration of renewable energy sources. The project works on hybrid AC-DC grids, allowing all the benefits from both technologies, alternating current and direct current, to be realised. This approach increases grid flexibility and allows more effective transmission and distribution of electricity. The project will develop smart grid technologies by focusing on the development and integration of DC and hybrid AC/DC grids. It will design and develop key components comprising MVDC circuit breakers, DC sensors, and other protection and automation devices critical for the grid. In addition, it will be developing power conversion technologies like DAB and MMC converters that will allow efficient and flexible management of the power flow. Moreover, HYPERRIDE will develop grid control algorithms-specific for DC and hybrid microgrids-that further optimise energy distribution and enhance stability in the integration of renewable energies. These demonstrations will be performed at the sites of different countries to test and validate these technologies, so they are ready for real-world applications. An overview of the concept of the HYPERRIDE Italian pilot is shown in Figure 4.

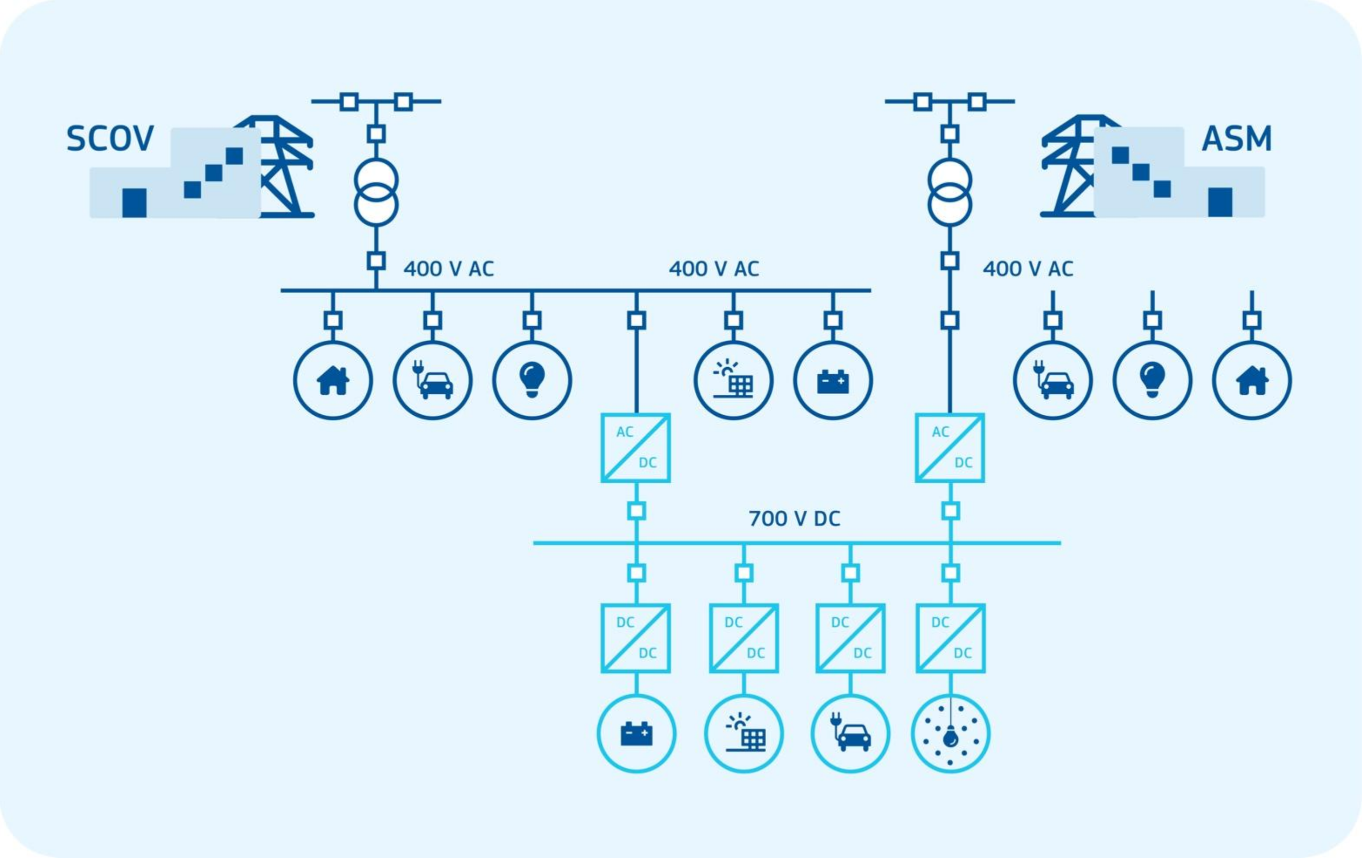


Figure 4: HYPERRIDE – Overview of Italian Pilot

The most significant issues identified concern:

- Coordination of protection in hybrid AC-DC grids reliable with regards to feeder selectivity; this topic is approached by refining the protection strategies with the aid of advanced technologies;
- Lack of established standards on both LVDC and MVDC grids: this is an area in which the project is progressing by engaging with standardisation authorities and promoting the development of new standards;
- Integration of various power conversion technologies into existing grids, managed at demonstration sites by extensive testing and validation;
- Ensuring grid resilience against faults, mitigated by the implementation of advanced fault detection and prevention algorithms in the control systems of the grid.

IANOS is advancing the smartification of energy systems on European islands by deploying innovative technologies that enhance grid efficiency and resilience. The project is integrating different energy storage systems, including biobased saline batteries for electricity storage and PCM thermal storage systems. Hybrid transformers and microinverters are being introduced to improve energy distribution, incorporating advanced materials and power electronics to enhance grid performance. Additionally, the innovative tidal kite technology harnesses energy from low-velocity tidal streams, providing a reliable source of renewable energy even in challenging conditions, and flywheel storage systems are also being tested, offering rapid energy discharge capabilities that support grid stability during peak demand. Smart energy routers manage the flow of energy between distributed generation sources, storage systems, and consumers, ensuring efficient and balanced energy distribution across the grid, and Vehicle-to-Grid charging stations enable electric vehicles to act as mobile energy storage units, feeding power back into the grid when needed, thus enhancing overall energy flexibility and sustainability on the islands. Specific tools, such as the FEID-PLUS and the Virtual Energy Console, allow monitoring and optimisation of energy use at the local level.

The most relevant difficulties in the project are related to:

- Reaching a high penetration of renewable sources in island energy grids; this challenge is overcome by the deployment in IANOS of different energy storage systems and of hybrid transformers and smart energy routers that manage the variability in these sources and assure stable energy distribution;
- Stability of energy storage: as mentioned above, the use in IANOS of different levels of advanced storage solutions, such as biobased saline batteries and flywheel systems, allows for reliable storage with rapid discharge capability to balance demand and supply;
- Exploitation of low-energy renewable sources: low-velocity tidal streams typical of shallow waters are difficult to harness; the IANOS Tidal Kite has been uniquely designed to efficiently operate within such conditions and is therefore being deployed to meet the challenge;
- Scalability and replication: scaling technologies up for wider applications across diverse islands and on the mainland in contexts with different energy needs is complex; IANOS overcomes this by testing and refining modular technologies such as the V2G charging station and microinverter PV systems that can be used across a wide array of local conditions.

2.2.3 Virtual Power Plant

VPP technologies integrate fragmented energy resources like small-scale solar or wind power plants but also storage systems into a single homogeneous, effective power plant. Such integration allows VPP to supply reliable power into the grid, reduce congestion and enhance energy efficiency. VPPs facilitate the penetration of intermittent renewable energy sources due to the flexibility and scalability of their energy management. Indeed, they respond rapidly to changes in energy demand or supply, hence they provide balancing services to the grid for stability and reliability of energy supplies. Moreover, VPPs allow active participation in energy markets through selling excess energy to the grid or providing ancillary services to the grid, such as frequency regulation or voltage support. They unlock improved efficiency and resiliency within energy systems using state-of-the-art control systems and data analytics capabilities in real time; thus, helping to pave a sustainable and decentralised energy system.

IANOS is developing VPPs to enable islands to achieve improved energy management and grid stability. The project combines all renewable energy sources, storage, and flexible loads into one unified VPP platform. Equipped with highly advanced tools, it ensures that dispatch is optimised in terms of energy assets, balancing supply and demand, through its Centralised Dispatcher, among other tools. It also has a Forecasting Engine that provides predictions of energy generation and consumption for grid management improvements. Ameland and Terceira are leading the implementation of VPP technologies through the deployment of smart energy routers, FEID-PLUS devices, and P2P Transactive Energy Trading Frameworks for efficient distribution and consumption. These technologies also aim at ensuring energy self-sufficiency, reduced carbon dioxide emissions, and increased resilience of island energy systems. A scheme of the IANOS VPP concept is shown in the following Figure.

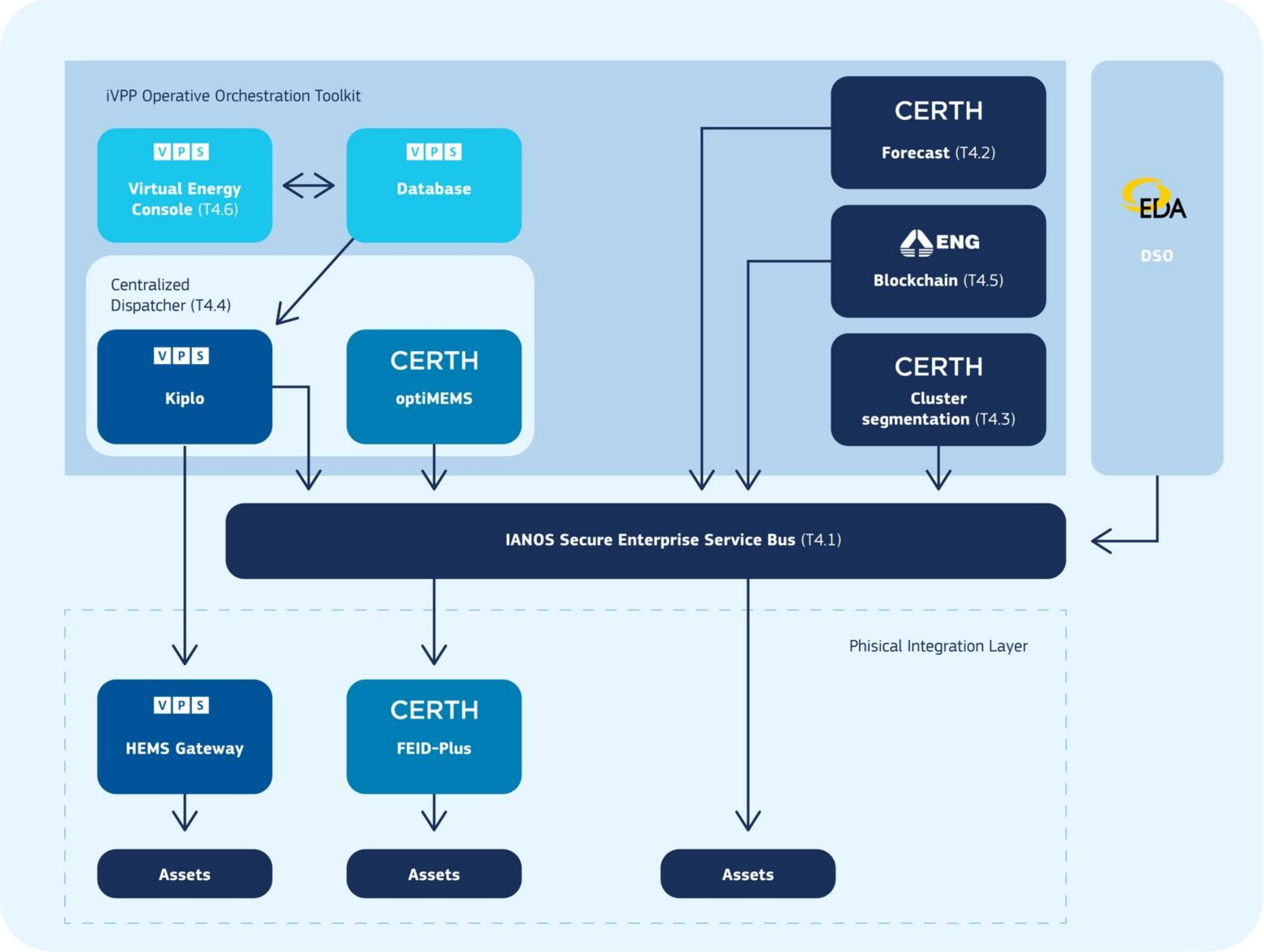


Figure 5: IANOS VPP Concept

The main issues in the technology implementation are associated with:

- Integration of diverse energy sources in VPP: managing the wide variety of energy sources, from solar and wind to tidal and geothermal within a single VPP framework is complex; IANOS addresses this by using the iVPP platform's advanced forecasting and dispatch tools to optimise the integration of these diverse sources, initially developed at single source level;
- Grid congestion management: high penetration of renewable energy sources can cause grid congestion, particularly in isolated island systems; the iVPP platform’s real-time monitoring and control capabilities, along with the deployment of smart energy routers, help mitigate congestion by efficiently managing energy flows;
- Ensuring accurate forecasts: accurate forecasting of renewable energy generation is crucial for effective VPP operation; IANOS iVPP embeds a Forecasting Engine that employs sophisticated algorithms to predict energy production and consumption, ensuring better grid stability;
- Market participation and energy trading: facilitating energy trading among prosumers on islands is challenging due to regulatory and technical barriers; the IANOS P2P Transactive Energy Trading Framework, leveraging blockchain technology, overcomes these barriers by creating a secure, transparent marketplace for energy exchange;
- Scalability and Adaptation: Scaling VPP solutions to different island environments with unique energy needs requires flexibility; IANOS ensures scalability by developing modular VPP components like FEID-PLUS devices and integrating open-source algorithms, allowing the platform to adapt to varying conditions across

the islands.

LocalRES is taking the idea of Virtual Power Plants a step further by aggregating local renewable energy sources and storage solutions with a sector-coupling approach. The LocalRES Multi-Energy Virtual Power Plant (MEVPP) tool empowers the community to optimise their energy flows while offering services both to the community and the system operators. The MEVPP optimises various energy vectors and services in both time-ahead planning and real-time operations based on community preferences, delivers user-friendly services for minimising energy costs while conforming to the community goals. It proposes other grid-friendly services like collective self-consumption, peak shaving and grid stability functions such as frequency control or voltage regulation to ensure high quality power both locally and externally. Besides that, it allows peer-to-peer energy sharing within the MEVPP thanks to its data-handling and communication architecture.

