interconnect

**interoperable solutions connecting smart homes, buildings and grids**

# WP13 – Supporting Common European Reference Framework via Demonstrators for Energy Applications

D13.5

## Results from Pilots and final contributions to CERF

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# EXECUTIVE SUMMARY

Following the adoption of the 'Digitalising the energy system' EU action plan, the InterConnect project was tasked with the role defining a blueprint for energy applications based on the Common European Reference Framework for Energy (CERF). The CERF is an extensive and scalable data and knowledge exchange framework which can be instantiated at different levels in support of innovative and user-engaging mobile applications. To do that, the InterConnect Semantic Interoperability Framework (SIF) and the Distribution System Operator Interface (DSOi) were further developed to demonstrate the ability to interconnect consumers, grid stakeholders, devices, and service providers to enable different consumer Energy Applications. In this way, the project developed and validated the CERF in 10 Member States. A first generation of applications was tested in the environment of 3 member states that already had InterConnect large scale pilots up and running. Nine additional countries were involved through a cascaded funding mechanism engaging both project partners as well as third parties to demonstrate the InterConnect solutions.

This document analyzes the main results and contributions of internal and external implementations of the energy application ecosystems to the CERF. It also provides an overview of the challenges and lessons learned that allowed us to propose a set of recommendations tackling the technical, regulatory, social, and economic aspects that need to be addressed. An overview of the underlying recommendations, divided by topic, is comprised within Table 1. These are presented following the framework used for the collection and assessment of results from the InterConnect pilots. In their final format, the jointly agreed recommendations consist of a core proposal to be considered for the 2$^{nd}$ generation blueprint for the CERF which itself is beyond the scope of the InterConnect project.

**TABLE 1: INTERCONNECT RECOMMENDATIONS TO THE SECOND-GENERATION BLUEPRINT OF THE CERF**

| | |
|---|---|
| **Data Sources** | |
| Technical | Building upon InterConnect solutions will help in the provision of semantically interoperable services and digital platforms that are needed to realize the CERF for energy. |
| Economic | Defining incentives and revenue mechanisms is essential to leverage data providers' contributions to the CERF. |
| Social | Fostering social strategies that encourage data owners to overcome their reservations about data sharing. |
| Regulatory | • Engaging stakeholders in open data initiatives and data sharing agreements is essential to increase the availability of public and common data sources.<br>• Implementing EU legislation and initiatives on data access (e.g. common European energy data space) will be the backbone for the development of the CERF. |
| **Data Repository and exchange** | |
| Technical | • A harmonized process should be followed before integrating existing data repositories to the CERF to guarantee interoperability.<br>• Data providers should partner with service providers to jointly present the real value behind data. |
| Economic | • Choosing a standard interface logic and data models and developing the energy application from them. |

| | |
|---|---|
| | • Relying on projects like InterConnect can help speeding up this process and lower the costs. |
| Social | The access to granular data referring to the specific electricity point of delivery might not be needed to develop the CERF. Aggregated data at higher levels of abstraction might suffice for many applications. |
| Regulatory | When integrating data repositories, the project recommends ensuring the compliance of the CERF based application with the GDPR |
| **Consumer Application** | |
| Technical | • Enabling a participative approach is essential to motivate end users in participating to the activity.<br>• A simple and direct language - using pictograms and colors – should be adopted to transfer information effectively to end users. |
| Economic | • Engaging end users to use energy saving applications, it is essential to implement and harmonize regulations that allow access to process signals across the EU.<br>• Individual metering and billing must be enabled to allow for the multiple households within an apartment building to participate in the provision of flexibility services. |
| Social | • Social responsibility plays an important role for user engagement. As such, it is important to showcase how their involvement yields tangible benefits for the environment.<br>• Simplifying the user experience by implementing automated responses based on the app recommendations is crucial to maintain user engagement over time. |
| Regulatory | Energy trading in local flexibility markets should be adopted to define the roles, responsibilities and rights of each stakeholder involved in the trading process. |
| **Replication and Scalability** | |
| Technical | Adopting standardized data exchange protocols through CERF can streamline the Energy application development process. |
| Economic | The access to price signals must be enabled for end users to ensure the replication and scalability of CERF based applications. |
| Social | • A consensus on data ownership must be reached to ensure that data generated by the customer belongs to the customer.<br>• Knowledge sharing and further development of InterConnect solutions through EU projects and initiatives is essential to build upon these results. |
| Regulatory | The differences in the transposition of European Directives into national regulations that pose an obstacle to the replication of CERF compliant energy applications across the Union, must be addressed. |

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AI | Artificial Intelligence |
| AIMD | Additive-Increase/Multiplicative-Decrease |
| API | Application Programming Interface |
| B2B2C | Business-to-Business-to-Consumer |
| B2C | Business to Consumer |
| BRP | Balance Responsible Party |
| CERF | Common European Reference Framework for energy |
| DSO | Distribution System Operator |
| DSOi | Distribution System Operator Interface |
| EC | European Commission |
| ENTSO-E TP | European Network of Transmission System Operators for Electricity Transparency Platform |
| ESG | Environmental, Social, and Governance |
| EU | European Union |
| EV | Electric Vehicles |
| GA | Generic Adapter |
| GDPR | General Data Protection Regulation |
| GIS | Geographic Information Systems |
| HEMS | Home Energy Management Systems |
| IoT | Internet of Things |
| IR | Interoperable Recommender |
| KE | Knowledge Engine |
| LV | Low Voltage |
| OC | Open Call |
| P2P | Peer-to-Peer |
| PV | Photovoltaics |
| REST | Representational State Transfer |
| SAREF | The Smart Applications REFerence ontology |
| SGTF | Smart Grids Task Force |
| SIF | Semantic Interoperability Framework |
| SO | System Operator |
| SSA | Service Specific Adapter |
| UC | Use Cases |
| UI/UX | User Interface/ User Experience |

# 1 INTRODUCTION

The EU funded InterConnect project is focused on developing and demonstrating advanced solutions for connecting and converging digital homes and buildings to guarantee a cleaner, secure, and affordable electrical system. With the **Digitalising the Energy System - EU Action Plan** published in October 2022, the European Commission remarked on the importance of consumer empowerment in the context of the energy transition and the optimisation of energy consumption. To this end, the Plan urged the introduction of consumer-focused digital tools directed to all customer segments to foster engagement and informed decision-making.

As part of this effort, the Commission committed to the development of a **Common European Reference Framework (CERF) for energy-saving applications,** allowing consumers to voluntarily improve their consumption management in order to reduce their energy costs and contribute to the overall stability and reliability of the energy system. Following the adoption of the Plan, the InterConnect project set as a new goal the contribution to the development of the CERF.

Building on the outcomes of the comprehensive landscape analysis led by ETRA [3] and the outcomes of the work of Expert Group 3 of the Smart Grids Task Force (SGTF) [4], the InterConnect project delivered the **first-generation blueprint of the CERF** in May 2023 [5]. The overarching goal is to demonstrate that EU is ready to capitalize on innovative technologies to mitigate the impact of energy crisis. End consumers are viewed as essential allies in achieving this objective. The key technological advancement required to support this mission is the achievement of inter and intra domain data interoperability on all levels.

The first-generation blueprint included the definition of the data sources, the targeted end-users, the recommendations for action, the intervention and implementation strategies, and the approach to field piloting to be conducted as part of the InterConnect project. A two-stage process was followed for the testing of the first CERF blueprint consisting of (a) the delivery of a Minimum Viable Product (MVP) and (b) the deployment of large-scale demonstrations. The latter were carried out in 3 existing InterConnect pilots and further scaled up to 9 additional external 3rd party pilots (through an Open Call for Demonstrators of Energy Applications) financed with a cascaded funding mechanism.

To this end, the InterConnect project adopted its Semantic Interoperability Framework (SIF), interoperable DSO interface (DSOi) and set of semantically interoperable services/digital platforms as the main enablers for realizing the CERF. Through these InterConnect enablers, the CERF becomes a semantically interoperable ecosystem of data sources and decision-making services. As such, the CERF is an extensive and scalable data and knowledge exchange framework which can be instantiated at different levels in support of innovative and user-engaging applications. In addition, four energy enablers for CERF were implemented and made available to be integrated and validated in the energy app demonstrators in their respective pilots:

1. **Interoperable data management services for two main data sources for fetching data in a SAREFized and SIF-compliant manner:**
- ENTSO-E transparency platform - a platform that facilitates the central collection and publication of electricity generation, transportation and consumption data and provides information for the pan-European market.
- Electricity Maps – A platform that provides information about sources of energy and CO2 footprint of its production.

2. **Interoperable Recommender service (IR)** which is a software framework that produces localized recommendations to be passed on to consumers by new and existing energy-saving mobile applications. The interoperable recommender uses information from ENTSO-E Transparency Platform to generate next day hourly recommendations on a national level to increase or decrease energy consumption. Recommendations are generated for every EU country yet may be more granular if DSO information is available.

3. **Eco tips service** with configurable notifications for end consumers informing and educating them on how to achieve recommended energy savings and become more energy aware.

4. **Energy Application demonstrator** with an open-source mobile app and dedicated open-source backend system.
- The mobile app is multiplatform (iOS and Android). It includes features for user onboarding, setting up user preferences/profile information (energy prosumer characteristics and location), receiving and displaying hourly consumption recommendation and providing feedback on the taken actions.
- Application backend provides SIF compliant, SAREFized and secured interface towards other interoperable services (like recommender service) and data sources.

These new software components are accompanied with the project's key exploitable results (SIF and DSOi) to build instances of CERF for energy in different pilots.

In this context, Task 13.5 of the InterConnect project assessed the main results and achievements of both internal and external implementations of the energy application ecosystems in order to identify identified challenges, lessons learnt and success stories from the testing of the first-generation blueprint of the CERF. Published at the conclusion of the project activities, the aim of this deliverable is to provide an overview of the results of Task 13.5 and provide a set of recommendations in support of the definition and deployment of the **second-generation blueprint of the CERF** which will be conducted by the ECLIPSE project funded under the Digital Europe Programme [6].

# 2 CONTEXT OF WP13

The current energy crisis triggered by the geopolitical instability and war in Ukraine has let the EC to consider all the existing measures to ensure that the EU energy system can safely operate despite the introduced uncertainties.