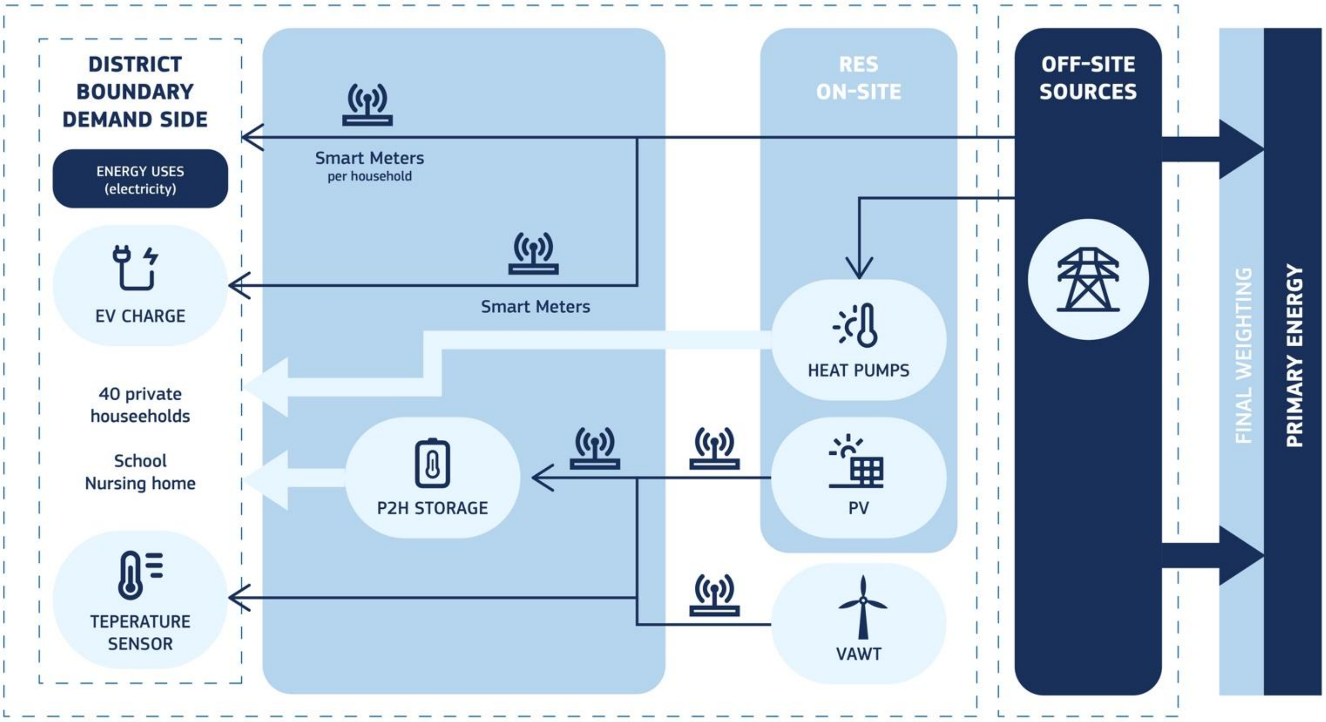


Figure 6: LocalRES Finnish Demo Monitoring Concept

The principal barriers for the proposed concepts are:

- Complexity of data integration: the management of high-resolution data from several energy vectors and sources represent a complex challenge; LocalRES develops advanced data-handling and communication architectures within the MEVPP to ensure seamless operation combined with real-time optimisation;
- Scalability of MEVPP: from small to very large RECs and in different areas of the world, the MEVPP must be flexible for adaptation to various local requirements; IANOS addresses this by the development of modular components of the MEVPP that can be customised on specific community needs;
- System reliability: integration of variable renewables into the grid while maintaining stability is complex; the focus of LocalRES is to improve the reliability of the grid while reducing end-user costs through the real-time optimisation and smart management tools deployed within the MEVPP;
- Barriers to market participation: due to regulatory and technical problems, the participation of RECs in market participation is not easy; LocalRES allows simplification of market access by implementing innovative business models and peer-to-peer energy trading frameworks for communities;
- Consumer engagement: the appropriate user interface and planning tools like those developed in LocalRES need to be used in the project, making it easy to create and manage RECs by citizens in an effective manner.

2.2.4 Citizen Engagement

The promotion of community energy initiatives and collective flexibility programmes is another important focus of the R&I projects to increase energy efficiency and develop sustainable practices. Such initiatives include the empowerment of citizens for energy transition by providing them with instruments and knowledge to deal with their own energy consumption and supply. Community energy projects, like local solar cooperatives or neighbourhood energy storage systems, but also community-led renovation projects, give several citizens the opportunity to co-invest in and profit from energy efficiency and renewable energy production/use. Flexibility programmes incentivise changes in consumer behaviour in response to grid conditions, shifting their energy use to times when excess renewable energy is available. This is combined with campaigns aiming at raising awareness of the many benefits realised through adopting more sustainable energy-use practices. The initiatives empower citizens by creating a sense of ownership and responsibility for the energy transition and support the development of a more sustainable and fair energy system.

HESTIA focuses on the participation of residential consumers, making them active actors for energy management, notably by invoking demand-response mechanisms and sharing flexibility. A participatory code signage process is embedded in the project, whereby the citizens are involved in creating solutions tailored to their needs. HESTIA employs financial, environmental, and social incentives that could motivate consumers to become active in energy consumption management. It provides a set of enabling tools like personalised energy services, user profiling, and a web-based dashboard showing in real time the energy usage to support active decisions by the residents. The behavioural insights are integrated in the Consumer Digital Twin model in order to predict and influence energy use patterns and assure that its approach is user-centric. Such engagement strategies eventually create an inclusive energy market in which residential users will contribute to grid balancing and sustainability efforts. For instance, Figure 7 shows the results of a survey carried out at the HESTIA Italian demo site on the behaviours that citizens are available to change to increase renewable energy production.

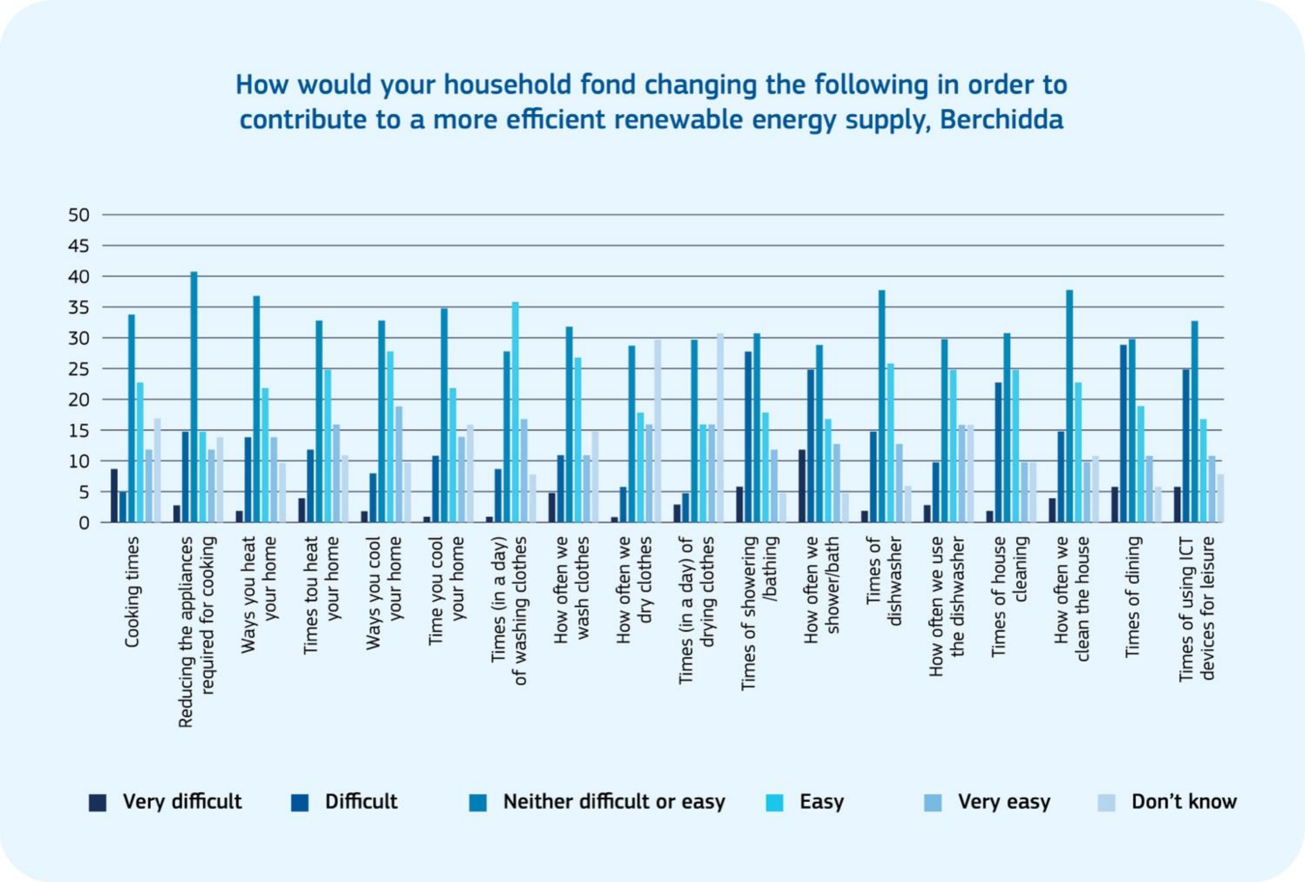


Figure 7: HESTIA Survey on Citizens Behaviour Change to Increase RES Supply

The main encountered issues are related to:

- Encouraging consistent user participation in demand-response programs, addressed by offering financial and environmental incentives;
- Aligning energy management with individual consumer preferences, tackled through personalised services and digital twin technologies;
- Overcoming technical literacy barriers among users, addressed with intuitive dashboards and user-friendly tools;
- Maintaining privacy in data collection, solved by anonymising data in user profiling and digital twin models and to design them as GDPR compliant;
- Ensuring equitable participation across diverse user groups, handled through tailored engagement methods and participatory design processes.

The engagement of citizens is at the core of LocalRES: renewable energy communities are indeed a form of collaboration between citizens, SMEs or municipalities, among others, that work together towards participation on the energy market (for self-consumption, production, etc.). Once the community of stakeholders is formed, most people struggle in finding the combination of technologies that can meet the needs and goals of the community. Usually, establishing a REC requires the identification of the existing energy resources and evaluation of different RES-based system configurations and operation modes to allow the community members to decide how they want to meet their needs, participate in the energy market and bring benefits for the community. The LocalRES planning tool will provide a set of scenarios representing different trajectories that the REC could follow, with associated indicators as a kind of pre-feasibility studies. The performance of each scenario will be assessed in terms of costs, carbon emissions, sustainability and safety of the REC energy system. The planning tool is intended for:

- Energy experts and decision makers, such as representatives of the community: the planning tool will provide them with a global vision of the REC energy system. The tool will give them the opportunity to design long-term scenarios, and assess the impact of each decision on the global cost and emissions of the system;
- Citizens of the community: not only will they be able to access the planning tool to visualise information on the REC, but they will also be able to assess their individual decisions (for instance, installation of rooftop solar panels) and visualise preliminary impacts, such as changes in the energy costs or emissions reduction.

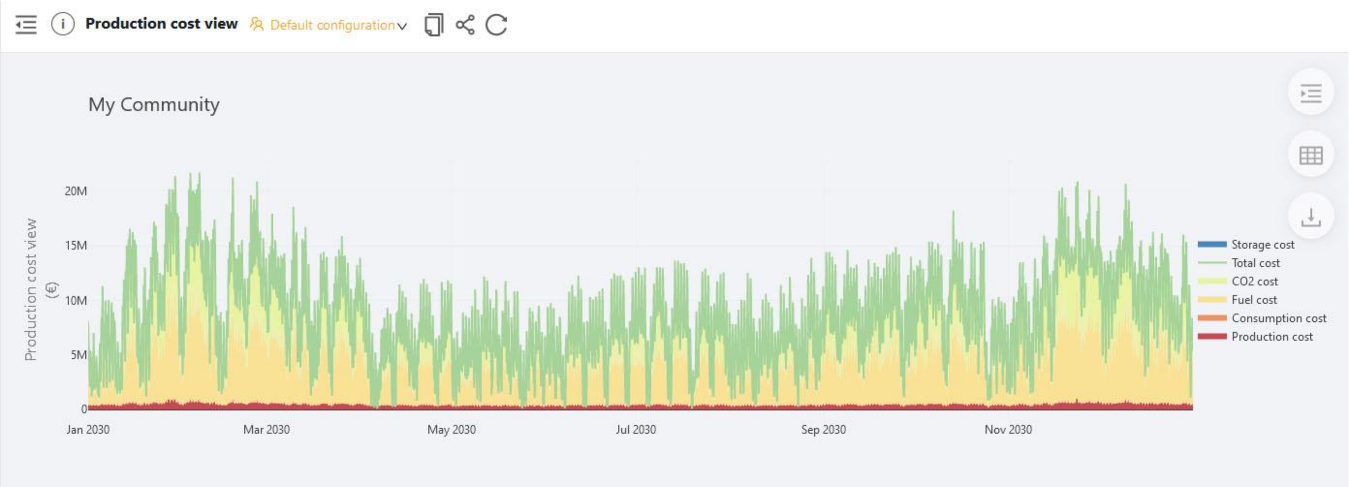


Figure 8: LocalRES Planning Tool Screenshot

The greatest innovation of the LocalRES planning tool lies in its double objective: to be used with the participation of the users so that they are part of the REC design, and to offer the users pre-feasibility studies that currently are so difficult to comprehend. Moreover, a key conclusion from the LocalRES participatory workshops was the value of local heroes or energy champions. These individuals, who represent the energy community from within, while maintaining close connections with energy experts and the municipality, can effectively bridge the communication gap between citizens and experts, thereby helping to engage and attract more interested parties to the energy community.

The most relevant needs identified include:

- Tool flexibility and customisation: the planning tool needs to be flexible to precisely meet citizens' needs and capture the site-specific characteristics and levels of expertise and development;
- Transparency on economic data: investment cost, benefits and return of investment should be transparent and directly correlated to real data so that citizens can trust the results and use them to plan their action;
- User-friendliness: tools for citizens should be simple and intuitive to use and therefore accessible to people with relatively lower technical literacy;
- Capacity building: success stories and data from other communities are important in the inspiration and driving of new and existing community energy initiatives; emphasising personal benefits is key to wider participation in energy communities.

2.3 DISCUSSION ON THE POTENTIAL OPPORTUNITIES AND STRATEGIES FOR SCALING UP PROJECT RESULTS

After identifying the common topics of research of the selected projects, a round table was organised among them to validate the topics, map activities carried out and gather their insights on potential opportunities and strategies for scaling up the project results in the future. Moreover, a review of the public deliverables and scientific publications released by the selected projects was carried out.

These activities identified a set of recommendations for making digital tools and technologies for smart grids more replicable in the future. These recommendations are related to interoperability, regulatory aspects, flexibility services, open-source integration, integration of emerging technologies and cybersecurity and privacy measures, as presented below:

- Interoperability: assess and ensure interoperability and compliance with industry communication standards for all digital services and platforms developed within the projects. Projects like HYPERRIDE and ELECTRON emphasise the importance of adopting open standards to enhance interoperability across digital tools and platforms. HYPERRIDE developed a hybrid AC-DC grid that integrates various renewable energy sources while maintaining compatibility with existing grid technologies. This approach promotes a seamless integration of new technologies with legacy systems, reducing costs and complexity for operators. Similarly, ELECTRON focuses on developing standards for data exchange and cybersecurity to ensure consistent communication and operation across diverse energy management systems, thereby fostering a more unified and resilient smart grid environment. From the European Commission side this could inform the development of dedicated standards for all digital tools developed and implemented in the EU.
- Regulatory Barriers: report and document the regulatory barriers found in various EU countries that impact the exploitation of the project results in the area of digital tools serving flexibility services, energy management and storage, with particular reference to energy markets. For example, IANOS and LocalRES reported inconsistencies in the regulations that hamper the participation of renewable energy communities in EU countries' markets. For example, while some EU Member States do not allow the energy community to provide grid services directly to DSOs/TSOs, others have limitations on P2P energy trading. This difference in national regulation also posed another challenge for LocalRES in the development of uniform community energy initiatives. EU-wide harmonised standards can help overcome those barriers and would therefore be an enabler of smart grid technologies in particular. It would thus enhance the contribution of local energy communities.
- Flexibility Services: the flexibility services supplied by the end users to the grid should be remunerated in a

clear, coherent, and standardised way throughout the EU Member States. HESTIA and IANOS developed models for rewarding consumers which offer flexibility services to the grid, e.g. based on the use of dynamic pricing models and of P2P trading frameworks. HESTIA implements demand response mechanisms and related management tools with user-friendly interfaces that ensure active consumer participation in energy management. IANOS on the other hand introduces advanced forecasting tools and strategies for community engagement to enhance flexibility services at the local level. Both demonstrate the need for a standard approach at an EU-wide level that can ensure consumers are adequately rewarded for the provided flexibility in favour of grid stability and efficiency.

- Open-Source Integration: include the most promising microservices from those developed in the projects of this cluster into a broader open-source tool to make high-quality services available to a wide range of for future users; this could for instance be achieved through new funding opportunities specifically designed to create an integrated tool building upon the results of the most promising completed projects, such as the HESTIA platform and forecasting tools, the LocalRES MEVPP and the IANOS Enterprise Service Bus (ESB) and P2P Transactive Network. Moreover, LocalRES and HYPERRIDE demonstrated the value of open-source microservice architecture. In the context of the LocalRES MEVPP tool, the design has been modular to ensure integration in/with other tools and customisation as needed. Also HYPERRIDE has worked on developing open-source platforms, specifically for the real-time energy management.
- Integration of Emerging Technologies: in the context of digital solutions applied to smart grids, recent developments like IoT, AI and blockchain can support the optimisation of grids operation and their decarbonisation; IANOS and HYPERRIDE for instance have integrated these solutions in their tools. IANOS deployed AI-driven algorithms for accurate predictions of renewable energy generation and consumption patterns, thus optimising the usage of energy storage systems with a view to enhancing grid reliability. HYPERRIDE uses IoT devices and blockchain technology for real-time data monitoring of secure energy trading and efficient energy distribution to ensure enhancement in grid flexibility and stability.
- Cybersecurity and Privacy: ensure that cybersecurity aspects are integrated into energy management systems and platforms and in grid stability/flexibility/management services. For instance, a good practice is the integration in tools of dynamic and continuous cyber-physical security risk assessment in compliance with the ISO/IEC 27001 standard on information security management. This is also highlighted by the ELECTRON project, which emphasised the importance of building robust cybersecurity measures into smart grid systems, together with tools for anomaly detection, risk assessment and secure communication to protect against cyberattacks. On the other hand, IANOS also focuses on privacy issues by employing encrypted data protocols to manage customer data in energy transactions and in forecasting tools. These practices could also be replicated more widely in the energy system to protect critical infrastructures.

3. CONCLUSIONS

This has involved rigorous data collection and survey-based assessment to identify highly mature projects and case studies across thematic areas. The results of the analysis offer a comprehensive view, beyond the individual projects themselves, of the technological advancements and their practical implications.

The key takeaways from the analysis are presented in the following Table.

Table 2: Key Takeaways from the Case Study

Advancements in Digital Platforms	Smart grid operations are improved by advancements in digital platforms including emerging technologies like AI, IoT and blockchain solutions. They allow for the monitoring, control, and optimisation of energy flow in real time, including the analysis of vast amounts of data to predict energy demand and supply patterns, hence smoothing the integration of renewables into the grid with increased efficiency and stability.
Hybrid Grid Technologies	Integrated AC-DC hybrid grid technologies allow flexibility and efficiency in transmission and distribution of electricity to be increased. The use of hybrid grids reduces energy loss, improves grid stability and assists in integrating renewable sources, particularly in those areas where the infrastructure needs an overhaul.
Energy Storage Systems	Different energy storage systems are available, whose characteristics in terms of capacity and charge/discharge speed allow a joint implementation in energy grids to maximise the efficiency and stability. They are useful especially during peak demand or low generation by renewable resources to ensure a continuous supply of energy and therefore improve grid resiliency.
Sector Coupling Technologies	A joint management of energy systems across different sectors, like electricity, heating&cooling and transport, can contribute to an integrated energy system. Sector coupling technologies help to efficiently utilise energy across different uses, limiting energy losses, thus contributing to load balancing in grids. In this context, a key role is played by IoT devices in smart grids, which allow for real-time monitoring and automated control of grid operations.
Virtual Power Plants	VPPs aggregate a range of distributed energy resources including solar, wind, hydro with energy storage systems into one integrated power plant. This can increase grid flexibility and allow VPP to offer balancing services like frequency and voltage regulation for grid stability. Virtual power plants also widen energy markets for small-scale energy producers and optimise decentralised renewable energy production.
Demand-Response Programs	Digital platforms allow consumers to participate more easily in demand-response programs. Real-time data on energy consumption and peak demand periods helps in shifting energy use to low-cost or high renewable energy availability periods. This increases grid stability and can provide consumers with a reward for the provided services, which, however, is not always clear and uniform across EU Member States.
Cybersecurity Measures	The integration of cybersecurity protocols is very important in smart grid systems, which are highly exposed to cyberattacks. Monitoring of anomaly and threat situations in cyber-physical systems should be continuously implemented

	in order to utilise real-time risk assessment and anomaly detection tools. Moreover, encryption of data and secure communication protocols safeguard critical grid infrastructures and consumer data against unauthorised access. The compliance with the ISO/IEC 27001 standard on information security management is a key requirement for IT systems dealing with energy grids.
Interoperability Standards	Interoperability of the digital platforms and systems ensures seamless grid operations even when dealing with devices of different generations and by different manufacturers. In this respect, it is recommended to adopt a set of standardised protocols that enable communication among the different systems including smart energy management devices and grid devices. The adoption of open standards decreases complexity and reduces costs of integrating new technologies into existing grid infrastructure.
Open-Source Tool Integration	Developing digital open-source tools allows more users to have access to advanced energy management solutions. Moreover, innovative open-source energy management technologies developed in R&I projects could be integrated to make them accessible and adaptable for a wide range of applications and contexts, joining the most successful microservices coming from different platforms.
Rewarding Flexibility Services	Flexibility services provided by end users should be rewarded in a clear and uniform way across EU Member States. Moreover, peer-to-peer energy trading among consumers is another way to share benefits related to community energy projects. To this end, blockchain technology brings forward a secure and transparent solution for the trading of energy in a P2P basis. It enables secured energy transactions among consumers by developing decentralised ledgers, hence reducing frauds in energy trading and increasing the transparency of energy flow in the grid.
Empowering and Engaging Consumers	Consumers can be empowered through capacity-building initiatives, through the creation of energy communities and through digital tools with user-friendly interfaces that allow their effective engagement in energy management at household and community level. Digital platforms provide instant data on energy use assist consumers in making informed decisions on the reduction of energy costs by shifting their usages to off-peak periods. In this way, consumers can be encouraged to actively participate in the energy transition.
Harmonisation of Regulation	Regulations across EU Member States should be harmonised in order to reduce obstacles to the development of smart grid technologies. The key focus points for fixing inconsistencies are related to the participation in the energy markets and the provision of grid services by end users and communities, as well as to making easier the permitting of smart grids-related projects.

4. ANNEX

4.1 Selection Criteria

4.1.1 CRITERIA #1: Level of Maturity

This criterion identifies projects that are in their final year and therefore well into the demonstration phases, where key activities and technologies are tested and refined. Such projects have typically overcome initial obstacles and uncertainties, allowing for a more thorough evaluation of their outcomes and impacts.

This maturity allows a detailed analysis of how effectively the project achieved its objectives, implemented innovations and addressed technical and operational complexities. Furthermore, projects at this stage offer a clearer picture of their potential for scalability and replicability, providing valuable insights into their broader applicability in the energy sector.

This approach not only enhances the credibility and relevance of case studies but also ensures their significant contribution to knowledge dissemination and learning across the sector. Practical lessons and best practices can be gleaned from projects that have navigated critical stages of development, thereby informing future initiatives.

The selection process leading to the presented results is based on all active BRIDGE projects. Among 105 active projects, only nineteen have reached a developmental stage suitable for the adopted criterion. Following the theoretical explanation of the criterion, Table 3 illustrates the outcomes derived from applying the project maturity criterion.

Table 3: Projects selected using the Criteria #1: Maturity Level

N. Project	Logo	Project	Full Title	Project Call	Start Date	End Date	Actual Month/ Final month	Link
1	accept active communities & energy prosumers for the energy transition	ACCEPT	ACtive Communities & Energy Prosumers for the energy Transition	LC-SC3-EC-3-2020: Consumer engagement and demand response	01/2021	06/2024	42/42	https://cordis.europa.eu/project/id/957781
2	CREATORS	CREATORS	CREATing cOmmunity eneRgy Systems	H2020-LC-SC3-2018-2019-2020: Decarbonisation of the EU building stock: innovative approaches and affordable solutions changing the market for buildings renovation	09/2020	06/2024	46/46	https://cordis.europa.eu/project/id/957815
3		ELECTRON	rEsilient and seLf-healed EleCTRical pOwer Nanogrid	SU-DS04-2018-2020: Cybersecurity in the Electrical Power and Energy System (EPES): an armour against cyber and privacy attacks and data breaches	01/2021	09/2024	35/36	https://cordis.europa.eu/project/id/101021936
4	eneuron	eNeuron	greEN Energy hUbs for local integRated energy cOmmunities optimizatioN	LC-SC3-ES-3-2018-2020: Integrated local energy systems (Energy islands)	11/2020	10/2024	46/48	https://cordis.europa.eu/project/id/957779

N. Project	Logo	Project	Full Title	Project Call	Start Date	End Date	Actual Month/ Final month	Link
5	Hestia	HESTIA	Holistic dEmand response Services for European residenTIAl communities	LC-SC3-EC-3-2020: Consumer engagement and demand response	11/2020	09/2024	46/47	https://cordis.europa.eu/project/id/957823
6	HYPERRIDE THE FUTURE OF POWER DISTRIBUTION	HYPERRIDE	Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment	H2020-LC-SC3-ES-10-2020: DC – AC-DC hybrid grid for a modular, resilient and high RES share grid development	10/2020	09/2024	47/56	https://cordis.europa.eu/project/id/957788
7	IANOS	IANOS	IntegrAted SolutioNs for the DecarbOnization and Smartification of Islands	H2020-LC-SC3-2020-EC-ES-SCC: Decarbonising energy systems of geographical Islands	10/2020	10/2024	47/48	https://cordis.europa.eu/project/id/957810
8	int:net	Intnet	Interoperability Network for the Energy Transition	HORIZON-CL5-2021-D3-01-03: Interoperability community	05/2022	05/2025	28/36	https://cordis.europa.eu/project/id/101070086
9	LocalRES	localRES	Empowering local renewable energy communities for the decarbonisation of the energy systems	LC-SC3-ES-3-2018-2020: Integrated local energy systems (Energy islands)	05/2021	04/2026[8]	40/60	https://cordis.europa.eu/project/id/957819

From the outset of our analysis, the LocalRES project met the maturity criterion (less 12 months to the end), with an initial completion date foreseen for April 2025. However, during the course of the study, the project was extended to April 2026. Given that this extension was confirmed when the analysis was nearly completed, we deemed it appropriate to keep the project within the scope of the study, considering the significant results it had already achieved.

N. Project	Logo	Project	Full Title	Project Call	Start Date	End Date	Actual Month/ Final month	Link
10	MAESHA	MAESHA	deMonstration of smArt and flExible solutions for a decarboniSed energy future in Mayotte and other European islAnds	H2020-LC-SC3-2020-EC-ES-SCC: Decarbonising energy systems of geographical Islands	11/2020	10/2024	46/48	https://cordis.europa.eu/project/id/957843
11	omega-x	OMEGA-X	Orchestrating an interoperable sovereign federated Multi-vector Energy data space built on open standards and ready for GAia-X	HORIZON-CL5-2021-D3-01-01: Establish the grounds for a common European energy data space	05/2022	04/2025	28/36	https://cordis.europa.eu/project/id/101069287
12	PLOTEC	PLOTEC	PLOCAN Tested Optimised Floating Ocean Thermal Eenergy Conversion Platform	HORIZON-CL5-2021-D3-03-10: Innovative foundations, floating substructures and connection systems for floating PV and ocean energy devices	11/2022	04/2025	22/30	https://cordis.europa.eu/project/id/101083571

N. Project	Logo	Project	Full Title	Project Call	Start Date	End Date	Actual Month/ Final month	Link
13	POCITYF	POCITYF	A POsitive Energy CITY Transformation Framework	H2020-LC-SC3-2018-2019-2020: Building a low-carbon, climate resilient future: Secure, Clean and efficient energy	10/2019	09/2024	59/60	https://cordis.europa.eu/project/id/864400
14	RE-EMPOWERED Renewable Energy EMPOWERing European & InDian Communities	RE-EMPOWERED	Renewable Energy EMPOWERing European and InDian communities	LC-SC3-ES-13-2020: Integrated local energy systems (Energy islands): International cooperation with India	07/2021	12/2024	38/58	https://cordis.europa.eu/project/id/101018420
15	RENergetic	RENergetic	Community-empowered Sustainable Multi-Vector Energy Islands	H2020-LC-SC3-2018-2019-2020: Building a low-carbon, climate resilient future: Secure, Clean and efficient energy	11/2020	10/2024	46/46	https://cordis.europa.eu/project/id/957845
16	Robinson	Robinson	Smart integRation Of local energy sources and innovative storage for flexiBle, secure and cost-efficIent eNergy Supply ON industralised islands	LC-SC3-ES-4-2018-2020: Decarbonising energy systems of geographical Islands	10/2020	09/2024	47/48	https://cordis.europa.eu/project/id/957752

N. Project	Logo	Project	Full Title	Project Call	Start Date	End Date	Actual Month/ Final month	Link
17	Sender	SENDER	Sustainable Consumer engagement and demand response	LC-SC3-EC-3-2020: Consumer engagement and demand response	10/2020	09/2024	47/48	https://cordis.europa.eu/project/id/957755
18	SERENE	SERENE	Sustainable and Integrated Energy Systems in Local Communities	H2020-LC-SC3-2020-EC-ES-SCC: Integrated local energy systems (Energy islands)	05/2021	04/2025	40/48	https://cordis.europa.eu/project/id/957682
19	SUSTENANCE	SUSTENANCE	Sustainable energy system for achieving novel carbon neutral energy communities	H2020-LC-SC3-2020-NZE-RES-CC: Integrated local energy systems (Energy islands): International cooperation with India	07/2021	12/2024	38/42	https://cordis.europa.eu/project/id/101022587

4.1.2 CRITERIA #2: Macro topic covered by the projects

In collaboration with the Commission, the decision was made to analyse the projects featured in the Brochure 2024[9] focused on nine macro topics (see Figure 9), each representing key segments of the energy value chain. These macro topics were identified to ensure that the selected projects address the most critical challenges related to the digital transformation of the energy sector.

The selection process first filtered the projects according to their maturity. Only projects that had demonstrated significant progress were considered for further analysis. After this filtering, the projects were grouped into nine macro topics, which encompass various aspects of the energy value chain, such as smart grids, intelligent energy management and consumer-oriented digital solutions. This enabled us to identify projects that substantially contribute to the integration of digital technologies into energy systems.

By focusing on these macro topics, the selected projects not only demonstrate a high level of maturity but also have the potential to significantly advance digitalisation in the energy sector. These projects provide valuable insights into how digital technologies can drive innovation and meet emerging market needs, offering best practices and lessons that can be applied to future initiatives.