This means that several options became a possibility to consider with regards to helping the energy system to become more resilient and thus better prepared to deal with the ongoing strategies related to the decarbonization (i.e., including the integration of renewable energy sources) with the energy supply limitations introduced by the war.

To ensure that consumers can make use of the EU energy system, seamlessly and conveniently, and at the same time take benefit from a stable a robust system that is able to cope with the increased electrification pressure and enable the integration of distributed renewable based generation. As such demand response initiatives have been sought to allow consumers to play another role: active participants in the paradigm change in the energy system.

Based on this assumption, that consumers can become active stakeholders in the enhanced operation of the electric systems, the strategy set in CERF paves way to the information flow from the current public data sources of the electric system operation state to the consumer to assume a participative role in changing the consumption habits in a way that improves the grid operation.

To provide a concrete implementation that allows this flow of information to reach the consumers in an actionable form, a specific mission was taken by the InterConnect project to use the interoperability developments carried throughout the project, to enable energy applications to be quickly implemented and making use of the SAREFization process employed on other circumstances, to provide access to the aforementioned actionable data.

Several data sources were assessed to deliver the necessary information to allow the implementation of simple mechanisms to consumers. One of such sources is the ENTSO-E transparency platform[1] that gathers information from several transmission system operators regarding the operation status of the grid, currently and in following hours. Another source of public data is the CO2 footprint of the energy generation system at the EU level, like the one within the Electricity Maps[2].

Despite the current availability of public information, there are still details to consider, namely the regularity of the information provided, the applicability to the different segments of the transmission system, the synchronicity of data (i.e., lack of data; provision at different hours;) among other factors.

Two additional requirements were introduced to enable data to be used by an energy application to guide consumers towards a set of relevant actions (i.e., increase/decrease the energy consumption at specific hours of the following day).

[1] For more information on the ENTSO-E transparency portal: https://transparency.entsoe.eu/

[2] For more information on the Electricity Maps: https://app.electricitymaps.com/map

The first requirement is due to the need to have a sound methodology that assesses the grid status (current and foreseeable) and determines the risk associated to consumer's actions. Thus, the created Interoperable Recommender that was developed by the consortium and published as an open-source tool[3] that provides all interested parties (including the project partners and associated entities such as those represented in the 2nd Open Call from the project) with next day hourly "traffic-light" recommendations on national level. Recommendations indicate whether or not consumption should be increased or decreased for each hour of the next day.

The second requirement is related to the need to specialize actions set forth to consumers from the transmission grid side. This is essential to ensure that the contribution from the demand side does not jeopardize the distribution grids' operation. Within InterConnect, the DSO Interface was used to specialize the actions inlaid from the Interoperable Recommender. The need to have this lower-level validation from the distribution grid side will become more relevant as the increase of renewable integration reaches larger figures. Figure 1 explains the interactions and the sequence of steps.

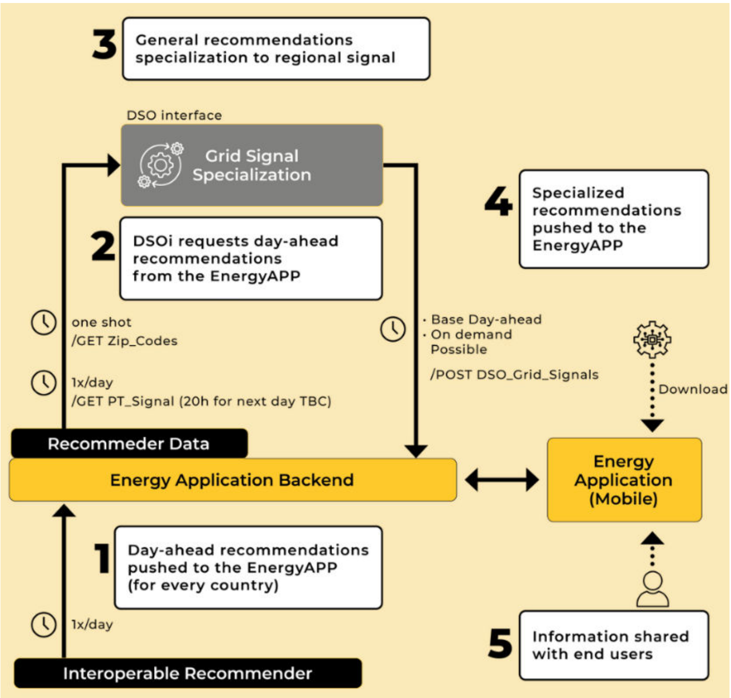


**FIGURE 1: DSO INTERFACE INTERACTIONS**

As it is further explained in the following chapters the development, implementation and validation provided the necessary ground to the project to position a set of recommendations to the future developments that can be carried out for the CERF.

[3] For more Information on the Interoperable Recommender: https://github.com/CPES-Power-and-Energy-Systems/interoperable-recommender-tso

# 3 METHODOLOGY FOR THE COLLECTION OF RESULTS

This chapter describes the methodology followed as part of Task 13.5 for the collection and analysis of results from the InterConnect pilots and the formulation of recommendations for the development of the second-generation blueprint of the CERF. The methodology was composed of the following steps:

(1) Analysis of existing work on the CERF for consumer applications.
(2) Definition of the assessment framework.
(3) Collection and analysis of pilot results and formulation of recommendations.

The following sub-chapters elaborate in detail on each of the steps above.

## 3.1 ANALYSIS OF EXISTING WORK ON THE CERF FOR CONSUMER APPLICATIONS

The first step of Task 13.5 consisted in the review of the existing publications addressing the CERF for consumer applications. This mainly included:

(1) The Digitalising the Energy System - EU Action Plan,
(2) The ETRA Report "Landscape analysis for energy platforms/consumer applications",
(3) The SGTF Expert Group 3 Report "Towards a Common European Reference Framework for a consumer application", and
(4) The first-generation blueprint of the CERF developed by the InterConnect project.

Out of these sources, (3) and (4) were analysed in depth and taken as a reference for the definition of a framework for the assessment of InterConnect pilot results (Step 2 of the methodology). An overview of the main elements of (3) and (4) is reported here below to provide the necessary context for the understanding of the next steps of this methodology.

On one hand, the **SGTF Expert Group 3 Report** assessed existing use cases for consumer applications and formulated recommendations for the effective establishment of a dedicated CERF. As indicated in the report, the CERF shall identify principles, requirements, and elements of consumer applications in relation to three essential components [4]:

(1) Data sources,
(2) Data repository and exchange, and
(3) Consumer application.

A detailed set of criteria, which can be found in *Annex I* of this document, was then defined for the mapping of existing use cases of consumer applications. Based on the outcomes of the analysis of 18 Use Cases (UCs), the report presents five key recommendations:

- SGTF R1: The CERF should define the levels of service (i.e., a qualitative measure of the provided service) for consumer applications according to the functionalities they offer.

- SGTF R2: For the highest level of service, a list of data requirements should be produced together with a list of data currently available in each Member State.
- SGTF R3: The CERF should define rules to harmonise metrics measuring impact in terms of energy savings and other indicators.
- SGTF R4: Interoperability and integration with 3rd party systems must be facilitated to maximize the impact of the CERF.
- SGTF R5: The CERF should be guided by principles that will foster consumer engagement and actionable measures, maximize customers' flexibility and consumption reduction, and support innovation and competition without hindering existing market activity.

On the other hand, InterConnect's **first-generation blueprint of the CERF** addressed six main elements, namely:

(1) The definition of data sources,
(2) The target end-users,
(3) The recommendations for action,
(4) The intervention strategy,
(5) The implementation strategy, and
(6) The approach to field piloting.

As depicted in Figure 2, the blueprint constituted part of an evolving strategy fostering the creation of energy applications across the EU.

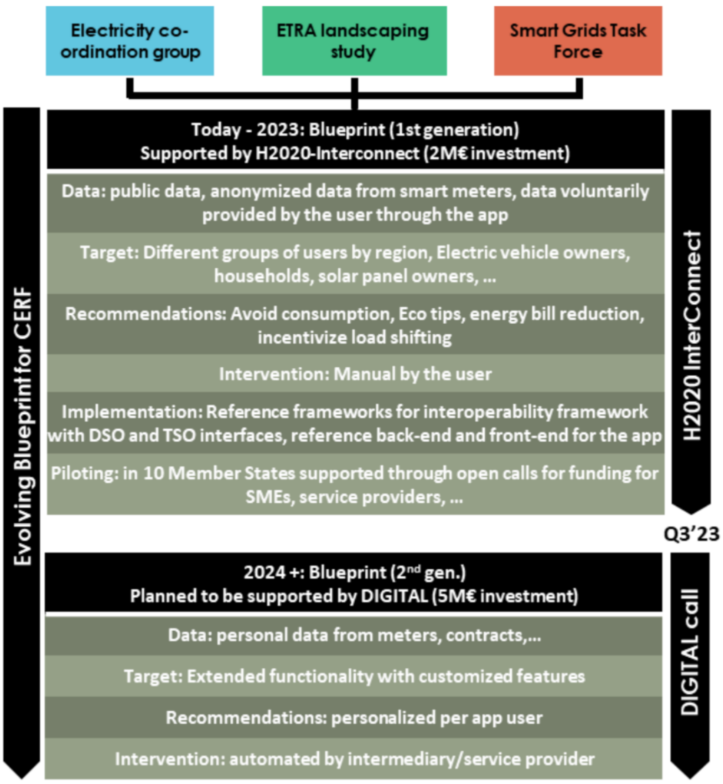


FIGURE 2: BLUEPRINT EVOLUTION FOR THE CERF FOR ENERGY SAVING APPLICATIONS

## 3.2 DEFINITION OF THE ASSESSMENT FRAMEWORK

The second step of Task 13.5 consisted in the definition of a framework for the collection and assessment of results from the InterConnect pilots. Based on the analysis of existing literature, it was decided to, first, provide a thorough overview of the characteristics of the InterConnect pilots and tested UCs by adopting the set of criteria defined by the SGTF EG3 (see *Annex I*). Secondly, it was decided to carry out a collection of lessons learnt, challenges and success stories from the pilots according to four categories. These consisted of the three essential components for the CERF identified by the SGTF EG3 (i.e., **Data sources**, **Data repository and exchange**, and **Consumer application**) and a fourth additional category aimed at addressing the need for a CERF supporting full scalability and replicability of consumer applications across the EU (i.e., **Replicability and scalability**).