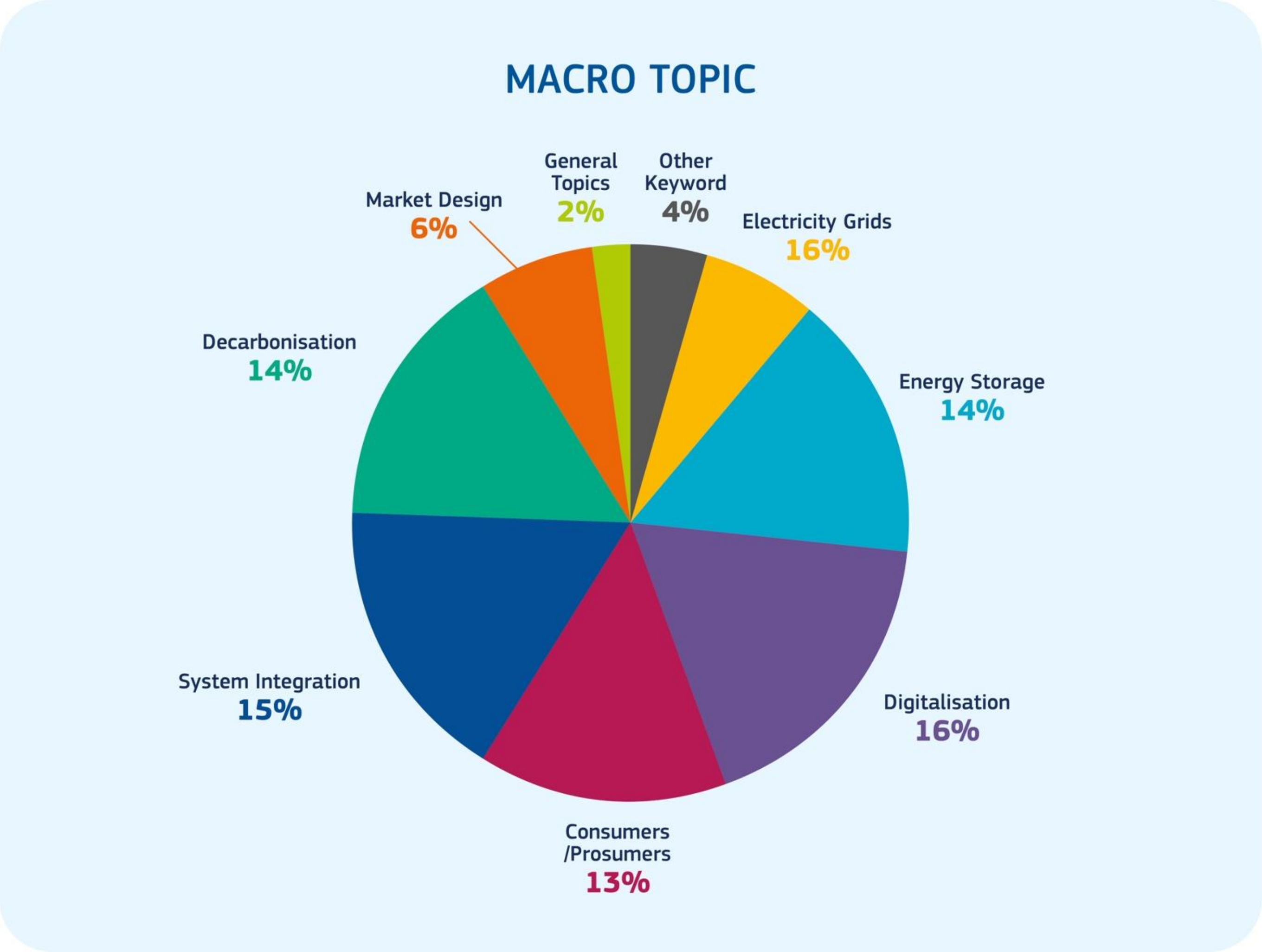


Figure 9: Project selection for Macro topics

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[8] Bridge Brochure 2024: https://op.europa.eu/en/publication-detail/-/publication/79e30192-4a3f-11ef-acbc-01aa75ed71a1/language-en/format-PDF/source-337202064

4.1.3 CRITERIA #3: Sub-topics covered by the projects

After identifying the macro topics, the team decided to increase the depth and accuracy of the analysis. The initial survey sent to the projects included a classification into specific subtopics within each segment of the energy value chain, providing a more detailed characterisation of the projects. This approach allowed for an in-depth examination of how each project contributes to different aspects of the energy sector.

Once this mapping was completed, the team decided to analyse digitalisation, with a particular focus on digital tools and technologies. This strategic focus was chosen to highlight the growing importance of digital solutions in addressing the challenges faced by modern energy systems. By focusing on this theme, the analysis sought to demonstrate how digital innovations are enhancing efficiency, strengthening resilience, and facilitating market adaptation throughout the energy value chain. Table 44 presents the empirical outcomes of macro and subtopics obtained.

Table 4: Keyword and Sub-topics

Keyword	Sub-topics
Electricity grids	Grid technologies – transmission system
	Grid technologies – distribution system
	Grid technologies – smart grids
	Power electronics, Direct Current (DC) grids and technologies
	Grid planning
	Grid operations / system resilience
	TSO-DSO cooperation
	System flexibility
Energy storage	Large scale - energy storage
	Distributed energy storage
Digitalisation	**Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)**
	General digital technologies and ICT solutions (AI, cloud computing, IoT, block chain, open-source software, etc.)
	Data exchanges and interoperability
	Cybersecurity
Technology for Consumers/prosumers	Consumer empowerment and development of skills
	Energy communities and collective flexibility

Keyword	Sub-topics
	Technologies for consumers (demand response, smart appliances, heating/cooling peak load management, etc.)
System integration	Energy system integration (across different energy carriers)
	Electrification and Distributed Energy Resources
	Energy services
Decarbonisation	Energy efficiency (including co-generation)
	Renewable energy sources
	Renewable heating & cooling
	Hydrogen and other low-carbon fuels
Market structure	Wholesale markets
	Cross-border collaboration
	Flexibility markets
General topics	Energy islands
	Innovative business models
	Recycling and circular economy
	Energy poverty
	Energy justice
	Engagement and empowerment
	Indicators

Table 5 encompass the logo and name of the project, as well as the sub-topics associated with the project, which specify which projects have been chosen for analysis in this case study analysis.

Table 5: Projects and subtopics selected for the analysis

N. Project	Logo	Project	Sub-topics selected for analysis
1	accept active communities & energy prosumers for the energy transition	ACCEPT	Out of Scope

N. Project	Logo	Project	Sub-topics selected for analysis
2	CREATORS	CREATORS	Out of Scope
3		ELECTRON	Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)
4	eneuron	eNeuron	Out of Scope
5	Hestia	HESTIA	Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)
6	HYPERRIDE THE FUTURE OF POWER DISTRIBUTION	HYPERRIDE	Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)
7	IANOS	IANOS	Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)
8	int:net	Intnet	Out of Scope
9	LocalRES	LocalRES	Digital tools and technologies for smart grids (energy management systems, Supervisory control and data acquisition - SCADA, digital twins, grid modelling, forecasting, etc.)
10	MAESHA	MAESHA	Out of Scope
11	omega-x	OMEGA-X	Out of Scope
12	PLOTEC	PLOTEC	Out of Scope

N. Project	Logo	Project	Sub-topics selected for analysis
13	POCITYF	POCITYF	Out of Scope
14	RE-EMPOWERED Renewable Energy EMPOWERing European & InDian Communities	RE-EMPOWERED	Out of Scope
15	RENergetic	RENergetic	Out of Scope
16	Robinson	Robinson	Out of Scope
17	Sender	SENDER	Out of Scope
18	SERENE	SERENE	Out of Scope
19	SUSTENANCE	SUSTENANCE	Out of Scope

4.2 Project description

4.2.1 ELECTRON

<table>
<tr><td colspan="2">ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)</td></tr>
<tr><td colspan="2">The ELECTRON project aims to enhance the resilience of Electrical Power and Energy Systems (EPES) against cybersecurity threats. It will develop an advanced EPES platform focusing on risk assessment, anomaly detection, failure mitigation, and personnel training using AR-VR technologies. The project targets improved cybersecurity, reduced downtime, enhanced system reliability, and better-trained personnel. Key impacts include strengthened EPES security and compliance with cybersecurity standards, aligning with EU priorities on critical infrastructure protection.</td></tr>
<tr><td>General context and scope of project</td><td>Context:
The electrical power and energy systems (EPES) is a complex yet critical infrastructure that is also vulnerable to cyberattacks. Protecting these systems is vital for the smooth operation of sectors like transportation, communication, industry, finance, disaster, response, water and energy. In this context, the EU-funded ELECTRON project will address the need to shield against a variety of threats – from cybersecurity incidents and privacy violations to electricity disturbances and severe human errors caused by a lack of relevant training. Specifically, the project will develop a new-generation EPES platform capable of empowering the resilience of energy systems through risk assessment, anomaly detection/prevention, failure mitigation and energy restoration.
Objective:
In the era of hyper-connected digital economies, the smart technologies play a vital role in the operation of the EPES, transforming it into a new, decentralised model with multiple benefits, such as distributed generation, pervasive control, remote monitoring, and self-healing. However, the growing number of cybersecurity incidents in EPES promotes the need for shielding against a variety of threats, ranging from cyberattacks, dynamic and evolving advanced persistent threats (APTs), and privacy violations, to electricity disturbances and severe human errors caused by lack of relevant training. The diverse threats that modern EPES are facing require novel and holistic solutions that employ cutting-edge technologies to detect and mitigate threats, while continuously assessing the dynamic EPES environment, ensuring compliance with the latest cybersecurity standards and training the EPES personnel to appropriately respond to cybersecurity incidents and mitigate the human-error factor. Considering these, ELECTRON aims at delivering a new-generation EPES platform, capable of empowering the resilience of energy systems against cyber, privacy, and data attacks through four main pillars (risk assessment and certification, anomaly detection and prevention, failure mitigation and energy restoration, and addressing internal</td></tr>
</table>

ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)	
	threats and gaps through AR-VR-based personnel training and certification), while fostering the cyber protection standardisation and certification via three novel authorities, namely the cybersecurity lighthouse, the cybersecurity training and certification authority, and the energy trading centre.
Organisational features of the project, including Consortium description	**Coordinator**: • NETCOMPANY - INTRASOFT **Partner**: • NETCOMPANY - INTRASOFT • PANEPISTIMIO DYTIKIS MAKEDONIAS • THALES DIS FRANCE SA • SCHNEIDER ELECTRIC FRANCE SAS • ATOS IT SOLUTIONS AND SERVICES IBERIA SL • DIMOSIA EPICHEIRISI ILEKTRISMOU ANONYMI ETAIREIA • INDEPENDENT POWER TRANSMISSION OPERATOR SA • CHECKWATT AB • INTEGRATED SOLUTIONS LLC • JOINT-STOCK COMPANY PRYKARPATTYAOBLENERGO • G.E. PUKHOV INSTITUTE FOR MODELINGIN ENERGY ENGINEERING OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE • ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS • NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU • GIOUMPITEK MELETI SCHEDIASMOS YLOPOIISI KAI POLISI ERGON PLIROFORIKIS ETAIREIA PERIORISMENIS EFTHYNIS • CYBERLENS BV • EIGHT BELLS LTD • LOGOS RICERCA E INNOVAZIONE • IDENER RESEARCH & DEVELOPMENT AGRUPACION DE INTERES ECONOMICO • INCITES CONSULTING SA • FUNDACION TECNALIA RESEARCH & INNOVATION • DIETHNES PANEPISTIMIO ELLADOS • SIDROCO HOLDINGS LIMITED • UNIVERSITY OF CYPRUS • IBM ISRAEL - SCIENCE AND TECHNOLOGY LTD (Israel) • UBITECH ENERGY • UNIVERSIDAD DE MURCIA • ISOTROL SA • ENERFIN SOCIEDAD DE ENERGIA SL • TUV AUSTRIA ROMANIA SRL • SOCIETATEA ENERGETICA ELECTRICA SA • COMPANIA NATIONALA DE TRANSPORT AL ENERGIEI ELECTRICE TRANSELECTRICA SA

ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)	
	• UNIVERSITATEA POLITEHNICA DIN BUCURESTI • ALTER TECHNOLOGY TUV NORD SA • NETCOMPANY-INTRASOFT SA • THALES DIS FRANCE SAS • METAMIND INNOVATIONS IKE • AZERBAYCAN DOVLET NEFT VE SENAYE UNVERSITETI • SCHNEIDER ELECTRIC ESPANA SA
Geographical coverage	Azerbaijan, Belgium, Cyprus, France, Greece, Israel, Italy, Luxembourg, Netherlands, Norway, Romania, Spain, Sweden, Ukraine
Project call number	Cybersecurity in the Electrical Power and Energy System (EPES): an armour against cyber and privacy attacks and data breaches
Project call name	SU-DS04-2018-2020
Budget	€ 7.998.887,01
Desired impacts (expectations at beginning of project)	**Challenges:** Cybersecurity threats for EPES, lack of awareness for EPES operational personnel on these threats; objectives: Provide a modern collaborative risk and certificate framework by involving different energy stakeholders in line with the Cybersecurity Act, meeting the EU cybersecurity policy and certification requirements for EPES, by designing and inaugurating the ELECTRON Cybersecurity Lighthouse; impacts: Provide to EPES stakeholders a next generation cyber-defence & protection framework, tested and validated in large scale, focused, and high-impact use cases involving actual European EPES infrastructure and stakeholders, Reduce the gaps, and failures coming from inside the EPES in terms of cyber awareness by setting up an efficient EPES cybersecurity training process based on advanced AR/VR technologies. All are in the process to be successfully achieved and demonstrated. So far, the feedback from the review process of the project outcomes is highly positive. Cyber security assessment might be a requirement for most of the R&I calls addressing especially between different EPES stakeholders, either as TSO/DSO cooperation, thins interaction in an electricity market framework, energy businesses, etc. This is especially highly important when these calls involve pilots in operational EPES environments.
Technologies and services that the project has the ambition to develop and serve	N/A

ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)

KER Type

Technological results: Scientific Results (scientific knowledge, discoveries, or insights generated as a result of the project); Intellectual Property - IP (patents, copyrights, trademarks, and other forms of intellectual property resulting from the project); Business Models and Strategies

KERs of the Project

KER 1	**ARMY**
Leader	UBITECH
Contributors	N/A
Country	Greece
KER info	ARMY is based on OLISTIC, an enterprise-scale cybersecurity risk management framework. It performs dynamically, continuously and near-real-time cyber-physical security risk assessment in compliance with the ISO/IEC 27001 standard on information security management addressing the various possible cascading effects that are associated with security incidents occurring from interacting entities and assets.

KER 2	**DARCY**
Leader	Universidad de Murcia
Contributors	N/A
Country	Spain
KER info	This asset is in charge of the dynamic security of IoT devices during its life cycle, generating potential mitigation actions to react to new vulnerabilities.

KER 3	**HaaS**
Leader	TECNALIA
Contributors	N/A
Country	Spain
KER info	The Honeynet as a Service (HaaS) provides proactive EPES honeynets without needing to deploy the honeypots at the real premises of the EPES organisation, thus minimising the deployment, configuration and maintenance costs.

KER 4	**ELECTRON SIEM**
Leader	ATOS
Contributors	N/A
Country	Spain
KER info	Specialised connectors for a wide range of sensors of the different types of anomalies, attacks and

ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)

	intrusions, and at different layers of visibility and operation. Directives for correlation of security events and other logs (both IT and OT) received from different sensors and EPES devices for consistent alarms' generation.

KER 5	ELECTRON Share Point
Leader	ATOS
Contributors	N/A
Country	Spain
KER info	Security-enhanced CTI sharing platform with discretionary privacy and access control.