As can be seen in Table 2, the four categories chosen for Tasks 13.5 assessment were mapped both to the set of criteria for UC analysis adopted by the SGTF EG3 and the elements of the first-generation blueprint of the CERF defined by the InterConnect project. This mapping would allow relating the InterConnect recommendations with the characteristics of its pilots and tested consumer applications, supporting the identification of areas that will require further investigation during the next stages of development of the CERF.

The table below showcases the correspondence between the set of criteria for UC analysis adopted by the SGTF EG3 [4] and the elements of the first-generation blueprint of the CERF defined by InterConnect [5].

**TABLE 2: MAPPING OF THE ASSESSMENT CATEGORIES CHOSEN FOR TASK 13.5.**

| TASK 13.5 ASSESSMENT CATEGORIES | SGTF EG3 USE CASE CRITERIA | FIRST-GENERATION BLUEPRINT ELEMENTS |
|---|---|---|
| Data sources | Type of data and access | Definition of data sources |
| Data repository and exchange | Type of data exchange<br>Capacity to integrate with 3rd parties | Implementation strategy |
| Consumer application | Functionalities<br>Expected impact<br>Incentives/engagement mechanism<br>Consumer segment<br>Origin (public/market party/SO) | Target end-users<br>Recommendations for action<br>Intervention strategy |
| Replicability and scalability | Country<br>Replicability across EU<br>Time to deliver | Field piloting |

From the analysis of collected information, this methodology envisioned producing recommendations clustered into the same four categories.

## 3.3 COLLECTION AND ANALYSIS OF PILOT RESULTS AND FORMULATION OF RECOMMENDATIONS

According to the defined assessment framework, the third and final step of Task 13.5 consisted of the collection and analysis of the energy application piloting results and subsequent formulation of the project recommendations. A first round of surveys was conducted to collect input from both the InterConnect pilots and the Open Call (OC) Demonstrators of Energy Applications. Specifically, the survey investigated the following:

- Challenges encountered by the pilots at regulatory, technical, economic and social levels.
- Lessons learnt and success stories from the pilot implementations at regulatory, technical, economic and social levels.
- Possible modifications or evolutions of the tested UCs during the course of the project, the reasons behind them and the resulting learnings.
- The contributions brought by the pilot testing to the future development of the CERF, the fundamental aspects to address in the second-generation blueprint, and the identified remaining challenges for the uptake of CERF-based energy saving applications.

Following the assessment framework established in section 3.2, a template was created to facilitate (a) the mapping of the pilots according to the template included in *Annex I* and (b) the clustering of challenges and lessons learnt in the four selected categories (Data sources, Data repository and exchange, Consumer application, and Replicability and scalability). A first analysis of the survey results allowed pre-filling the template for each pilot and OC demonstrator. The completion of the information was then tasked to the pilot leaders and OC mentors. When required, short interviews were scheduled to clarify or further investigate the provided feedback. This allowed the production of recommendations under the four categories defined in Task 13.5 assessment framework. A further categorisation of the recommendations allowed to distinguish them between regulatory, technical, economic and social recommendations resulting in the definition of the next steps towards the full-scale deployment of the CERF.

# 4 OVERVIEW OF ENERGY APPLICATION IMPLEMENTATIONS

This chapter provides an overview of the scope, objectives and outcomes of the internal (i.e. the InterConnect pilots) and external (i.e., the InterConnect OC demonstrators) implementations of the energy application to provide the context necessary for the elaboration of the challenges, lessons learnt and recommendations in the next chapters. In addition to the information reported in this chapter, *Annex II* provides a detailed mapping of the implementations according to the criteria defined by the SGTF Expert Group 3.

## 4.1 THE INTERCONNECT PILOTS

This section focuses on the energy application implementations carried out as part of the InterConnect pilots. A detailed description of the ecosystem and architecture at the core of the energy applications can be found in D13.2 [7] while further information on the results of pilots can be found in D13.4 [8].

### 4.1.1 THE PORTUGUESE PILOT

The objective of the InterConnect Portuguese pilot was to engage consumers in reacting to grid signals and contributing to the power network resilience through the *Wattchr* energy application, Figure 3. Relevant recommendations for demand side operation would be used to inform consumers about the best time to increase or decrease consumption during the following day.

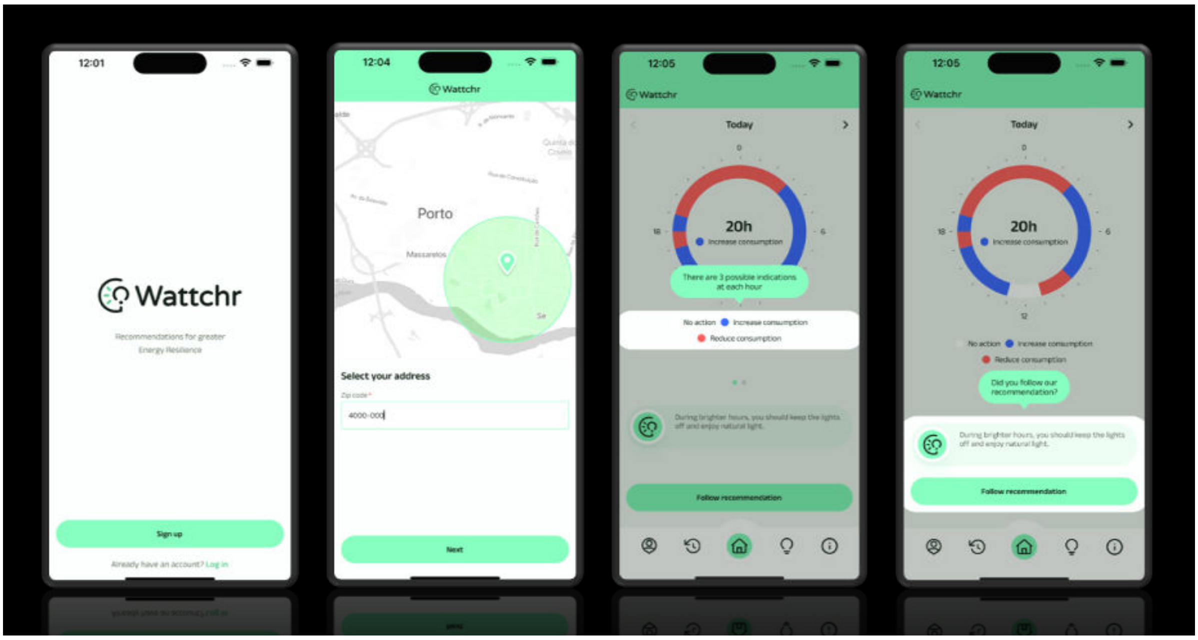


FIGURE 3: WATTCHR, THE PORTUGUESE ENERGY APPLICATION

To this end, the pilot makes use of the IR to determine the impact of an increase or decrease in energy consumption on the interconnected European transmission network and its potential severity and risk due to technical and operational constraints. This information is further specialized through the DSOi which allows the Portuguese DSO (E-REDES) to include local limitations from the distribution grid, specified through the use of zip codes. As a result, the application enables tailored consumer responses according to their geographic location.

### 4.1.2 THE ITALIAN PILOT

The goal of the Italian InterConnect pilot was to support the real estate developer of three large-scale social housing settlements in Milano, counting more than one thousand single housing units, with digital initiatives promoting the adoption of environmentally friendly behaviours of the residents. The introduction of a Flexi App functionality in the Planet App developed by Planet Smart City, Figure 4, aimed to nudge users to consume electricity during times when its production would cause fewer carbon emissions.

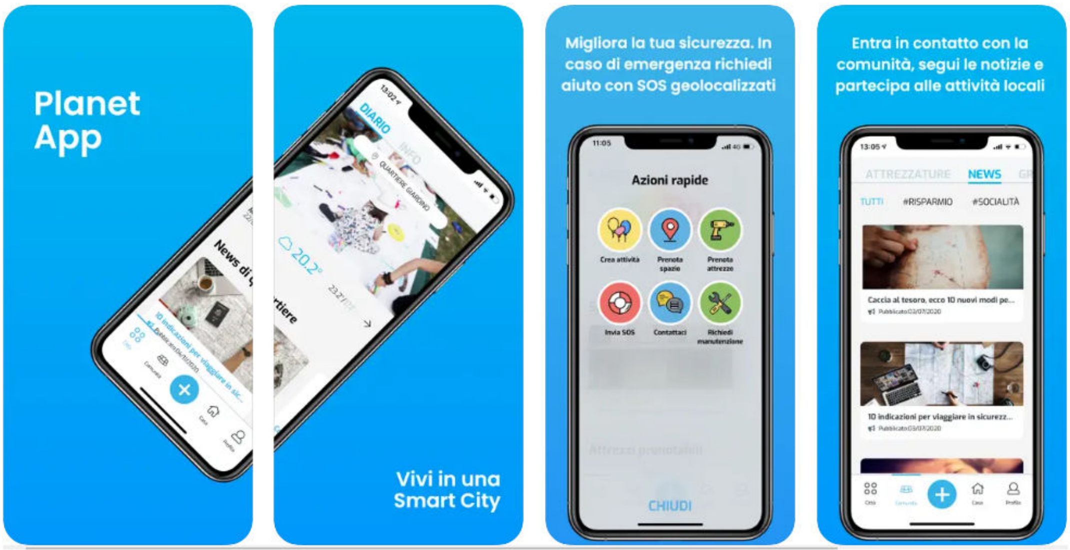


**FIGURE 4: THE PLANET APP, CUSTOMISED WITH A FLEXI APP FUNCTIONALITY FOR THE ITALIAN IMPLEMENTATION**

The application provides recommendations and records interactions with end-users, allowing for a qualitative estimation of the environmental impact of consumption shifts in terms of carbon emissions reduction. The resulting information provides valuable insights on how to address social engagement and consciousness, offering the potential of supporting Environmental, Social and Governance (ESG) rating assessments and sustainability reporting for real estate developers.

### 4.1.3 THE GREEK PILOT

The Greek pilot provided consumption recommendations using the energy application through a mobile application developed by AUEB-RC which was already part of the InterConnect Greek large-scale demonstrator. As part of the demo, the Greek pilot mobile application,

Figure 5, already provided several features such as residential energy monitoring, device control, green recommendations, demand response actions, push notifications, gamification, and user feedback. For the objectives of WP13, the application was further developed to incorporate grid recommendations from the energy application. The recommendations were built upon publicly available data at TSO level, specifically from ENTSO-E, and offered more localized advice at the zip code level through data obtained from the Greek DSO HEDNO, leveraging on the InterConnect DSOi.

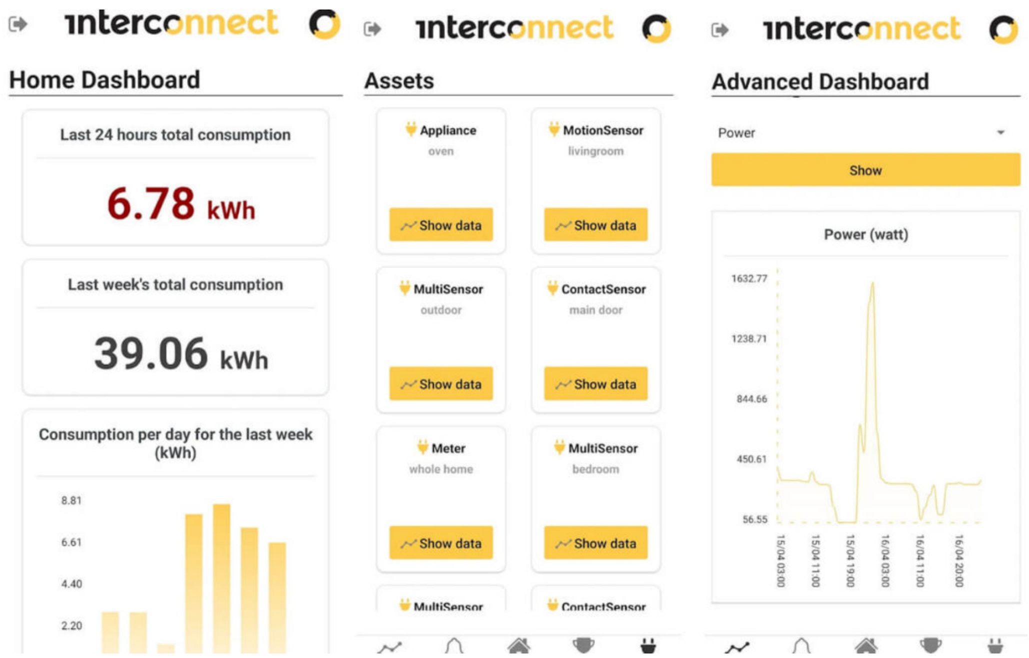


**FIGURE 5: THE GREEK PILOT APPLICATION**

With the energy application, the 145 pilot users were provided with a comprehensive 24-hour forecast of energy consumption recommendations sourced directly from the grid. This forecast was detailed on an hourly basis, highlighting specific times when it would be beneficial to either ramp up or scale down electricity usage. Such guidance was aimed at assisting users in adjusting their consumption patterns to enhance the overall stability of the local and national electricity grid.

### 4.1.4 THE DUTCH PILOT

Many parts of the Netherlands are affected by network congestion issues due to the high penetration of Electric Vehicles (EV) and solar Photovoltaics (PV) installations in compact areas and the occurrence of simultaneous electricity generation and EV charging at specific times of the day. Hence, the objective of the Dutch InterConnect pilot was to stimulate end-users to shift their energy consumption to prevent grid congestion occurrences and release capacity for customers waiting to be connected to the grid.

To this end, the Dutch pilot focused on grid areas which are suffering from regular overload situations and, for this reason, are placed on a grid improvement list. The mentioned overloads can caused both by consumption peaks (e.g., from heat pumps and EV chargers) and generation peaks (e.g., rooftop PV installations). The concept developed by Stedin, the Dutch DSO involved in the pilot, is called eKlok (*electricity clock,* Figure 6) and is intended to appear both as a large physical clock both on public squares for general public understanding and made available on smartphone apps.


**FIGURE 6: THE EKLOK APPLICATION FROM THE DUTCH PILOT**

The first implementation of the energy application demonstrator by Stedin is to be conducted in Houten, a municipality in the province of Utrecht. In this area, an MV/LV transformer that has been deployed in a suburb, will provide real-time sensor readings. Stedin trained an Artificial Intelligence (AI) algorithm to accurately predict congestions based on historical data and weather forecasts, taking notion of special days such as school and public holidays where people are typically spending less or more time at home. A prediction model estimating the load of the local grid elements for a seven-days-ahead timeframe (with a granularity of fifteen-minute periods) is used to prevent overload of the grid. The resulting information is communicated to the energy application which allows visualisation of the grid status for the upcoming days using a colour-coding mechanism (green, orange, and red indications). The application will further provide recommendations on how to prevent the occurrence of congestion issues.

### 4.1.5 THE BELGIAN PILOT

The Belgian pilot created a CERF demo to illustrate the use and merits of semantic Knowledge Interactions over the SIF to seamlessly connect to (and switch between) recommender services. To this purpose, VITO created a recommender service that generates recommendations to increase or decrease consumption or shift EV charging and white goods usage at selected timeslots, based on information about the carbon intensity forecast of electricity. The ambition of the pilot was twofold. First, the pilot demonstrated the use of the carbon-intensity-based recommender to feed the Energy App to trigger user actions based on recommendations ("human-in-the-loop" approach). Second, the Thor Park pilot[4] demonstrated the seamless switching between the recommender and the ENTSO-E TP without requiring recommender-specific application changes or customizations.

[4] For more information on the Thor Park Pilot: https://interconnectproject.eu/nl/pilots/belgium-2/genk-thermovault-2/

# 4.2 THE INTERCONNECT OPEN CALL DEMONSTRATORS

This section focuses on the external implementations of the energy application carried by 3rd parties selected under the InterConnect OC for Demonstrators of Energy Applications[5]. An overview of the six projects selected for the development and integration of their solutions can be found in Figure 7.

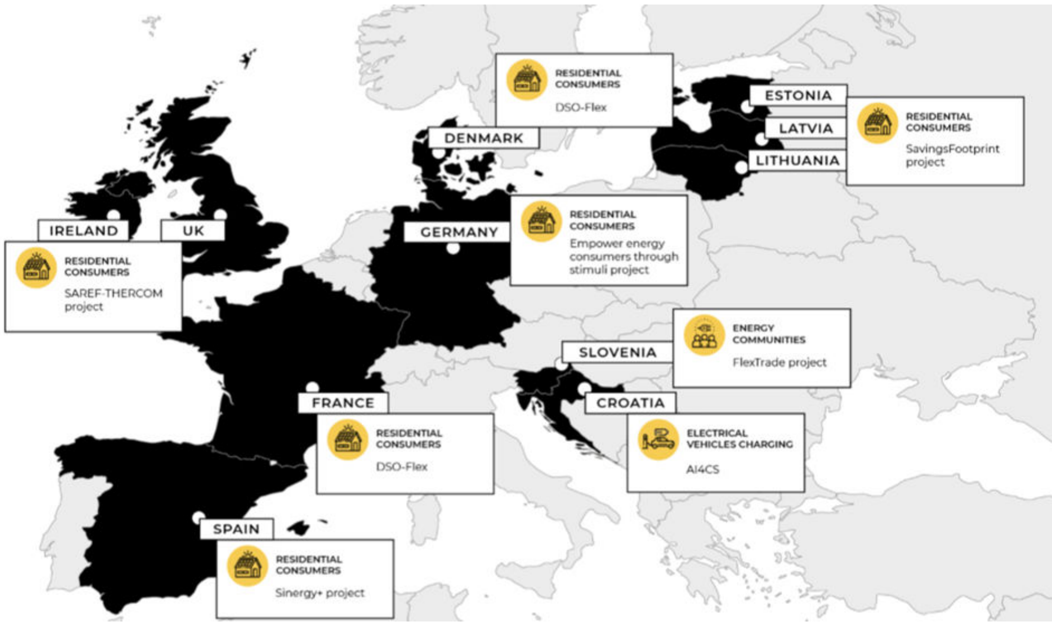


FIGURE 7: THE PILOTS SELECTED UNDER THE OC FOR DEMONSTRATORS OF ENERGY APPLICATIONS

## 4.2.1 AI4CS (CROATIA)

The AI4CS (AI for Charging Stations) project tested a mobile application guiding EV owners to public charging stations. The pilot was carried out in Croatia, involving the charging station network operated by Hrvatski Telekom. More than a hundred of their users tested the application for more than one month, receiving its recommendations and guidance.

The AI4CS application suggests to the user a charging station according to its forecasted availability and a timeslot for charging that the IR indicates as appropriate with respect to grid stability and the electricity production mix. The objective of AI4CS was to improve customer experience as well as provide support to the grid, shifting consumption outside of peak load times and to times characterised by a greener electricity production mix.

## 4.2.2 SAVINGSFOOTPRINT (ESTONIA, LATVIA, LITHUANIA)

The goal of the SavingsFootprint pilot was to empower residential energy consumers by enabling them to consume energy more efficiently, reducing their energy bills, and lowering

[5] For more information on the Open Call: https://interconnectproject.eu/open-calls/

greenhouse gas emissions associated with their consumption. At the same time, SavingsFootprint aimed to educate consumers to optimize their consumption profiles based on behavioural changes as well as equip them with the knowledge necessary for participating in the provision of flexibility services to system operators.

The SavingsFootprint application provides specific recommendations to residential customers advising them to adapt their behaviour and informing them of their carbon footprint. Two customer segments were addressed by the pilot, according to two different business models:

(1) Direct interaction with households in the role of non-paying users – Business-to-Consumer (B2C) model.
(2) Indirect interaction with households through 3rd party service providers (e.g., banks, fuel retailers) – Business-to-Business-to-Consumer (B2B2C) model.

Revenues from the application are foreseen to be mostly collectable from 3rd party service providers (B2B2C model).