KER 6	ARTutor
Leader	Democritus University of Thrace
Contributors	N/A
Country	Greece
KER info	ARTutor is an Augmented Reality educational platform which consists of a web-based authoring tool and a mobile application. The mobile application serves as the gateway that trainees use to access the augmented books created in the accompanying authoring tool.

KER 7	SDN Controller & Dashboard
Leader	University of Western Macedonia
Contributors	N/A
Country	Spain
KER info	The SDN Controller and a custom-tailored SDN dashboard are brought by UOWM to provide the fault-tolerant and scalable control plane as well as the appropriate REST interfaces utilised by ELECTRON to mitigate cyberthreats.

Technology Readiness Levels (TRL) of the Priority Project Components (PPC) upon completion of the project

Simulation methods and digital twins at distribution and transmission level for power electronics driven networks: TRL 1-2; TRL 3-5; TRL 6-8

Next generation of DMS: TRL 6-8

Next generation of measurements and GIS for distribution grids: TRL 6-8

Wide area monitoring, control and protections: TRL 6-8

Initial TRL - Final TRL

KER	Initial TRL	Final TRL
KER1	4	6

ELECTRON (rEsilient and seLf-healed EleCTRical pOwer Nanogrid)			
	KER2	5	6
	KER3	5	7
	KER4	6	7
	KER5	5	7
	KER6	6	7
	KER7	5	7
Hypothesis of product or service that could be marketed if the project meets TRL 8/9 criteria	N/A		

4.2.2 HESTIA

HESTIA
(Holistic dEmand response Services for European residenTIAl communities)

The project "HESTIA" focuses on developing a cost-effective solution for next-generation demand-side response services, engaging residential consumers in flexibility sharing and grid balancing. Key activities include exploiting energy demand flexibility, valorising energy efficiency, and involving residents in solution design. Measurable outcomes include replicability through agent-based concepts, transforming residential customers into active energy sector participants, reducing emissions, and establishing an open flexibility marketplace. Overall, HESTIA aims to enhance sustainability, promote consumer engagement, and drive innovation in the energy sector.

General context and scope of project	**Context:** Ensuring secure and affordable energy supplies to EU citizens is a top priority and purpose of an integrated energy market. This is especially true in a world that is becoming increasingly connected, and where energy consumers demand innovative technologies. It is within this energy ecosystem that the EU-funded HESTIA project is developing a cost-effective solution for the next-generation demand-side response services. It aims to leverage consumer engagement, energy and non-energy services while engaging with residential consumers, who represent an untapped sector. The key will be to encourage residential consumers to engage in flexibility sharing and grid balancing. According to HESTIA, user-personalised services will help lay the foundation for an open marketplace and new grid reality. **Objective**: HESTIA aims to provide a cost-effective solution for the next-generation DR services which will leverage the consumer engagement, energy and non-energy services, while dealing with both energy supply and demand side in a holistic manner. HESTIA intends to engage with residential consumers representing a still largely untapped sector, while enabling them to play an active role in flexibility sharing and grid balancing. HESTIA will enable residential DR services through: (i) exploitation of energy demand flexibility by engaging the consumers in demand-side management activities, and (ii) valorisation of energy efficiency in multi-carrier energy dispatching and optimal operation of building systems. HESTIA will exploit the consumer engagement as part of cooperative DR strategy at the community level, i.e. clusters of individual consumers and prosumers. To motivate the consumers to actively participate, HESTIA will leverage the financial, environmental and social drivers, while cross-fertilising them to maximise the impact. HESTIA will involve the residents in the designing of the solutions through participatory co-design processes. HESTIA will create community engagement methodology and organisational tools with a high acceptance, that can be replicated and provide the corresponding tailored toolsets for a broader rollout. HESTIA will exploit the aggregated energy resource flexibility at the demand side, in terms of cumulative energy consumption, distributed energy

HESTIA **(Holistic dEmand response Services for European residenTIAl communities)**	
	generation and storage, to better manage the disparity between energy demand, RES availability and grid requirements. User-personalised services will be delivered via a fully service-oriented, flexible ICT platform, underpinned by agent-based concepts, consumer digital twin and non-intrusive data analytics. This way, HESTIA will set the foundation for an open marketplace and a new grid reality, while steering consumer engagement according to the grid requirements and promoting RES and sustainable behaviour.
Organisational features of the project, including Consortium description	**Coordinator:** • SINLOC – Sistema Iniziative Locali **Partner**: • AXPO ENERGY SOLUTIONS ITALIA - S.p.a. • ELECTRICITE DE FRANCE • AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH • R2M SOLUTION SPAIN SL • ENERGIES 2050 • MUNSTER TECHNOLOGICAL UNIVERSITY • AALBORG UNIVERSITET • I. LECO • DUNEWORKS BV • FOR YOUR ENERGY FREEDOM BV • INSTITUT MIHAJLO PUPIN • ALBEDO ENERGIE • COMMUNAUTE D'AGGLOMERATION COMMUNAUTE PARIS-SACLAY • GRID ABILITY SCARL • MIDAC SPA • DEVELCO PRODUCTS AS • EUROPEAN INNOVATION MARKETPLACE ASBL • ASSOCIACIO CLUSTER DIGITAL DE CATALUNYA
Geographical coverage	Austria, Belgium, Denmark, France, Italy, Ireland, Netherlands, Serbia, Spain
Project call number	LC-SC3-EC-3-2020
Project call name	Consumer engagement and demand response
Budget	€ 5.995.690,00
Desired impacts (expectations at beginning of project)	**Challenge**: To put consumers / prosumers at the heart of the energy market and to develop and test new cost-effective solutions for consumers based on the next generation of energy services for consumers that are beneficial to the

<table>
<tr><th colspan="2">HESTIA
(Holistic dEmand response Services for European residenTIAl communities)</th></tr>
<tr><td></td><td>integration of RES into an efficient operation of the grid and of the power system, which will allow to better predict and incentivise consumer behaviour. Engaging consumers and prosumers in demand-response mechanisms and other energy services - based on dynamic prices as well as on incentives from grid operators to adjust energy consumption or production to help maintain frequency stability, manage congestion or address other grids constraints - has the potential to bring benefits to consumers and to the energy system.

Scope objectives:

1. To develop and test novel solutions and tools for demand response and energy services, using real consumption data and feedback from the testing of services with the objective to improve predictability of consumption and consumer behaviour (aiming to create a digital twin of the consumer).
2. To demonstrate services that bring a fair share of benefits to consumers and to the energy system, in particular the electricity grid, taking into account the existing EU framework and the proposed measures under the Clean Energy for all Europeans Package, including the relevant measures on demand response, active customers, energy communities and dynamic price contracts.

Expected impacts:

3. Increased use of demand response across the European energy system.
4. Increased predictability of consumption patterns and consumer behaviour.</td></tr>
<tr><td>Technologies and services that the project has the ambition to develop and serve</td><td>No challenges, scope objectives and expected impact(s) of the call were omitted in the HESTIA project. All aspects were covered to some extent.</td></tr>
<tr><td>KER Type</td><td>Further R&I, Scientific & education, Public, Commercial</td></tr>
<tr><td>KERs of the Project</td><td>
<table>
<tr><th>KER 1</th><th>HESTIA integrated solution (HESTIA platform)</th></tr>
<tr><td>Leader</td><td>All Consortium</td></tr>
<tr><td>Contributors</td><td>N/A</td></tr>
<tr><td>Country</td><td>All Consortium country</td></tr>
<tr><td>KER info</td><td>The HESTIA platform is a centralised tool formed by different modules for managing, forecasting, storing and remunerating the Demand Response actions performed by the users. It will serve to exploit the existing energy assets' flexibility at residential level, to give higher value to energy demand and RES availability, providing flexibility services to smart grids. User-centred and user-personalised (energy and non-energy services) are being developed to create a fully service-oriented, flexible ICT platform, underpinned by</td></tr>
</table>
</td></tr>
</table>

HESTIA
(Holistic dEmand response Services for European residenTIAl communities)

	agent-based concepts, consumer digital twin and non-intrusive data analytics.

KER 2	Agent-Based Demand Response control
Leader	AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH
Contributors	N/A
Country	Austria
KER info	HESTIA will provide an agent-based framework that will allow decentralised negotiation between and among flexibility providers, and LV/MV grid operators. The goal of the agent-based optimal control is to enable targeted optimal energy dispatch control both automatically (e.g., fully automated control of energy units) and by engaging the end consumers (e.g., recommendation support in manual load shifting). By utilising agent-based technologies, it is possible to decompose the system into different loosely coupled autonomous agents with internal private operational models. Agents are engaged via negotiation mechanisms allowing them to coordinate their joint participation in DR programs. This approach provides a flexible and efficient way to enable localised trading at multiple coordination levels with shared constraints/objectives, mutually generate value and optimally operate the distributed assets with the capabilities of performing optimal control strategies (at both building and neighbourhood level). In addition, this architecture minimises the amount of data that needs to be exchanged while ensuring the information privacy of users. In short, this architecture overcomes autonomy, privacy and scaleability issues.

KER 3	Energy dispatch optimiser
Leader	INSTITUT MIHAJLO PUPIN
Contributors	N/A
Country	Serbia
KER info	HESTIA will unlock the full potential of DR via optimal automated control of dispatchable energy assets. The energy dispatch optimisation is based on the energy hub concept and represents a service that analyses a multitude of parameters that depict the ways in which an energy system (like a household) is managed and provide a holistic way in which said management should be done. This service analyses various factors like variable energy prices, forecasted local RES

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	production, customer requirements encoded in the forecasted load curve or appliance usage schedule and assumed flexibility levels, and results in a set of suggestions depicting optimal behaviour. Concretely, these include: - How energy from various sources should be utilised, e.g. when to import from and when to export to the grid, - How the load flexibility should be utilised, e.g. when to increase and when to decrease the load, when to defer loads, etc., - How to manage the storage assets, i.e. how and when to charge or discharge them.

KER 4	**Model Predictive Control (MPC)**
Leader	R2M Solution Spain S.L., AUG-E
Contributors	N/A
Country	Spain, Belgium
KER info	Model Predictive Control (MPC) is the basis of energy management in HESTIA at the building level, taking advantage of predicted demand and reduced order building models. HESTIA has developed MPC control algorithms, to be deployed on-top of reduced order models, that dynamically optimise the operation of the building taking into account the main interactions of the systems and factors that contribute to the building's thermal performance and uncertainties. To continuously recalibrate the model (self-learning capability) and reduce these uncertainties, the models work with moving horizon estimators (MHE). Cost functions are integrated into the MPC algorithms and can be defined considering the user preferences. In addition, the MPC is integrated with the Energy Hub, taking the optimal consumption profile as input. These algorithms will generate dynamic setpoints for HVAC’s terminal units, based on outdoor conditions (actual and predicted) and the expected usage of the building systems (both thermal and electrical load). In this way, the MPC will enable energy efficient operation of the building, thereby increasing energy savings, while maintaining comfort requirements and reducing energy costs.

KER 5	**RES & storage model**
Leader	INSTITUT MIHAJLO PUPIN
Contributors	N/A
Country	Serbia

KER info	The Energy Demand Forecaster is a service which is accurately able to forecast the energy consumption and production of households, with as little human interaction as possible. The service will be able to predict the electricity and heating/cooling demand of a dwelling, building or neighbourhood, for a 24-hour period ahead. The demand forecaster will be able to learn the behaviour of the occupants based on historical data and offer predictions of different parameters. This demand is predicted by applying Machine Learning (ML) techniques, thus providing high-precision energy demand prediction.

KER 6	**Energy forecasting service**
Leader	AUG-E
Contributors	N/A
Country	Belgium
KER info	HESTIA has also developed an Energy Production Forecaster. In order to properly run dependent algorithms such as the optimisation service or model predictive control-based systems, sufficient data has to be provided. Therefore, models of energy-related assets like renewable energy sources (RES) and energy storage are crucial parts of various energy management systems. On the one hand, RES models provide information such as how much, and at what time, energy is expected to be produced, enabling the planning of energy consumption in the future. On the other hand, energy storage supplement RES as a means of providing flexibility by allowing prosumers to consume their locally generated energy, or energy imported at a lower price, not only at the moment of generation/import, but also later in time. Therefore, properly depicting related storage behaviour is a must-have feature for energy management solutions.

KER 7	**Consumer Digital Twin**
Leader	MUNSTER TECHNOLOGICAL UNIVERSITY
Contributors	N/A
Country	Ireland
KER info	The Consumer Digital Twin model comprises well-established theories from social science and behavioural psychology, such as the action-regulation-theory, the high-performance-cycle, the theory of planned behaviour, and the social cognitive theory.

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	The model enables the estimation of behaviour relevant parameters from the human interaction with the system, the computation of behaviour related KPIs, and the integration of the users into the overall system design and operation optimisation process. This SSH-based user behaviour model helps technology and service providers who want to build tailored solutions for specific customer segments by providing a realistic assessment of human activity at home, helping them to test their solutions virtually in a realistic simulated environment.

KER 8	**Non-Intrusive Load Monitoring**
Leader	INSTITUT MIHAJLO PUPIN (IMP)
Contributors	N/A
Country	Serbia
KER info	Non-Intrusive Load Monitoring (NILM) is a service that provides disaggregated individual electrical consumption on the appliance level, allowing to estimate the activities taken by the users in a completely non-intrusive manner. Therefore, it is intended for households which are not equipped with sensors measuring appliance consumption. The purpose of the NILM service is to influence the users to further improve their consumer behaviour, regarding energy efficiency. By means of machine learning (ML) data processing, NILM takes aggregated energy consumption data from e.g. smart meters and disaggregates it to make estimations of the consumption of individual appliances. For this, models are developed for each appliance. The required sampling period is approximately 5 seconds. Significantly overtime intervals are possible but the estimations could become less accurate. During the training phase, energy consumption data on the appliance level is needed to train the models whilst in the utilisation phase, only aggregated data is needed. An innovative Domain Adversarial Neural Network (DANN) approach is deployed for improved generalisation capabilities.

KER 9	**User profiling service**
Leader	AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH
Contributors	N/A
Country	Austria

HESTIA
(Holistic dEmand response Services for European residenTIAl communities)

	KER info	The User Profiling Service (UPS) enables classifying households' consumption into groups based on the similarity of consumption patterns. This service helps to obtain a better overview of energy consumption profiles, allowing for more precise day-ahead energy demand forecasting and enabling flexibility trading on household, building or neighbourhood level. The UPS surfaces information about consumption behaviour with potential for improvement, thus allowing to take targeted energy saving measures towards repeated inefficient consumption patterns. Consumption time series are enriched with metadata about activated devices such as their type or location. Activated devices are electrical appliances (e.g. dryers, ACs or washing machines, etc.) connected directly or through a smart plug to a central energy control system like a Building Energy Management System (BEMS). BEMS are not as widespread in dwellings as they are in offices and commercial buildings, but since the renovation wave for buildings has a strong focus on residential, partner expect BEMS to be way more common in residential buildings in the next five years. Individual consumption time series are summed together into predefined groups. The HESTIA UPS obtains its data from a dedicated data collector as developed by DEV and IMP and will not communicate directly with the appliances in the buildings. These data collectors will manage privacy issues and deliver the data anonymised to HESTIA UPS. Aggregation can be performed on a household, building or neighbourhood level. Thus, aggregated time series are split into daily energy consumptions and methods for time series clustering are used to group daily per-household consumptions based on their similarity. The average of all the daily consumption patterns in a cluster is representative cluster consumption. Using the discovered clusters, it is possible to associate each household's daily consumption with a profile, and thereby with a machine-readable label. Discovered labels can be further used for training the model to forecast the day-ahead consumption profile. This model incorporates all the available monitoring data such as consumption, occupancy, and similar internal dynamic signals, static information about the household, building or neighbourhood such as physical properties, as well as external information such as weather data and holidays.