### 4.2.3 EMPOWER ENERGY CONSUMERS THROUGH STIMULI (GERMANY)

The “Empower energy consumers through stimuli” application integrated the SAREF-CERF concept into a previously developed energy community where demand-side flexibility from heat pumps and household appliances was activated and guided by a local “stimulus” representing the instantaneous value of energy (high if the energy is imported from the grid, low if it is exported from the community).

During the project, part of the existing functionalities were SAREFized, particularly to import grid status information and merge these stimuli with the already existing ones. As a result, demand-side flexibility is not only activated to maximize the value of local energy self-consumption but also to provide support to distribution and transmission grids.

### 4.2.4 DSO-FLEX (DENMARK AND FRANCE)

By gathering data from various sources to monitor and manage energy flows, the DSO-Flex energy-saving application aimed to make energy use more efficient and integrate renewable sources across different domains, including homes, businesses, and electricity grids. In turn, this would result in the reduction of energy costs for users, a decrease in carbon emissions, and the improvement of energy system maintenance and planning. DSO-Flex also investigated how to aggregate energy flexibility from homes to offer a greater positive impact on grid stability.

The pilot targeted industrial, commercial, and residential areas and involved both energy providers and users. Adjustments to the application were made according to user feedback, enhancing its interface, accuracy, and flexibility. The application works seamlessly with existing energy systems, thanks to the adoption of standardized data-sharing protocols. In the future, DSO-Flex plans to expand its features, integrating with new energy markets, and employing AI for smarter energy management.

### 4.2.5 FLEXTRADE (SLOVENIA)

In response to the growing establishment of citizen and renewable energy communities and the emergence of local energy flexibility markets, FlexTrade aimed at the development of a platform for real-time active monitoring and control of data-driven energy communities. The specific objectives of the project included:

(1) The analysis of relevant flexibility pre-aggregation solutions for energy communities allowing for interoperability and integration with other stakeholders in the energy supply value chain via open APIs, shared and interpretable data models, and standardized protocols and interfaces.
(2) The extension, adaptations, and integration of existing in-house solutions from the H2020 projects BRIGHT[6], MATRYCS[7], PHOENIX[8] and BD4NRG[9] supporting implicit and explicit demand-response schemes for service provision at the community level.
(3) The design, testing and validation of the FlexTrade solution in a real-life pilot with community members.

The development of the FlexTrade solution entailed:

- From the technology perspective, the instantiation of a flexibility pre-aggregation tool to enable protocols as well as semantic interoperability.
- From the business perspective, the introduction of empowerment tools and engagement schemes at the intra- and inter-community levels. At the latter level, the solution focused on peer-to-peer energy trading and flexibility sharing based on analytics-based optimization, making use of the IR service developed by the InterConnect project.

The pilot involved a community, a Balance Responsible Party (BRP) and a DSO acting as the beneficiary of the flexibility services. The instantiation of services followed an already established energy market mechanism and marketplace between the community and the BRP for the provision of flexibility services to the DSO.

### 4.2.6 SYNERGY+ (SPAIN)

The Synergy+ project in Spain tested a new feature for the already existing ecosystem of Simon-connected devices. The existing solution allowed final users to check and control thermostats, switches, lights and sockets. By taking part in the InterConnect OC call, the demonstrator integrated energy consumption and derived prices, as well as outdoor weather information that allowed the 37 end-users involved in the pilot to better plan their energy consumption when demand is lower and adjust indoor climate based on outdoor forecasts.

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[6] For more information on the BRIGHT project: https://www.brightproject.eu/

[7] For more information on the MATRYCS project: https://matrycs.eu/

[8] For more information on the PHOENIX project: https://phoenix-h2020.eu/

[9] For more information on the BD4NRG project: https://www.bd4nrg.eu/

# 5 CHALLENGES AND LESSONS LEARNT TOWARDS THE REPLICATION OF THE CERF

This chapter reports and analyses the challenges, lessons learnt, and success stories identified by the internal and external implementations of the energy application. Based on the classification defined in section 3.2, these are presented in four categories: Data sources, Data repository and exchange, Consumer application, and Replicability and scalability. Where possible, the findings were also distinguished among the **regulatory**, **technical**, **economic/business** and **social** domains.

## 5.1 DATA SOURCES

The first challenge identified by the InterConnect pilots is related to the **low availability of public, common data sources**. Such low availability can be attributed to several technical issues, including data fragmentation, lack of interoperability and limited access to data sources. These may arise due to the existence of incompatible data schemes in existing legacy systems, proprietary formats, and differing data standards employed by stakeholders. Furthermore, **access to available sources often requires the payment of a subscription fee**. Besides, when available, public sources such as the ENTSO-E Transparency Platform greatly supported the elaboration of recommendations to end-users based on the grid status.

In the three demo sites of the Italian pilot, located in different areas of Milan, the availability of TSO data was an important enabler for the use of the Flexi functionality of the Planet App. The data supports both the application of the optimization algorithm, activating implicit flexibility offered by IoT-connected devices, and raising user awareness about their consumption.

Even when public data is available, uniformity across the EU can still be improved. In the case of the ENTSO-E Transparency Platform (TP), **InterConnect pilots observed differences in data availability across European countries and a lack of consistency** for specific data points, especially the ones related to interconnections with neighbouring countries.

Overall, from a regulatory standpoint, **data accessibility rules are yet unclear**. Access to data is the backbone of energy service provisions. Specifically, access to consumption and generation data from smart meters, both at main and sub-meter levels, is not yet ensured throughout Europe. **Pan-European guidelines for meter data access and sharing are lacking.** In relation to this, it should not be forgotten that **the smart meter roll-out in Europe is still not concluded, significant differences exist across Member States.** Information on carbon emissions from electricity production, grid status and electricity tariffs for end users play a fundamental role in the formulation of recommendations and incentives capable of effectively nudging user consumption behaviour to reduce their carbon footprint. At the same time, energy consumption and generation data from end customers are necessary to make well-targeted recommendations for the provision of both explicit and implicit flexibility to contribute to grid stability. Additionally, pilots remarked on the **importance of the availability of near real-time data to support decision-making and triggering actions with a real positive impact on the grid**.

In the Greek demo, while TSO data was publicly accessible, information pertaining to specific segments of the distribution network remained proprietary under the DSO. Thanks to the collaboration established with the Greek DSO in InterConnect, detailed data, tailored to the geographical regions of the pilot, could be accessed and used in the testing activities.

A specific challenge is related to the **low availability of public regional grid data from DSOs** and the availability of **Low Voltage (LV) topology data** which, due to the local characteristics of distribution grids and frequent field interventions, **might not be fully correct in DSO's Geographic Information Systems (GIS)**. Accurate topology information is a focus topic for DSOs, and highly important for the generation of accurate grid signals.

In SavingsFootprint pilot, different sources of grid data were connected to the developed system to provide historical, real-time as well as estimated flexibility market data. Based on actual price data from NordPool, recommendations to shift the consumption from high-priced hours to lower-priced hours were formulated. However, the pilot did not manage to integrate with national DSO data hubs of the Baltic countries as initially planned due to restrictions to their access.

The InterConnect pilots pointed out how common sources of data allow the use of a single software module to serve a plurality of geographical areas, enabling value creating for all the engaged energy application users. In some of the pilot countries, the **existence of a central data hub** was found to **significantly facilitate data access** thanks to the reduced number of integration steps to be performed and the fact that data was available free of charge.

In the Estonian OC pilot, energy service providers can easily connect to the national data hub which includes main smart meter measurements from all electricity and gas connection points. Nevertheless, even though all Baltic countries have a central data hub for electricity metering data, access rules differ. Language barriers, contractual requirements, restrictions for certain types of stakeholders and free vs. paid data access rules constitute barriers to replicability.

Lastly, the **lack of data marketplaces where stakeholders can buy, sell, or exchange energy-related data** was identified as a challenge for the creation of the CERF. This might be **due to the lack of clear economic incentives for data providers, the challenges arising from monetizing data values and the lack of effective pricing structures**. Also, **data owners may feel data sharing as a risk to their competitive advantage or intellectual property**, especially without clear protection and financial benefits from it.

## 5.2 DATA REPOSITORY AND EXCHANGE

Moving to data exchange, one of the main challenges encountered by the pilots was the integration of different data sources into the developed solutions. **Different sources and data hubs** were found to **still adopt different, and often proprietary, Application Programming Interfaces (APIs), data semantics, data formats, and communication protocols**, even within the same countries. Additionally, **data sources** often **do not have (public) APIs and**

**their integration requires dedicated effort**. For instance, a challenge encountered with the ENTSO-E TP was that each TSO submits data for periods of different length. Hence, despite the existence of a single portal, each data source must be analysed and handled at the TSO level. Moreover, different knowledge/data representations are adopted by each TSO, partly due to the differences in national regulations. Nevertheless, the Interconnect pilots' success stories show how these interoperability obstacles can be overcome.

In the Croatian OC pilot, many integrations were successfully performed to provide valuable services to the energy application users. Firstly, the integration with the existing local flexibility marketplace (DSO-level) allowed performing local optimization based on time-varying network tariff and cost of energy, discriminating the cases of (i) consumption only, (ii) presumption and (iii) availability of local storage. Secondly, the integration of commercial Home Energy Management Systems (HEMS) allowed optimizing the control of electric vehicle charging fleet sessions, with the potential integration of Additive-Increase/Multiplicative-Decrease (AIMD) control mechanisms for automated demand-response.

The introduction of the CERF and InterConnect solutions is regarded as a way to simplify access to grid-related data, saving time and resources in performing different integrations for different raw data sources. The InterConnect project has in fact demonstrated that **it is possible to support all the tested energy applications by adopting the same interoperability approach**, hence contributing to one of the main objectives of the CERF: **fostering interoperability in an agnostic way**.

In the Slovenian OC pilot, the FlexTrade platform makes use of both the DSOi and IR service to access and integrate carbon intensity information, prosumer data and electricity prices from the ENTSO-E Transparency Platform.

In order to deliver tailored recommendations to users, rather than generic ones, pilots required local grid information. InterConnect pilots highlighted that **data exchange formats and methods adopted by TSOs and DSOs still largely lack standardization**. Here, the DSOi represented the facilitating tool to access distribution grid data and generate signals that could be sent with higher geographical granularity.