HESTIA
(Holistic dEmand response Services for European residenTIAl communities)

KER 10	**User benchmarking service**
Leader	INSTITUT MIHAJLO PUPIN (IMP)
Contributors	N/A
Country	Serbia
KER info	The proposed user benchmarking service is intended to provide a fair comparison of energy efficiency between households, as applied within HESTIA, and therefore create a competitive environment that motivates end users to improve their habits and their energy efficiency. The comparison/ranking will be made within user groups that share certain characteristics (e.g. type of building, occupancy, etc.) so it is reasonable to compare their energy efficiency. The service will only use anonymised data (i.e. the end-users will know their position in the ranking, but not against whom of their neighbours they are being compared, e.g., percentages, # of households performing better, etc.). The service is capable of using a gamification strategy by giving rewards (i.e. points) and penalisations to the end users according to their behaviour changes (behaviour change, not just based on consumption change). Also, their responsiveness to the platform's recommendations influences the rewards and penalties given.

KER 11	**User engagement methodology**
Leader	AALBORG UNIVERSITET (AAU), DUNEWORKS BV (DW)
Contributors	N/A
Country	Denmark, Netherlands
KER info	Fluctuations in energy supply require robust, sustainable flexibility solutions. For them to be robust and sustainable, they need to be inclusive. Developing and deploying such solutions therefore requires the collaboration and coordination of multiple stakeholders, not the least the end users of these solutions. The user engagement approach developed in HESTIA facilitates such collaboration by providing developers the means to involve users and other stakeholders in the design process in a meaningful and fair way, through two main components: • Freely available guidelines for user recruitment and active engagement in flexibility solutions. The guidelines can be used by ESCo's and utilities to assess and adjust their own design and

HESTIA
(Holistic dEmand response Services for European residenTIAl communities)

	implementation processes, but they can also be used as orientation for a subcontract with participation professionals. • A participatory design service for an inclusive and participatory design process, where users and developers alike co-create the flexibility solutions to be deployed. The process allows participants to select which energy-related practices are targeted and how to ensure that DR solutions respect user needs and capacities and effectively service the grid.

KER 12	**Energy management dashboard**
Leader	AUG-E
Contributors	N/A
Country	Belgium
KER info	HESTIA's web-based energy management dashboard serves as a personal energy performance assistant that will provide residents with decision support and real-time notifications. The dashboard lets customers: • provide insights into their own energy usage and how it affects your electricity bill; • understand the relationship between individual energy & community energy production and use; • provide actionable tips on how to lower energy costs; • test and demonstrate the effect of novel renewable policies and dynamic tariffs; • receive advisory service that can simulate the effects of buying renewable or flexible assets or applying novel tariff schemes; • enable automated steering of renewable and flexible assets in order to reduce the time to turn on their investments; and • raise awareness on how individual residents can participate in the renewable energy transition.

KER 13	**Automated DR settlement**
Leader	GRID ABILITY SCARL (GRB)
Contributors	N/A
Country	Italy
KER info	Automated DR settlement is a blockchain-based marketplace for P2P transactions that is secure, interoperable and transparent. GRB's solution

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	provides human-readable Smart Contracts, for remuneration of shared flexibly and exchanged energy. This service will allow for distributed management, smart billing and automated settlement procedures for P2P/P2G trading. In this way, GRB opens the way to the creation of new decentralised market models, thus adapting to future smart distribution network requirements. When a DR request is honoured, a reward system needs to be established. The automated settlement service allows that the user's DR actions are registered automatically in the system/platform. There will not always be a reward, but the objective is to prove that it is possible that the DR actions (energy exchange) get registered automatically (settlement). The innovation is in the implemented customer privacy protection measures which also enables interoperability with systems across Europe and makes this module of the business logics easily scalable.

KER 14	**Energy gateway**
Leader	DEVELCO PRODUCTS AS (DEV)
Contributors	N/A
Country	Denmark
KER info	Squid.link Gateway (hardware) is an all-in-one solution for connecting IoT devices across models and wireless protocols. The gateway supports a wide range of communication protocols (including Zigbee, Z-Wave, WLAN, Wireless M-Bus, and Bluetooth Low Energy). The gateway hosts a programmable Linux-platform and is integrated with a wide variety of cloud solutions. The Squid.link Gateway includes an application called Squid Smart App which includes a restful API, providing an interface between applications and the devices. Develco has recently released Squid.link 2 which will be tested and improved within the HESTIA project. DEV aims at improving the Squid Smart App commissioning and installation process for the new generation of squid.link gateways. The feedback through real-life integration and testing at the pilot site will be used for improving the commissioning and installation process.

KER 15	**Energy storage system**
Leader	MIDAC SPA
Contributors	N/A

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Country	Italy
KER info	The Energy Storage System is integrated into the local grid to enhance the energy self-consumption, improving their functionality and its connectivity to the pilot site. MID is currently working on an integrated, all-in-one, energy system where the battery and the inverter are integrated. Today, both battery and inverter are already on the market as separate products.

Technology Readiness Levels (TRL) of the Priority Project Components (PPC) upon completion of the project

Value of Consumer/Customer acceptance and engagement: TRL 6-8

Utilisation of communication networks including cyber security: TRL 6-8

Cross-sectorial flexibility use cases: TRL 6-8

Value assessment of the integration of buildings, infrastructure and smart communities in a RES-based energy system: TRL 6-8

Control and operation tools for the integration of buildings and smart communities: TRL 6-8

Initial TRL - Final TRL

KER	Initial TRL	Final TRL
KER1	4	7
KER2	5	6
KER3	5	7
KER4	5	7
KER5	6	7
KER6	7	9
KER7	5	7
KER8	5	6
KER9	6	7
KER10	5	6
KER11	5	8
KER12	7	9
KER13	6	8
KER14	8	9
KER15	8	9

Hypothesis of product or service that could be marketed if the project meets TRL 8/9 criteria

There are 4 KERs that have reached TRL8-9 by the end of the HESTIA project:

- KER06: Energy forecasting service
- KER12: Energy management dashboard
- KER14: Energy gateway
- KER15: Energy storage system

4.2.3 HYPERRIDE

HYPERRIDE
(Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment)

The HYPERRIDE project aims to implement DC and hybrid AC/DC grids to enhance energy distribution efficiency and resilience. Key objectives include technological advancements in DC grid components, resilience enhancement through fault mitigation and cybersecurity solutions, and renewable energy integration. Demonstrations in multiple countries validate the technologies, with outcomes including improved grid reliability, increased renewable energy penetration, and development of business models for new products/services. The project's focus lies in advancing grid technology, enhancing resilience, and facilitating renewable energy integration to support European energy efficiency and sustainability.

General context and scope of project	**Context**: Global climate change is critically related to human activity and the energy that powers it. Enhancing energy efficiency and sustainability is thus a key pillar of most policy initiatives. Currently, most power grids rely on alternating current (AC) because generators, motors and transformers use the induction principle. With increasing contributions from internal direct current (DC) based renewable energy sources, electromobility and battery storage, low-voltage DC grids or DC coupled with AC in a hybrid network a more stable, efficient and sustainable electricity distribution could be created at lower costs. The EU-funded HYPERRIDE project is developing technologies to make this possible with planned demonstrations in a variety of use cases, accompanied by business models for the resulting products, services and applications. **Objective**: The project HYPERRIDE (HYbrid Provision of Energy based on Reliability and Resiliency via Integration of DC Equipment) contributes to the field implementation of DC and hybrid ACDC grids. Starting with the definition of the most relevant fields of application for DC grids (local microgrids, grid enforcement to overcome congestions, coupling of AC grid sections, etc.), the enabling technologies will be specified in detail on different levels. Starting from the system perspective, guidelines for grid planning and operation are developed. To optimise invest for the use case dependent use of assets available sizing tools are adapted for the field of DC grids. DC circuit breakers are key technologies for grid protection needed to overcome the main concerns related to these infrastructures. Therefore, HYPERRIDE will raise the TRL of the most promising approaches currently available with a focus on MVDC breakers. To enable grid automation DC sensors are developed further to provide field ready devices to create data for optimal grid automation. Automation algorithms will be created, validated in a test platform, and transferred towards demonstration. This also involves concepts and solutions for cyber security and fault detection. In case of grid faults necessary solutions are developed to prevent cascading effects. For fault prevention databases are created to trigger preventive measures. With demonstrations in three countries (Aachen/Germany, Lausanne/Switzerland, Terni/Italy) the project will

HYPERRIDE (Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment)	
	showcase the relevant enabling technologies within a wide range of use cases. Benefits of the solutions will be evaluated, especially the integration potential of renewables with respect to conventional AC grids. Finally, business models are created for the products, services and applications in HYPERRIDE. Consequently, HYPERRIDE will actively identify and provide solutions to overcome barriers for a successful rollout of new infrastructure concepts throughout Europe.
Organisational features of the project, including Consortium description	**Coordinator:** • AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH **Partner:** • SCIBreakREAK AB • RWTH-RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN • EATON ELEKTROTECHNIKA SRO • EPFL-ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE • ZELISKO-DR. TECHN. JOSEF ZELISKO FABRIK FUR ELEKTROTECHNIK UND MASCHINENBAU GMBH ENGINEERING - INGEGNERIA INFORMATICA SPA • ASM TERNI SPA • FLEXIBLE ELEKTRISCHE NETZE FEN GMBH • EMOTION SRL
Geographical coverage	Austria, Czech Republic, Germany, Italy, Sweden, Switzerland
Project call name	DC – AC-DC hybrid grid for a modular, resilient and high-RES share grid development
Project call number	H2020-LC-SC3-ES-10-2020
Budget	€ 6.965.520,50
Desired impacts (expectations at beginning of project)	DSO electricity grid challenges: 1. (local) peak power bottlenecks in balancing fluctuating new high-power loads (EV, heat pumps) and generation profiles (PV, wind), 2. vulnerable grids in context of cascading fault effects and cyber security issues due to multiple new ICT access points from application side. Objectives: modular, resilient and high RES- share grid development by hybrid AC-DC technologies. Impacts: 1. HYPERIRIDE develops and demonstrates key enabling technologies and automation solutions on target TRL 5-8, and 2. shall foster the low carbon energy transition in facilitation planning and targeting investments in the sector.

HYPERRIDE
(Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment)

All of the objectives cited above were addressed according to the workplan. Protection coordination of PE converters and external protection devices remain a challenge (e.g. feeder selectivity for Terni demo).

Technology: Protection coordination solutions concerning hybrid AC-DC DSO electricity grids for LVDC and MVDC (feeder selectivity with PE converters and external protection equipment). Commercial building blocks (PE converters AC-DC and DC-DC) and large research infrastructure with certification for higher MVDC voltages up to 100 kVdc or +/- 50 kVdc as pendants to MVAC levels 12, 24, 36 kV) and corresponding multi-megawatt power range. Scalability and replicability of cost-effective use cases and business models, especially. for MVDC. Certification of existing (and new) DSO grid cables and OH lines LVDC and MVDC for operation with MVDC like for HVDC cables. Integration of relevant DC standardisation authority members and -initiatives in the project, since (fundamental standards are missing for LVDC and MVDC). Further, the project develops qualification and training facilities for these new technologies y for planning and operational staff.

Technologies and services that the project has the ambition to develop and serve

There was none omitted at all.

See under ‘KERs of your project’

KER Type

Technological results: Scientific Results (scientific knowledge, discoveries, or insights generated as a result of the project); Hardware; Software; Business Models and Strategies

KERs of Project

KER 1	5 kV VARC MVDC Circuit Breaker (SCiBreak) and 14 kV MVDC Circuit Breaker based on VI technology (Eaton)
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SciBreak (SME)
Country	Austria, Switzerland, Germany, Italy , Sweden, Czech Republic, Netherlands
KER info	Hardware and software development of the MVDC circuit breaker, test, and validation at SCiBreak and EATON laboratories and at the German pilot site at RWTH Aachen (5 kV breaker).

KER 2	Active DC Front End Converter for LV grids
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SciBreak (SME)
Country	Austria, Switzerland, Germany, Italy , Sweden, Czech Republic, Netherlands

HYPERRIDE
(Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment)

KER info	With its controlled neutral line, the AC connection is suitable to provide positive, negative and neutral sequence currents and hence it is capable of AC balancing functions in addition to the DC droop control. This includes all necessary means to act as a smart active front end in a hybrid AC-DC grid including low voltage ride through and base functions towards the DC side (droop control functions).

KER 3	**MVDC-LVDC power conversion technologies based on DAB (RWTH) and MMC (EPFL) technologies**
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SciBreak (SME)
Country	Austria, Switzerland, Germany, Italy , Sweden, Czech Republic, Netherlands
KER info	DC transformers using Dual Active Bridge (DAB) and LLC converter topology which enable full and bidirectional power control and power flow optimisation.

KER 4	**Current and voltage sensors for MVDC**
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SciBreak (SME)
Country	Austria, Switzerland, Germany, Italy , Sweden, Czech Republic, Netherlands
KER info	For an intelligent, “smart” power grid and active load management it is indispensable to install current and voltage measurement at the relevant points in the medium voltage MVDC grid. Development of sensor concept and development for accurate measurement of MVDC voltage.

KER 5	**DMU (DC Measurement Units) for AC-DC grids, device and software**
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SciBreak (SME)
Country	Austria, Switzerland, Germany, Italy, Sweden, Czech Republic, Netherlands
KER info	DMU-M provides UTC synchronised accurate measurements for monitoring purposes. DMU-P

	provides UTC synchronised fast measurements for protection purposes.

KER 6	**Open and secure ICT platform for modular hybrid AC-DC grids**
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SCiBreak (SME)
Country	Austria, Switzerland, Germany, Italy, Sweden, Czech Republic, Netherlands
KER info	Including an adapted tool for threat detection (SUCCESS Toolbox extension)

KER 7	**Grid control algorithms for DC and hybrid microgrid applications**
Leader	AIT
Contributors	EPFL, RWTH Aachen, EMOTION (SME), ENGINEERING, Eaton, SCiBreak (SME)
Country	Austria, Switzerland, Germany, Italy, Sweden, Czech Republic, Netherlands
KER info	Droop curve, local control, central control, virtual impedance, control algorithm, virtual microgrid, Input: optimisation regime, local droop curve parameters.

Technology Readiness Levels (TRL) of the Priority Project Components (PPC) upon completion of the project

Technical barriers and technical measures for the integration of RES at multiple levels and sectors: TRL 6-8 (only for power grids and up to 5 kV, +/- 2,5 kVdc voltage.)

Control and operation tools for a RES-based energy system: TRL 6-8

Infrastructure requirements and network technologies: TRL 6-8 (only for power grids and up to 5 kV, +/- 2,5 kVdc voltage.)

Planning of a resilient system with massive penetration of RES: TRL 6-8

Technical and economic implication of decarbonisation of transport sector: TRL 6-8 (only for LV power grids)

Enhancing effectiveness of energy system operation and resilience with electromobility: TRL 6-8 (only for LV power grids)

Initial TRL - Final TRL

KER	Initial TRL	Final TRL
KER1	5	7
KER2	6	9
KER3	4	5

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(Hybrid Provision of Energy based on Reliability and Resiliency by Integration of DC Equipment)

KER4	5	7
KER5	5	7
KER6	5	7
KER7	5	8

Hypothesis of product or service that could be marketed if the project meets TRL 8/9 criteria	Active DC Front End for LV grids (AIT Smart Grid Converter) will be scaled based on licensed manufacturing.