In the German OC pilot, DSO grid data was processed to derive stimuli for users that supported the reduction of grid congestion issues, thus providing benefits for the operator. The same SAREFized sub-process was used to process these DSO data as we had already used to process energy community grid data.

The most accurate way to evaluate and share grid and demand response signals within the CERF would be referring to the specific electricity point of delivery. However**, sharing data with such granularity gives rise to two concerns**: the first is **related to technical complexity in case of scale-up and** the second to **personal data privacy**.

To address these concerns, the Portuguese pilot chose to resort to zip codes to refer to geographical locations based on a cost-benefit assessment. This approach allowed gathering district-level information and offering advice aligned with the actual local state of the grid without compromising the anonymity of served users.

It shall be taken into account that **national regulation and geography-specific characteristics might pose limitations to the chosen approach**.

One final concern advanced by the pilots is related to the adequacy of the adopted communication infrastructure. In fact, **Internet, public communication and cloud infrastructures are not specified to ensure minimum latencies, cybersecurity protection or response to failure**.

The German OC solution is based on a closed control loop that validates the impact of control actions implemented in response to the generated grid stimuli. To ensure the resilience and stability of the system, the execution of this control loop is decentralised through the establishment of a dedicated IoT infrastructure. This way, the impact of the control actions is first checked at the local level and then at the central (transmission) level.

## 5.3 CONSUMER APPLICATION

Looking at the energy consumer application, the main focus moves to the user. From the social perspective, **the main challenge remains to technologically and socially engage the consumer to become a regular participant in demand response initiatives**. As the shift or modification of consumption patterns remains a voluntary choice, **defining clear benefits and drivers for the end users to follow the recommendations delivered through the application is of paramount importance**. No silver bullet exists to address the complex dimensions of user engagement and behavioural change, hence, different drivers were explored and assessed in the InterConnect pilots.

The primary insight from the InterConnect pilots was the significance of monetary benefits. **Dynamic tariffs support implicit flexibility provision by motivating users to shift consumption to periods of the day characterised by lower electricity prices**. When prices reflect grid status, this produces a benefit on network operation. Nevertheless, **dynamic tariffs or tariffs with time differentiation are currently not available in the majority of EU member states [9]**.

In Italy, dynamic network tariffs are not available. To generate price signals to the users, the algorithm developed by the Italian pilot used as a reference the *Prezzo Unico Nazionale [10]* (*National Single Price*, i.e. the reference wholesale price for electricity purchase on the Italian Power Exchange) and information on carbon emissions from electricity generation.

Beyond economic benefits, social responsibility was demonstrated to play an important role in user engagement. **Increasing citizen awareness of how their consumption behaviour can benefit society by supporting the stability of their national grid and promoting the energy transition is a challenge** to consider in future implementations of the CERF.

Providing users with a clear view of how their combined actions can produce a real, positive impact on their local grid creates a sense of community and encourages behavioural change.

In the Greek demo, upon accessing the energy application, users are greeted on their landing page with daily grid recommendations. This not only served as a reminder of their potential contribution to grid stability but also successfully encouraged them to adjust their consumption habits accordingly.

**Social responsibility is closely linked to consumer awareness of their environmental impact**. In the InterConnect pilots, coupling information on energy consumption with the related carbon footprint proved beneficial to achieve higher user engagement. The stability of the offered services is also fundamental for retaining users.

In the Italian pilot, reinforcing the information with cost signals to environmental impact was key to engaging end users. This proved strong enough to liaise with end users by empowering them with a central role in the energy ecosystem, regardless of the application of gamification mechanisms. Furthermore, direct engagement and animation were fundamental to motivating end-users.

The establishment of energy communities has a beneficial impact on increasing awareness and reinforcing a shared sense of social responsibility among their members. However, **in many European countries, the provisions related to renewable and citizen energy communities have not yet been fully transposed into national legislation [11] together with related requirements and support mechanisms**. As a consequence, the uptake of communities in different Member States is at varied maturity stages.

Another potential offered by energy applications is the establishment of new and mutually beneficial interactions between companies and users

In the Croatian OC pilot, the developed energy application created value both for the charging station operator (Hrvatski Telekom) and the subscribers saving them time, costs and reducing their carbon footprint.

Apart from requiring strong incentives, **it takes time before the effects of behavioural change can be appreciated and this can lead to the end-user reluctance to keep using the application.** In this sense, several pilots reported that end users preferred to utilize a simple button instead of a complete application. For instance, having to manually adjust consumption when receiving a recommendation is time-consuming and requires effort, creating a complexity for users. Hence, **the automation of demand response mechanisms can act as an accelerator, provided that their conditions are accepted by the end-user**.

In the German OC pilot, a recommendation to avoid energy use in a specific period is translated into a financial stimulus upon which devices can react. The same effect (e.g., operating a dishwasher at another time) of manual intervention can be achieved by automatically changing the device operation, minimising user efforts.

Above all, **maintaining the engagement of customers over time is a challenge**. As the condition of the local grid might call for the activation of flexibility only in specific and spaced-out periods of time, there is a risk of losing the attention and interest of the consumer.

To face this concern, the Dutch pilot proposes a push mechanism (i.e., the user receives an alert of an upcoming overload situation) rather than a pull mechanism (i.e., the customer needs to open the energy application to receive grid signals). This way, it is not necessary for the user to deliberately check the application.

The InterConnect experience showed that **establishing a participative approach for the development of the application allows for improvement and fine-tuning of the adopted engagement strategies and tools**.

In the Italian pilot, UI/UX logics were refined over time to engage the end users more efficiently. The service design followed a participative approach, based on the feedback and indications received from both involved community managers and real estate developers.

Many of the pilots collected user feedback to make iterative adjustments to the applications' interfaces and interaction mechanisms. This enhanced the quality of the tools and ensured users could take action without being overwhelmed. This demonstrates how consumers can play an active role in the energy transition, despite the difficulties perceived by the majority of European citizens.

The interface of the Portuguese application evolved to include visual elements to help the consumers in reacting more clearly to the received grid signals. More than 30 residential customers were actively and successfully involved in the pilot.

Nevertheless, it should not be forgotten that not all electricity users are the same. Thus, different drivers and incentives will impact them to a different extent. As **wealthier households** are more likely to own rooftop PV systems, EVs and smart home appliances, they **have a higher potential to offer demand-side flexibility and**, as a consequence, **to achieve larger energy savings compared to the share of the population that experiences energy poverty and social challenges**. Concerning this, **energy literacy barriers also require consideration in the design of applications**.

During the evaluation of their solution, the Synergy+ OC pilot in Spain found out that end-users can understand data provided in euros better than in kWh. Providing them with monetary information helps maintain higher engagement.

Looking at the provision of grid services, different remaining challenges were identified by the pilots. The low availability of dynamic tariff models to incentivise the provision of implicit demand-side flexibility has already been illustrated above. **The trading of explicit demand-side flexibility is** also **hindered by the lack of clear regulatory frameworks** and **potential conflicts emerging between new local flexibility markets and existing market schemes**.

The DSO-Flex OC pilot developed a system working with real-time data for tracking energy production, consumption, and settlements to establish a local energy trading mechanism. However, the pilot ran into some difficulties due to the lack of clear regulations and rules for peer-to-peer energy trading in France. Hence, the testing activities were conducted through simulations and not in a real-life setting.

Furthermore, **although non-firm connection agreements have been identified as promising tools for optimising the use of available grid capacity and relieving grid congestion issues their adoption** across Europe **is still limited**. [12]

In the Netherlands, DSOs may only offer contracts to clients characterised by fixed capacity that must be fully available 24/7. According to the Dutch pilot experience, allowing for more flexible capacity offers in contracts may support the flattening of the load curve at the local level, encouraging users to consume energy in different time slots and at the same time free up grid capacity for new consumers to be connected to the grid (which currently is a nation wide issue).

Lastly, it should be noted that **not every household has its own grid connection point and, thus, might not have the possibility to choose its own electricity supplier or aggregator, control its energy footprint or provide demand response services**. This is often the case in apartment buildings where grid connection to the grid contractually takes place at the building level and not separately for each flat.

## 5.4 REPLICABILITY AND SCALABILITY

By utilizing the SIF, InterConnect laid the groundwork for replicating the energy application UCs across different European countries and seamlessly integrating it with new recommendation systems. This approach significantly minimizes the need for extensive backend and frontend development, facilitating a more efficient and adaptable expansion of offered services. However, some scalability and replicability challenges remain.

The first set of challenges is related to data. As mentioned in the previous sections, the availability of common or interoperable grid data sets would foster replication across Europe. However, these **data sources are often missing, cannot be freely accessed or no public APIs are provided**. Furthermore, **a consensus on data ownership has not yet been reached hindering data sharing**, especially in the case of data generated by customers (e.g. smart meter measurements, EV charging data, and data gathered by IoT devices).

Looking at scalability, it should be kept in mind that **processing data in large volumes will introduce a major technical challenge** as in the case of daily information processing for the entirety of LV grids in Europe, which account for more than six million electricity delivery points. Similarly, the efficient utilization of smart metering data to provide near real-time services will require the acquisition of data with higher granularity. Hence, **enhanced processing abilities are necessary in view of a rollout of energy applications across the entire grid**.

When developing the energy-saving application, the DSO-Flex OC pilot faced a technical challenge with the Knowledge Engine Runtime's handling of high-resolution data, specifically of one-second data. The issue highlighted the need for improved technical capability for scalability.

Lastly, on data, **standardisation remains a key concern**. In fact, **a recommendation ontology remains to be standardised, improved and adopted by data sources**. The created SSAs should be available as open source to foster re-use and improvement.

For the scope of the InterConnect pilots, an implicit "recommendation ontology" was set as the source for the knowledge interaction definitions. Based on the Belgian pilot experience, partners suggest its standardisation, for instance, as part of the existing SAREF4ENER ontology. The ontology could be further refined to facilitate higher time granularity and quality of the recommendations.

A replicability challenge reported by multiple InterConnect pilots is related to the learning curve for the implementation of the InterConnect solutions. In fact, **while developers commonly have expertise in the use of syntactic APIs they might be acquainted with semantic representation**. As a consequence, **significant time and resources need to be allocated to the initial phases of integration**.