4.2.4 IANOS

IANOS
(IntegrAted SolutioNs for DecarbOnisation and Smartification of Islands)

The project, IANOS, aims to revolutionise energy systems in European islands by demonstrating integrated solutions for decarbonization and smartification. It focuses on deploying advanced technologies like smart grids, renewable energy generation, and energy storage systems. Key objectives include enhancing energy efficiency, promoting renewable energy adoption, and empowering local communities. Measurable outcomes include increased renewable energy penetration, reduced carbon emissions, and improved energy self-sufficiency. Overall, IANOS seeks to serve as a model for island decarbonization and contribute to broader European energy transition goals.

General context and scope of project	**Context**: Home to more than 2 200 inhabited islands, the EU is committed to facilitating their clean energy transition. A long-term framework can ensure the islands are able to generate their own sustainable, low-cost energy. The EU-funded IANOS project is working in this direction starting from the islands of Terceira (Azores), Ameland (Netherlands), Lampedusa (Italy), Bora Bora (France) and Nisyros (Greece). Bringing together 34 experienced partners from nine European countries, the project will adopt an island energy transition strategy focused on energy efficiency, decarbonisation through electrification and support from carbon-neutral fuels, and the empowerment of local energy communities. The findings will help to significantly reduce fossil fuel consumption, bringing the EU one step closer to reaching its climate-neutral goals. **Objective**: IANOS brings together two Lighthouse (LH) islands (Terceira-PT, Ameland-NL), and three Fellow islands (FI) (Lambedusa-IT, Bora-Bora-FR, Nisyros-GR), all sharing a common vision of decarbonizing their energy systems and be energy independent until 2050. Thirty-four (34) strongly experienced partners from nine (9) European countries join forces to deliver smart technological, economic and social innovations, providing systemic optimisation starting from an Energy Community-centric approach. IANOS adopts an Island Energy Transition Strategy built around three (3) Island Energy Transition Tracks that focus on: a) Energy efficiency and grid support for extremely high RES penetration, b) Decarbonization through electrification and support from non-emitting fuels, c) Empowering Local Energy Communities (LEC). Through IANOS an impressive repository of elements (technologies, tools, methods) will be demonstrated in the two LH islands and within nine (9) carefully defined Use-Cases (UCs) that will lead to: a reduction of fossil fuel consumption by 379.7 GWh/y, an increase in RES utilisation by 83.6 GWh/y, increase accuracy of vRES forecasts by >10% and reduce energy bills of end users by >15%. In total, 900 participants (prosumers/consumers) will be involved in LECs by the end of IANOS. Elements to be demonstrated include: an iVPP operative orchestration toolkit, smart energy routers, hybrid transformers, flywheel storage, biobased batteries, heat batteries, tidal kite, an auto-generative digester and the IANOS Energy Planning

IANOS
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	and Transition Suite (IEPT). The replication potential of IANOS UCs will be evaluated in the three FIs. Due to their current local energy mix, Terceira and Ameland can particularly act as LHs for geothermal and hydrogen-centred island economies, respectively. To reach all these goals, a total of 121.6M€ will be invested by the 2 LH ecosystems, while another 60.4M€ will be fuelled by the 6 FI ecosystems during IANOS (until 2025).
Organisational features of the project, including Consortium description	**Coordinator:** • EDP NEW **Partner:** • UNINOVA • EFACEC ENERGIA - MAQUINAS E EQUIPAMENTOS ELECTRICOS SA • EDA - ELECTRICIDADE DOS ACORES SA • EFACEC ELECTRIC MOBILITY, SA • GOVERNO REGIONAL DOS ACORES • VIRTUAL POWER SOLUTIONS SA • TERALOOP OY • SUNAMP LIMITED • BEMICRO LDA • GEMEENTE AMELAND • STICHTING NEW ENERGY COALITION • ALLIANDER NV • SUWOTEC BV • AMELANDER ENERGIE COOPERATIE • Stichting Hanzehogeschool Groningen • NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO • NEROA BV • REPOWERED BV • SEAQURRENT HOLDING BV • BAREAU BV • GASTERRA BV • COMUNE DI LAMPEDUSA E LINOSA • CONSIGLIO NAZIONALE DELLE RICERCHE • COMMUNE DE BORA BORA • AKUO ENERGY SAS • DIMOS NISUROU • ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS • ETRA INVESTIGACION Y DESARROLLO SA • ENGINEERING–INGEGNERIA INFORMATICA • RINA CONSULTING SPA • EUROPEAN RENEWABLE ENERGIES FEDERATION-FEDERATION EUROPEENE DES ENERGIES RENOUVELABLES • ELLINIKI ETAIREIA ENERGEIAKIS OIKONOMIAS

<table>
<tr><th colspan="2">IANOS
(IntegrAted SolutioNs for DecarbOnisation and Smartification of Islands)</th></tr>
<tr><td></td><td>• UBITECH ENERGY</td></tr>
<tr><td>Geographical coverage</td><td>Belgium, Greece, Finland, French Polynesia, Italy, Netherlands, Portugal, Spain, United Kingdom</td></tr>
<tr><td>Project call name</td><td>Decarbonising energy systems of geographical Islands</td></tr>
<tr><td>Project call number</td><td>H2020-LC-SC3-2020-EC-ES-SCC</td></tr>
<tr><td>Budget</td><td>€ 6.999.654,65</td></tr>
<tr><td>Desired impacts (expectations at beginning of project)</td><td>N/A</td></tr>
<tr><td>Technologies and services that the project has the ambition to develop and serve</td><td>N/A</td></tr>
<tr><td>KER Type</td><td>Technological results; Intellectual Property - IP (patents, copyrights, trademarks, and other forms of intellectual property resulting from the project); Business Models and Strategies</td></tr>
<tr><td>KERs of the Project</td><td>
<table>
<tr><th>KER 1</th><th>iVPP platform: Centralised Dispatcher [Terceira]</th></tr>
<tr><td>Leader</td><td>CERTH</td></tr>
<tr><td>Contributors</td><td>CWD</td></tr>
<tr><td>Country</td><td>Greece</td></tr>
<tr><td>KER info</td><td>The Centralised Dispatcher is part of the IANOS iVPP Operative Orchestration Toolkit (iVPP) that contains functionalities to provide energy flexibility services and foster island self-consumption according to each use case specification.
CERTH optiMEMS component is utilised to evaluate the optimal dispatch scheduling on the island of Terceira, in the cases i) of the large-scale BESS, ii) of several residential controllable devices such as SUNAMP heat batteries and electrochemical batteries, iii) of EV charging stations charge/discharge setpoints</td></tr>
</table>
<table>
<tr><th>KER 2</th><th>iVPP platform: Centralised Dispatcher [Ameland]</th></tr>
<tr><td>Leader</td><td>TNO</td></tr>
<tr><td>Contributors</td><td>NEROA</td></tr>
<tr><td>Country</td><td>Netherlands</td></tr>
</table>
</td></tr>
</table>

IANOS
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KER info	Ameland's iVPP platform integrates flexible energy assets at the island and implements an optimal dispatch plan that deals with grid congestion while integrating as many renewable energy sources as possible. Ameland's iVPP utilises ReFlex technology to create the optimal dispatch plan.

KER 3	**iVPP platform: Forecasting Engine**
Leader	CERTH
Contributors	N/A
Country	Greece
KER info	By creating forecasting algorithms for both energy consumption and generation, this component generates the essential inputs for the decision support system (Centralised Dispatcher), assisting in the optimal programming and managing of the grid assets. Furthermore, forecasts will be provided for the energy market prices, and more specifically for the day-ahead price, intraday price, imbalance price, and frequency containment reserves (FCR).

KER 4	**iVPP platform: - Intelligent Segmentation & Clustering Engine**
Leader	RINA Consulting S.p.A
Contributors	N/A
Country	Italy
KER info	This tool will be able to provide a detailed overview of the energy portfolio creating clusters of residential users based on various objectives and thus delivering insightful information for the end user. Also, it will be integrated with the Forecasting Engine of the iVPP to assist with the (aggregated) forecasting of residential loads. The Aggregation and Intelligent Segmentation component consists of three different submodules that: examine typical consumption patterns, detect the most appropriate set of customers for demand response schemes and examine the daily variation of the consumption time series. Towards this end, three different clustering algorithms (k-means, Spectral and Hierarchical) are utilised and the best performing one according to certain metrics and domain knowledge will be kept.

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KER 5	**iVPP platform: IEPT toolkits (specifically VERIFY and INTEMA.grid)**
Leader	CERTH
Contributors	N7A
Country	Greece
KER info	VERIFY-D offers a holistic life cycle tool applicable in energy networks considering both existing energy grid infrastructure and comparisons with planned energy grid interventions. Multiple energy grid sectors, such as power plants production units, energy storage, and public infrastructures (e.g. lighting) can be incorporated to the life cycle analysis, specifically for the case of district-level interventions. INTEMA.grid offers an energy planning and transition decision support tool able to simulate multi-vector energy systems, integrated, accounting also the grid topologies and interconnections among variable systems. Both tools are designed to be interoperable with multiple commercial platforms, if deemed as necessary, since are based on open-source algorithms, house developed by CERTH, through appropriately selected APIs offering the ability for instant communication and data exchange. Particularly, the analysis results of the VERIFY-D platform offer an accurate energy intervention planning mechanism through the quantify of environmental and economic impacts and further evaluation through the operation assessment specialised on IANOS demo sites.

KER 6	**iVPP platform: - P2P Transactive Energy Trading Framework**
Leader	ENG
Contributors	It can be proposed as a single framework or as part of a comprehensive iVPP platform. Other partners' involvement will depend on how the iVPP platform will be commercialised. If it was presented as a joint of the several tools that compose the iVPP platform, it would need to be treated as joint ownership.
Country	Italy
KER info	It implements a marketplace for prosumers that intend to exchange their energy extra production with those that need some, temporarily limited, extra consumption on respect of their usual baseline. The exchange of energy is operated within a community leveraging on blockchain technology and smart contract for tokens

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	transactions. among prosumers, assuring immutable and accessible transaction.

KER 7	iVPP platform: - Virtual Energy Console
Leader	CWD
Contributors	N/A
Country	France
KER info	The Virtual Energy Console is an iVPP module that consists of the User Interface (UI) dashboards for monitoring the whole VPP operation

KER 8	iVPP platform: Enterprise Service Bus
Leader	ETRA
Contributors	It will depend on how the iVPP platform is commercialised. If it was presented as a joint of the several tools that compose the iVPP platform, it would need to be treated as joint ownership.
Country	Italy
KER info	Allows the communication of the different components in the iVPP and other elements in the IANOS architecture.

KER 9	FEID PLUS
Leader	CERTH
Contributors	N/A
Country	Greece
KER info	FEID-PLUS (Fog Enabled Intelligent Devices) is equipped with embedded communication interfaces, either directly on the main unit or in the form of add-ons; it can communicate unobtrusively with most used wired or wireless communication protocols. FEID-PLUS will be utilised as a local energy management system, which will collect and monitor real-time data through deployed smart sensors, plugs and field-level interfaces. In addition, FEID-PLUS will perform optimisation procedures for the management and consequently the local control of the building loads.

KER 10	PCM Thermal Storage Heat Batteries
Leader	SUNAMP
Contributors	N/A
Country	United Kingdom

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KER info	Heat Batteries are modern-day, energy saving thermal stores made with a high-performance phase change material (PCM technology) to deliver fast flowing hot water, reliably, safely and efficiently.

KER 11	**V2G Charging & Services on Terceira**
Leader	EFAEM
Contributors	N/A
Country	France
KER info	The EV Charger is constituted by several high efficiency power electronic conversion stages, using the latest technology in terms of semiconductors and conversion topologies for the inclusion of the bidirectional power capability. The charger will incorporate a dedicated interface and control module with the iVPP. Additionally, grid support features will be developed and validated in the Terceira pilot.

KER 12	**DefPi Platform**
Leader	RINA Consulting S.p.A.
Contributors	N/A
Country	Italy
KER info	The platform will be able to gather data and to send steering signals to the involved assets.

KER 13	**Smart Energy Router**
Leader	UNINOVA
Contributors	N/A
Country	Italy
KER info	The Smart Energy Router is a power electronics device that manages the energy transfer from/to different sources (distribution grid, RES-based distributed generators), loads and electricity storage system.

KER 14	**Flywheel**
Leader	TERALOOP
Contributors	N/A
Country	Finland
KER info	The Teraloop solution of a flywheel differs from conventional flywheel solutions by using a patented and prototyped hub less outer-rotor design. The flywheel will be integrated to the energy system for power

IANOS
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	management and fault ride through at a local industrial site.

KER 15	Tidal Kite
Leader	SQH
Contributors	N/A
Country	Swiss
KER info	TidalKite technology is a renewable energy solution that harnesses energy from tidal streams. The TidalKite technology is based on an underwater kite operated perpendicularly to a water stream that creates a traction force that is converted into electricity. The TidalKite technology is unique in its capability to exploit energy from low velocity tidal streams in shallow waters.

KER 16	Hybrid Transformer
Leader	EFACEC Energia
Contributors	N/A
Country	Portugal
KER info	The Hybrid Transformer is an innovative distribution transformer that incorporates new materials, power electronics technology and an advanced monitoring system.

KER 17	PVs with microinverter
Leader	Bemicro LDA
Contributors	N/A
Country	Portugal
KER info	BeON’s microinverters allow for individual power generating PVs to directly connect to any electric socket (Pluginverter), just like a common electric appliance, in a safe, reliable, and simple way. This bypasses the need to connect to a switchboard or to an exclusive power line for the PV, cutting down on infrastructure needs, space, and costs. To integrate these highly distributed systems in Smart Grids a communication interface and API protocol will be developed in order to provide demand/response capability thus supporting local grid infrastructure capability and stability.

KER 18	Biobased saline batteries
Leader	SuWoTec

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Contributors	N/A
Country	Netherland
KER info	Bio Based Battery technology is a unique and safe renewable energy solution that stores energy to have better use of local energy harvested from local resources like the sun, hydropower, wind or other means you have to store it locally for local use.

KER 19	IANOS Energy Planning and Transition suite (IEPT)
Leader	UBE, CERTH, TNO
Contributors	N/A
Country	Greece
KER info	A suite that supports the investments of the different stakeholders providing a holistic approach that quantifies both the costs and benefits of the IANOS interventions in the demonstration sites, i.e., Lighthouse and fellow islands of IANOS, as well as providing a tool that facilitates the fundraising campaigns.

Technology Readiness Levels (TRL) of the Priority Project Components (PPC) upon completion of the project

N/A

Initial TRL - Final TRL

KER	Initial TRL	Final TRL
KER1	6	8
KER2	6	8
KER3	6	8
KER4	6	8
KER5	6	8
KER6	6	7
KER7	6	8
KER8	6	8
KER9	6	8
KER10	9	9
KER11	5	5
KER12	N/A	N/A
KER13	5	7
KER14	6	8
KER15	6	8
KER16	5	7
KER17	2	8
KER18	6	8
KER19	4	7

IANOS **(IntegrAted SolutioNs for DecarbOnisation and Smartification of Islands)**	
Hypothesis of product or service that could be marketed if the project meets TRL 8/9 criteria	N/A

4.2.5 LocalRES

LocalRES
(Empowering local renewable energy communities for the decarbonization of the energy systems)

Community-led energy projects have a huge potential to drive the energy transition and offer new and attractive opportunities for decarbonising local energy systems. However, the design, planning and operation of RECs are still a great challenge for most citizens and local actors due to the novelty of this legal figure and the inherent complexity of community energy systems. LocalRES project aims at bridging these gaps and boosting the setting up of RECs by developing digital tools that support the co-design of the local energy landscape and enable the optimal management of energy systems.

General context and scope of project

Context:

A socially fair energy transformation is within reach of citizens through the availability of the right digital tools. The EU-funded LocalRES project will deploy innovative local energy systems to put renewable energy into the hands of communities and people. The project will boost structural changes in the current energy system at different levels: generation, market, distribution and consumers. To this aim, the project will develop a planning tool to enable citizen participation in the renewable energy communities' planning and decision-making processes, and a multi-energy virtual power plant (MEVPP) approach for optimising in real-time different energy vectors (electricity, heating, mobility) and different energy and flexibility services.

Object:

LocalRES project will deploy innovative local energy systems driven by renewable energy communities for a socially fair energy transformation that puts renewable energy into the hands of communities and people. LocalRES will deliver new digital tools that will boost the expected structural change in the current energy system at different levels: 1) generation, increasing the number of small power producers of renewable energy; 2) market, creating local energy markets that enable prosumers to trade energy volumes of their choosing within local communities; 3) distribution, establishing a multidirectional energy flow and promoting REC driven energy services, and 4) consumers, empowering consumers to be active and participating in the energy system and the design of their own renewable energy communities (REC). The main objective of LocalRES is to demonstrate at TRL8 innovative local energy systems in a sector coupling approach, which will be able to interconnect and optimise the joint operation of different energy vectors (electricity, heating, mobility, etc.) by maximising the RES contribution and enhancing the energy system flexibility and supply security. The focus is on the renewable energy communities as main actors for leading the structural change in the current energy system towards the decarbonisation of the local energy systems based on an integrated multidirectional flow approach and prosumers, allowing to maximise the replicability and upscale the potential of the decentralised solutions developed

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	in the project. The LocalRES solutions promote a secure, sustainable, competitive and affordable energy supply for everyone.
Organisational features of the project, including Consortium description	**Coordinator:** • FUNDACION CARTIF **Partner:** • AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH • ARTELYS • CENTRICA BUSINESS SOLUTIONS BELGIUM • FLEXENS OY AB • RINA CONSULTING SPA • DOWEL INNOVATION • ENERGY CITIES ASSOCIATION • ACCADEMIA EUROPEA DI BOLZANO • MUNSTER TECHNOLOGICAL UNIVERSITY • TEKNOLOGIAN TUTKIMUSKESKUS VTT OY • KOKAR KOMMUN • R2M ENERGY SRL • COMUNE DI BERCHIDDA • EZE BARRIZAR KOOP ELK TXIKIA • AYUNTAMIENTO DE ISPASTER • FUNDACION TECNALIA RESEARCH & INNOVATION • AIGUASOL CONSULTING SCCL • UNIVERSITAT PASSAU • MARKTGEMEINDE OLLERSDORF IM BURGENLAND • REVOLT SOCIETA A RESPONSABILITA LIMITATA • ASTEA SPA
Geographical coverage	Austria, Belgium, Finland, France, Germany, Italy, Ireland, Spain
Project call name	Integrated local energy systems (Energy islands)
Project call number	LC-SC3-ES-3-2018-2020
Budget	€ 6.095.862,50
Desired impacts (expectations at beginning of project)	**Relevant challenges:** The fast growth of energy production from renewable energy sources offers new and economically attractive opportunities for decarbonising local energy systems (e.g. isolated villages, small cities, urban districts, rural areas with weak or non-existing grid connections).

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Novel approaches to optimise network architecture, planning and development based on the opportunities offered by integrated local energy systems and enabled by digitalisation and power electronics can contribute to addressing the challenge, as can storage of electricity in all energy vectors.

Scope objectives:

- develop and demonstrate solutions which analyse and combine, in a well delimited system, all the energy vectors that are present and interconnect them, where appropriate, to optimise their joint operation that is demonstrated by an increased share of renewables in and higher energy efficiency of the local energy system.
- develop solutions and tools for the optimisation of the local energy network, that also have a high replication potential across Europe.

Expected impacts:

- validate solutions for decarbonisation of the local energy system while ensuring a positive impact on the wider energy infrastructure, on the local economy and local social aspects, and local air quality;
- enhance the involvement of local energy consumers and producers, preferably by creating energy communities in the development and the operation of local energy systems and test new business models;

Challenges:

To address the challenges above, the LocalRES project will deploy innovative local energy systems driven by renewable energy communities for a socially fair energy transformation that puts renewable energy into the hands of communities and people. LocalRES will deliver new digital tools that will boost the expected structural change in the current energy system at different levels: 1) consumers, empowering consumers to be actively involved from the design phase of their own RECs until the real time dispatching and management; 2) generation, increasing the number of small power producers of renewable energy; 3) market, creating local energy markets that enable prosumers to trade energy volumes of their choosing within local communities, and 4) distribution, promoting REC driven energy services.

Scope objectives:

- To define services driven by REC and its related business models
- To empower renewable energy communities via a planning (analytical and design) tool
- To effectively integrate multiple energy networks and combine energy vectors via a MEVPP in a sector coupling approach
- To demonstrate solutions for the decarbonisation of the local energy systems in 4 different EU contexts
- To give feedback and recommendations to market design and policies with a focus on the RECs

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Expected impacts:

- **IMPACT1**. Validate solutions for decarbonisation of the local energy system while ensuring a positive impact on the wider energy infrastructure, on the local economy and local social aspects, and local air quality.
  The four demonstration cases are fully committed with LocalRES towards the decarbonisation and digitalisation of their local energy systems addressing their specific challenges. Relevant and representative facilities of the complementary demo sites have been selected to deploy an ambitious demonstration of innovative technologies together with the integration of the existing solutions and facilities that will deliver high impacts, positively combining their effects on the energy infrastructure, on the local economy, local social aspects and local air quality. The integration of the different demonstration actions identified in Section 1.3 will have a positive impact in LocalRES demos with energy savings on average up to 25% that leads to a GHG reduction of 596 tCO2/yr.
- **IMPACT2**. Enhance the involvement of local energy consumers and producers, preferably by creating energy communities in the development and the operation of local energy systems and test new business models

LocalRES aims to address this by working closely with citizens and communities across a series of workshops, actively encouraging participants to provide inputs for the design of the RECs. LocalRES will significantly contribute to overcome the old ‘centralised’ market thinking that in many countries prevents citizens from participating, making it easier for citizens to join energy communities. LocalRES actions related to consumers' involvement in the energy market will be accompanied by sound business models. LocalRES will actively collaborate with BRIDGE initiative in order to further enhance and test innovative business models (check Section 2.1.3 for more details on LocalRES involvement within BRIDGE). Based on previous work by the BRIDGE Business Models Working Group, LocalRES will go further and develop innovative business model approaches:

- Digital planning tool development and studies of its potential for the enhancement of RECs creations
- Business models that quantify the potential of aggregated controllable loads (through the provision of system services or release value through price arbitrage within existing energy market) via MEVPP approach
- Tariff structures as a way to deliver best value for consumers and service providers (P2P trading, smart contracts)
- Development of suitable business models for the creation of RECs, providing relevant basis for the translation of the directive into national and regional legislation in the different member states of the REDII
- Impact of General Data Protection Regulation (GDPR)
- Aggregator/supplier business models for exploitation of aggregated local small-scale storage and generation. The business models developed within LocalRES for the support of RECs will include the potential of providing non-

<table>
<tr><th colspan="2">LocalRES
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<tr><td></td><td>energy services to the citizens via the REC. Energy services, where appropriate, will be combined with additional non-energy services and foster the take-up of smart energy communities (in particular P2P energy markets).

All these challenges, objectives, impacts are still in the process of being addressed</td></tr>
<tr><td>Technologies and services that the project has the ambition to develop and serve</td><td>N/A</td></tr>
<tr><td>KER Type</td><td>Technological results: Scientific Results (scientific knowledge, discoveries, or insights generated as a result of the project); Intellectual Property - IP (patents, copyrights, trademarks, and other forms of intellectual property resulting from the project); Software; Business Models and Strategies</td></tr>
<tr><td>KERs of the Project</td><td>
<table>
<tr><th>KER 1</th><th>Planning Tool for Energy Communities</th></tr>
<tr><td>Leader</td><td>Artelys and Fundacion CARTIF</td></tr>
<tr><td>Contributors</td><td>CARTIF Artelys, Centrica Business Solutions Belgium AIT CARTIF VTT University of Passau EURAC</td></tr>
<tr><td>Country</td><td>France, Spain, Belgium Austria Spain Finland Germany Italy</td></tr>
<tr><td>KER info</td><td>The LocalRES Planning Tool will provide a set of scenarios representing different trajectories that the REC could follow, with associated indicators as a kind of pre-feasibility studies. The performance of each scenario will be assessed in terms of costs, carbon emissions, sustainability and safety of the REC energy system.
Many tools exist on the market, but the LocalRES planning tool is the first to be designed specifically to respond to the needs of the renewable energy communities’ members including energy experts and the citizens using a friendly user interface.</td></tr>
</table>
<table>
<tr><th>KER 2</th><th>MEVPP tool</th></tr>
<tr><td>Leader</td><td>Centrica Business Solutions Belgium</td></tr>
<tr><td>Contributors</td><td>CARTIF Artelys, Centrica Business Solutions Belgium AIT CARTIF VTT University of Passau EURAC</td></tr>
<tr><td>Country</td><td>France, Spain, Belgium Austria Spain Finland Germany Italy</td></tr>
<tr><td>KER info</td><td>The MEVPP will enable to offer collective services both within the community and to the external DSO in a way that the energy networks can work smoothly based on self-management mechanisms. Providing all these</td></tr>
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(Empowering local renewable energy communities for the decarbonization of the energy systems)

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<tr><td></td><td><table><tr><td></td><td>services will be possible thanks to the high-resolution data-handling communication architecture of the MEVPP with the demonstration assets.
The LocalRES MEVPP optimises local renewable energy usage, ensuring fair pricing, comfort, and community benefits by reducing end-user costs, enhancing grid reliability, and enabling community sharing and aggregator participation.</td></tr></table></td></tr>
<tr><td>Technology Readiness Levels (TRL) of the Priority Project Components (PPC) upon completion of the project</td><td>Value of Consumer/Customer acceptance and engagement: TRL 6-8
Cross-sectorial flexibility use cases: TRL 6-8
Value assessment of the integration of buildings, infrastructure and smart communities in a RES-based energy system: TRL 6-8
Control and operation tools for the integration of buildings and smart communities: TRL 6-8
Planning for resilient integration of buildings and infrastructures in an integrated energy system: TRL 6-8</td></tr>
<tr><td>Initial TRL - Final TRL</td><td><table><tr><th>KER</th><th>Initial TRL</th><th>Final TRL</th></tr><tr><td>KER1</td><td>6</td><td>8</td></tr><tr><td>KER2</td><td>3</td><td>7</td></tr></table></td></tr>
<tr><td>Hypothesis of product or service that could be marketed if the project meets TRL 8/9 criteria</td><td>The LocalRES Planning Tool will provide a set of scenarios representing different trajectories that the REC could follow, with associated indicators as a kind of pre-feasibility studies. The performance of each scenario will be assessed in terms of costs, carbon emissions, sustainability and safety of the REC energy system.</td></tr>
</table>

4.3 Project Key Exploitable Results

The KER details summarising the survey responses provided by the projects are presented in a table below. These responses, as reported in Chapter 1, were instrumental in formulating our analysis, providing comprehensive data highlighting key aspects of each project, including objectives, progress, and significant results. This detailed information facilitated a thorough understanding and evaluation of the projects, ensuring a robust and thorough analysis.

Table 6: Summary of KERs

Project name	ELECTRON	HESTIA	HYPERRIDE	IANOS	LocalRES
KER 1	ARMY (enterprise-scale cybersecurity risk management framework)	HESTIA integrated solution (HESTIA platform)	5 kV VARC MVDC Circuit Breaker (SCiBreakREAK) and 14 kV MVDC Circuit Breaker based on VI technology (Eaton)	iVPP platform: Centralised Dispatcher [Terceira]	Planning Tool for Energy Communities, with expert and non-expert interfaces
KER 2	DARCY (charge of the dynamic security of IoT devices during its life cycle)	Agent-Based Demand Response control	Active DC Front End Converter for LV grids	iVPP platform: Centralised Dispatcher [Amerland]	MEVPP tool (The LocalRES MEVPP optimises local renewable energy usage)
KER 3	HaaS (The Honeynet as a Service)	Energy dispatch optimiser	MVDC-LVDC power conversion technologies based on DAB (RWTH) and MMC (EPFL) technologies	iVPP platform: Forecasting Engine	-
KER 4	ELECTRON SIEM	MPC Model Predictive Control (Model Predictive Control)	Current and voltage sensors for MVDC	iVPP platform: Intelligent Segmentation & Clustering Engine	-
KER 5	ELECTRON Share Point (Security-enhanced CTI sharing platform)	RES & storage model	DMU (DC Measurement Units) for AC-DC grids, device and software	iVPP platform: IEPT toolkits (specifically VERIFY and INTEMA.grid)	-
KER 6	ARTutor (Augmented Reality educational platform)	Energy forecasting service	Open and secure ICT platform for modular hybrid AC-DC grids	iVPP platform: P2P Transactive Energy Trading Framework	-

Project name	ELECTRON	HESTIA	HYPERRIDE	IANOS	LocalRES
KER 7	SDN Controller & Dashboard (SDN Controller and a custom-tailored SDN dashboard)	Consumer Digital Twin model	Grid control algorithms for DC and hybrid microgrid applications	iVPP platform: Virtual Energy Console	-
KER 8	-	NILM (Non-Intrusive Load Monitoring)	-	iVPP platform: Enterprise Service Bus	-
KER 9	-	UPS (User profiling service)	-	FEID PLUS (Fog Enabled Intelligent Devices)	-
KER 10	-	User benchmarking service	-	PCM Thermal Storage Heat Batteries	-
KER 11	-	User engagement methodology	-	V2G Charging & Services on Terceira	-
KER 12	-	Energy management dashboard	-	DefPi Platform	-
KER 13	-	Automated DR settlement	-	Smart Energy Router	-
KER 14	-	Energy gateway	-	Teraloop solution of a flywheel	-
KER 15	-	Energy storage system	-	Tidal Kite technology (renewable energy solution)	-
KER 16	-	-	-	Hybrid Transformer	-
KER 17	-	-	-	PVs with microinverter	-

Project name	ELECTRON	HESTIA	HYPERRIDE	IANOS	LocalRES
KER 18	-	-	-	Biobased saline batteries	-
KER 19	-	-	-	IANOS Energy Planning and Transition suite (IEPT)	-

List of References

[1] BRIDGE Website: https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/

[2] CORDIS database: https://cordis.europa.eu/it

[3] European Commission: https://cinea.ec.europa.eu/programmes/horizon-europe/h2020-programme_en

[4] European Commission: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[5] Survey #1: https://ec.europa.eu/euSurvey/runner/bridgeSurvey2023

[6] Survey #2: https://ec.europa.eu/eusurvey/runner/7a874f25-a4bf-a3ce-8c2c-1083d9151f77

[7] Bridge Brochure 2024: https://op.europa.eu/en/publication-detail/-/publication/79e30192-4a3f-11ef-acbc-01aa75ed71a1/language-en/format-PDF/source-337202064

[8] Bridge Brochure 2024: https://op.europa.eu/en/publication-detail/-/publication/79e30192-4a3f-11ef-acbc-01aa75ed71a1/language-en/format-PDF/source-337202064

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The Servive Contract (n. cinea/2023/op/0001/si2.901723) supports BRIDGE activities, funded by the EU.