The AI4CS OC pilot faced technical challenges in implementing the SSA which required more time than anticipated. Once software integrators concluded this first stage, though, the development of additional SSAs proved to be straightforward.

In general, **potential application developers might not be acquainted with the CERF initiative**. Thus, **decision-makers at the company level might be reluctant to start developing energy applications due to a lack of confidence in the proposed framework**.

The DSO involved in the Dutch pilot, Stedin, required significant guidance and onboarding from the Interconnect partners on the CERF as employees were not familiar with the concept and were less inclined to adopt such a framework over tools developed in-house.

Beyond the project, **the main scalability and replicability challenge will be the support and maintenance of the implemented integrated InterConnect solutions and services**.

Additional regulatory barriers to replication are related to the **significant differences in the transposition of European Directives into national regulation**. In those countries where forward-looking regulation encourages DSOs to improve network management, energy applications can best support the integration of new technologies and services towards an efficient energy system. Nevertheless, a major success of the InterConnect pilots was proving that the developed components can serve the exchange of grid information in different EU countries, regardless of the individual energy regulatory frameworks.

Looking at the energy application, **automation of currently manual functions should be regarded as a priority for scalability** together with **customization and personalization of services while respecting user privacy**. **Modularity and flexibility were identified as advantageous characteristics in the design of the energy applications**. A higher degree of adaptability supports the use of the application across a range of different operational scales and energy needs, improving its versatility towards scaling up and replication.

A major success in the design of the energy application of the DSO-Flex OC pilot, was its adaptability to various setups, allowing users to easily and seamlessly integrate their diverse energy systems. This proved to be particularly beneficial for grid operators and large commercial and industrial facilities.

# 6 RECOMMENDATIONS

According to the challenges, lessons learnt and success stories identified in chapter 5, this chapter reports the recommendations formulated by the InterConnect project in support of the definition and deployment of the second-generation blueprint of the CERF. The recommendations are clustered according to the same four categories (Data sources, Data repository and exchange, Consumer application, and Replicability and scalability) and, where possible, distinguished among the **regulatory**, **technical**, **economic/business** and **social** domains.

## 6.1 DATA SOURCES

To overcome the challenges related to the low availability of public, common data sources as well as the lack of consistency for specific data points across the EU identified by the InterConnect pilots, several recommendations can be considered.

Firstly, the promotion of additional data sources in a public manner is crucial to allow further development of energy applications and address local characteristics in the different Member States. To further develop the CERF, the InterConnect project recommends **establishing data-sharing agreements between the different stakeholders and encouraging their engagement in open data initiatives to help increase the availability of public and common data sources.** The availability and accessibility of these sources are essential to support the development of third-party applications and services that leverage energy data. This recommendation is in line with the SGTF R2 recommendation that advocates for the mapping of currently available data in each Member State.

In addition, the project advises **implementing existing EU legislation and initiatives on data access (e.g. common European energy data space) for the development of the CERF.** These will enable the creation of a central data hub granting access to data sources which are currently unavailable across the EU. Access to this detailed information would significantly enhance the relevance of energy applications in the context of energy management and grid optimization. The energy savings resulting from the CERF would, in turn, provide incentives for the roll-out of smart meters across the EU, showcasing the benefits of having access to metering data for the different stakeholders as long as the privacy and ownership of data are preserved, as discussed below.

A proper regulatory framework is essential to support different parties in joining forces to overcome technical issues such as those related to incompatibility of data formats or protocols. From a technical perspective, standardization is essential to ensure interoperability and data quality, facilitating data-driven decision-making and innovation in the energy sector. In this sense, the project suggests **building upon the InterConnect SIF which has been proved to be successful in supporting the set of semantically interoperable services/digital platforms that are needed to realize the CERF for energy.** In this context, the SIF has also been successful in providing interoperable LV topology data and can help overcome the challenges related to the low availability of data from DSOs.

When it comes to the economic and social barriers associated with data sources, on the one hand, the project advises **defining incentives and revenue mechanisms to compensate data providers for their contributions when developing the CERF.** This is essential to leverage value on existing data assets to generate revenue and facilitate the creation of data marketplaces. Moreover, it is essential that data owners can grasp the economic benefits arising from sharing the data as well as the value beyond the financial gain, which can be shown by showcasing the non-financial benefits of data sharing, such as improved standing and prominence within the industry. On the other hand, the project **recommends the adoption of social strategies that create a supportive ecosystem that encourages data owners to overcome their reservations about data sharing.** In this context, education and training have been essential to address misconceptions and concerns about data sharing in the different pilots on InterConnect.

## 6.2 DATA REPOSITORY AND EXCHANGE

The issues identified in the data repository and exchange category refer to the systems, platforms, or mechanisms designed to store, manage, and facilitate the sharing of data among multiple stakeholders. In InterConnect, the repository and data exchanges were UC-dependent. In this context, one of the main challenges encountered by the pilots was the integration of different data sources into the developed solutions. Different sources and data hubs were found to adopt different and proprietary APIs, data semantics, formats and protocols. Nevertheless, the InterConnect pilots' success stories show how these interoperability obstacles can be overcome. Based on this, the main recommendation when it comes to the integration of existing data repositories and services is to, in order, **assess data quality and reliability, get familiar with the APIs and data models, investigate if efforts were already made to map these to specific standards/best practices and then build adapters to ensure interoperability.** Considering the relevance of grid data for the CERF, **it is** also **recommended that grid operators agree on common data representations and a coordinated cadence for collecting and publishing data,** for instance in the case of the ENTSO-E TP.

As mentioned in the previous chapter, many data sources, which might be considered key for building energy applications, are still private or kept behind paywalls. This makes operational costs and initial integration efforts of application developers much more challenging.In this context, if data providers want to open their sets to the public (or selected stakeholders) and in line with data space initiatives, the project suggests **choosing a standard interface logic and data models** (e.g., through an ontology like SAREF) **and developing the application from them.** These interfaces should rely on the results of projects like InterConnect to accelerate the development process and lower the associated costs. What InterConnect is bringing with the SIF and SAREF compliance drastically reduces the overhead of integrating new services and data sources and allows teams to focus on data analysis and the creation of added value for users. This recommendation is in line with the SGTF R4 recommendation which highlights that interoperability and integration with 3rd party systems must be facilitated to maximize the impact of the CERF.

Finally, the project encourages **data providers to partner with service providers to jointly maximise the real value behind data.** Building data access, analysis, filtering services specific to a data set can drastically increase its usability within CERF and as a basis for building scalable and cost-effective energy apps.

Another lesson learned within InterConnect is that the most accurate way to evaluate and share grid and demand response signals within the CERF would be referring to the specific electricity point of delivery. However, sharing data with such granularity gives rise to personal data privacy concerns considering that sharing individual electricity consumption patterns could reveal sensitive information about occupants' behavior or routines. In this context, the project proved that **it may not always be necessary to use highly granular data for effective grid management or demand response. Aggregated data at higher levels of abstraction might suffice for many applications.** Moreover, the introduction of a system that involves sharing highly granular data would likely face regulatory hurdles and security concerns. In this regard, the project recommends **ensuring the compliance of the CERF-based application with the GDPR and other regulatory measures and considering the use of aggregated data at higher levels of abstraction.**

## 6.3 CONSUMER APPLICATION

When looking at the energy consumer application, the focus is shifted towards the user. As such, the following lines will draw recommendations to overcome the challenges related to consumer engagement both from the technical and social standpoints.

From a social perspective, the InterConnect pilots highlighted the significance of economic benefits to engage end-users. Dynamic tariffs allow sending economic signals to end-users to modify their behaviour, however, they are currently not available in most EU Member States. In this context, the project advises **coordinating the implementation and harmonisation of regulations, policies and incentives at the EU and national levels to allow end-user access to price signals.** Beyond economic benefits, social responsibility was demonstrated to play an important role in user engagement. In this sense, a recommendation would be to **couple economic signals to the users with a view of how their actions produce a real, positive impact on the environment.**

In the InterConnect pilots, integrating data about energy consumption with its corresponding carbon footprint proved beneficial to achieve higher user engagement. Nonetheless, sustaining this engagement over time is a challenge, as they might lose interest or find the interaction with the application too time-consuming, especially when it comes to manually adjusting consumption. In this context, **the user experience can be simplified by implementing automated responses based on the application's recommendations.** Additionally, the project proposes **establishing an exchange with users to ensure continuous improvement of the app to ensure their active engagement over time.** From a technological perspective, energy-saving technologies and practices can be complex, requiring consumers to understand technical details about their energy consumption and interaction with the grid. It has been proved that user-friendly animations and energy literacy are essential to engage end-users in the energy app. To this end, **it is important to use simple and direct language** (e.g. making use of graphics) **to transfer information**

**effectively and keep the interest and participation of end-users** Nonetheless, sustaining this engagement over time can be challenging if the service is not stable. Consumers can become sceptical about the effectiveness or reliability of energy-saving technologies if they have negative experiences. As such, **it is essential to guarantee the stability of the digital services provided to retain users.**

Moving now to consumer engagement in the provision of grid services, the pilots reported issues concerning the lack of clear rules and regulations for energy trading in local flexibility markets, hampering the trading of explicit demand-side flexibility. In this sense, **the development of new regulations should clearly address energy trading in local flexibility markets. These regulations should provide a comprehensive outline of the roles, responsibilities, and rights of each stakeholder involved in the trading process. Alongside flexibility markets, other mechanisms fostering flexibility should be out in place, such as non-firm connection agreements and dynamic tariffs for end-users that are still not available in most EU member states.**

Lastly, **enabling individual metering and billing is particularly important to allow the participation of multiple households within an apartment building or housing complex in the provision of flexibility services.** This aspect is particularly important considering that in 2022, 47.5% of the EU population lived in apartment buildings [13] and is in line with the SGTF R5 recommendation that the CERF should be guided by principles fostering consumer engagement while maximizing consumer flexibility.

## 6.4 REPLICABILITY AND SCALABILITY

Based on the success of replicating the InterConnect solution across 10 Member States, the project recommends **adopting standardized data exchange protocols through CERF.** This adoption can significantly streamline the development process, leading to faster application delivery. Such standardization ensures free access to consistent data sources facilitating cross-border interoperability, allowing the application to operate seamlessly across various EU member states. Moreover, the application's scalability within the different countries hinges on its ability to adapt to local data formats and exchange methods while adhering to standardized solutions. This flexibility is crucial for expanding the application's reach to diverse audiences and accommodating unique data management and infrastructure needs across different regions.

However, to guarantee user engagement and social acceptability of CERF-based energy applications, it is important to **reach a consensus on data ownership, ensuring that data generated by the customer belongs to the customer.** In this context, the project puts forth **including in these agreements not only electricity measurements but also data from IoT devices belonging to the customer or purchase information held by the sellers of goods and services. This data needs to be easily made available and shareable. Using semantically-based representations (i.e., SAREF and its extensions) ensures replicability and scalability.** That was demonstrated via the toolset of the SIF that allowed the project and the open call pilots to integrate additional elements more easily, with a clear alignment with the CERF.

It is equally important to address the unfamiliarity of potential application developers with the CERF can lead to the reluctance of decision-makers at the company level to engage within the proposed framework. To tackle this obstacle, the project encourages **involving company decision-makers in discussions about the CERF and organizing informative sessions at the European level.** Moreover, **it is crucial to address the differences in the transposition of European Directives into national regulation that pose an obstacle to the replication of CERF-compliant energy applications across the Union and enable access to price signals.**

Lastly, in parallel to the recommendations above, the support and maintenance of the implemented integrated InterConnect solutions and services are crucial for the scalability and replicability of the energy applications tested within InterConnect. In this context, while the project has concluded some agreements with BDVA and Linux Foundation for Energy to maintain the solutions provided, the project suggests **taking the solutions further with EU projects and initiatives that build upon these results.**

# 7 CONCLUSIONS AND WAY FORWARD

This deliverable represents the successful conclusion of WP13 of the InterConnect project and it showcased the contributions of the project towards the development of the CERF in line with the Digitalising the Energy System EU Action Plan. The document showcased how the InterConnect SIF and DSOi have been further developed to realise 10 CERF-compliant Energy Applications, tested in different Member States.

The main achievements from these activities include enhanced user engagement, changes in energy consumption patterns, improvements in grid stability, and increased energy efficiency. These outcomes not only confirm the effectiveness of the SIF and the DSOi but also underscore the essential role of consumer involvement in the energy transition.

The main challenges and lessons learned towards the replication of the CERF have been clustered considering the regulatory, technical, economic and social domains based on the results and contributions of both internal and external implementations of the energy application ecosystems to the CERF that have been presented following the framework used for the collection and assessment of results from the InterConnect pilots.

The assessment of these lessons has led to several recommendations that can be presented by considering their regulatory, social, technical, or economic perspective. All in all, it can be argued that the solutions proposed by InterConnect demonstrated to be effective in the provision of semantically interoperable services and digital platforms that are needed to realize the CERF for energy. The project also provided some valuable recommendations arising from the lessons learned.

Therefore, building upon these solutions and considering these recommendations in future EU projects and initiatives such as the DIGITAL Call dedicated to the Common European Reference Framework for energy-saving applications will expedite the process while reducing costs of defining the CERF and enabling a common data and knowledge exchange framework within the EU that can be instantiated at different levels in support of innovative and user engaging applications.

# REFERENCES

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[13] Eurostat, Housing in Europe - 2023 interactive edition, Available here.

# Annex I. SGTF EG3 TEMPLATE FOR USE CASE MAPPING

The table reports the set of criteria adopted by the SGTF EG3 for the mapping of use cases of consumer applications. The text in italics provided an explanation of each criteria. The same template table was chosen to provide a description of the InterConnect use cases reported in Annex II.

<table>
<tr><td colspan="2">Name: Designation of the Pilot</td></tr>
<tr><td colspan="2">Country: Country or countries where the consumer application addressing the UC is available.</td></tr>
<tr><td colspan="2">Functionalities: What is delivered to the consumer (e.g. metrics on savings, general/targeted advice, direct action on appliances, …).</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td><u>Passive vs. Active</u>: Active (e.g., triggering actions automatically) or passive (e.g., provision of information so the consumer can choose to act).</td></tr>
<tr><td><u>Level of granularity and timeliness</u>: Granularity of the data (e.g., high level for smart or sub-meter data, low level for total supply/demand of energy) and timeliness, (e.g., near real-time or with a lag time of in minutes/hours/days).</td></tr>
<tr><td><u>Type of meter of other device used</u>: E.g. smart meter, submeter or other hardware.</td></tr>
<tr><td>Open/Closed data: Is data open/closed source? If closed, what are the conditions of use?</td></tr>
<tr><td><u>Cloud-based vs. localized</u>: Is data stored and computed in the cloud or at grid edge?</td></tr>
<tr><td><u>Access and exchange conditions</u>: Is the data publicly available? Is it considered sensitive? Is it owned? Which are the eligible parties that may access it? What are the criteria for sharing it? Which data protection measures shall be applied when data is transferred or at rest?</td></tr>
<tr><td colspan="2">Expected impact: Indication of the expected impact of the UC implementation (e.g., number of application users, triggered energy savings, measurable demand response, etc.).</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: The business case (e.g., contribution to public welfare, reducing CO2 emissions, improving the energy system, saving money or getting other rewards)</td></tr>
<tr><td rowspan="2">Capacity to integrate with 3rd parties</td><td><u>Yes/No</u>: Can the application be used to access financial rewards/incentives? Can it be used by other agents to leverage effects?</td></tr>
<tr><td>What 3rd parties</td></tr>
<tr><td colspan="2">Consumer segment: E.g., households, SMEs, large industrials, widespread for all consumers…</td></tr>
<tr><td colspan="2">Replicability across EU: Is the UC easy to replicate or does it depend on national specificities with barriers for this replication (e.g., maturity of existing market, level of smart-meter roll-out and integration in a smart grid, …)?</td></tr>
<tr><td colspan="2">Time to deliver: Is the UC quickly implementable or does it require longer time to implement?</td></tr>
<tr><td colspan="2">Origin: public/market party/SO – Is the UC developed by a public entity, market party or SO?</td></tr>
</table>

# Annex II. MAPPING OF ENERGY APPLICATION IMPLEMENTATIONS

## INTERCONNECT PILOTS

### PORTUGUESE PILOT

<table>
<tr><th colspan="2">Name: Wattch.r</th></tr>
<tr><td colspan="2">Country: Portugal</td></tr>
<tr><td colspan="2">Functionalities: inform the consumers of the best time of the day to increase, decrease or maintain their consumption. Collects user feedback on how likely consumers are to adopt the recommendations. Educates the consumer on daily actions that have a positive impact on a more sustainable energy use.</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td><u>Passive vs. Active</u>: Passive. App uses information from the Interoperable Recommender, DSO Interface, and collects end-user feedback on the taken behavior.</td></tr>
<tr><td><u>Level of granularity and timeliness</u>: Granularity of the recommendations for load increase and decrease is 1-hour, specific to each zip-code.</td></tr>
<tr><td><u>Type of meter of other device used</u>: Smart metering may be indirectly used to generate grid signals from the DSO side. The app does not provide metering functionalities.</td></tr>
<tr><td><u>Open/Closed data</u>: IR and DSOi recommendations are open-data, feedback is private data from the consumer.</td></tr>
<tr><td><u>Cloud-based vs. localized</u>: Both</td></tr>
<tr><td><u>Access and exchange conditions</u>: Recommendations are generated by INESC TEC interoperable recommender system departing from publicly available ENTSO-E data. User data (identification, zip-code, household composition and assets with flexibility potential available) is privately stored. The terms and conditions are detailed <u>here</u>.</td></tr>
<tr><td colspan="2">Expected impact: 30+ end users in scope of the Portuguese demonstration.</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: Notifications for new recommendations or daily updates to bring users to the application. New daily Eco-Tips about sustainable energy consumption.</td></tr>
<tr><td rowspan="2">Capacity to integrate with 3rd parties</td><td><u>Yes/No</u>: Yes</td></tr>
<tr><td>Integration with DSO systems, Flexibility systems and / or Energy Management systems. Interface established via the Semantic Interoperability Framework interface which can extend to other domains.</td></tr>
<tr><td colspan="2">Consumer segment: Residential consumers.</td></tr>
<tr><td colspan="2">Replicability across EU: The app will work for all countries for which the recommender system is generating data. Native languages for other countries would require that inclusion.</td></tr>
<tr><td colspan="2">Time to deliver: Already deployed in Portugal for the general public.</td></tr>
<tr><td colspan="2">Origin: public/market party/SO</td></tr>
</table>

## ITALIAN PILOT

<table>
<tr><th colspan="2">Name: Planet App</th></tr>
<tr><td colspan="2">Country: Italiy - Milano. Pilot sites in the social houses districts of: Moneta, Merezzate and Quintiliano</td></tr>
<tr><td colspan="2">Functionalities: Residents are nudged to consume electricity at the time it contains less embodied carbon. The recommendations are pushed through the app and records interactions with end users, allowing a qualitative estimation of the impacts on the environment in terms of reduction of carbon emissions. The Planet App backend was enriched with data analytics services to have a deeper understanding on user experience and evolved its logics to highlight in a more comprehensive and effective way the role that an end user can have in lowering the impacts on the environment.</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td><u>Passive vs. Active</u>: Both. IoT devices are automatically rescheduled, according to data coming from the grid, previsional data and carbon related information. Passive strategies are actuated within the Flexi feature where the end-users are nudged to behave differently, thus actuating some ecotips shared with them thoughout a digital touchpoint.</td></tr>
<tr><td><u>Level of granularity and timeliness</u>: 2G meters provide data on energy consumption for single housing units with 15 min granularity. Data from the grid, forecasting, and actuation strategies are collected and sent back with one day granularity.</td></tr>
<tr><td><u>Type of meter of other device used</u>: Smart meters, energy aggregation components ( edge controlling unit - Distech controller).</td></tr>
<tr><td><u>Open/Closed data</u>: Closed, upon terms and condition agreement. Data pseudonimized have been let available for external stakeholders (e.g.: OC1 activities of InterConnect).</td></tr>
<tr><td><u>Cloud-based vs. localized</u>: N/A</td></tr>
<tr><td><u>Access and exchange conditions</u>: Data containing sensitive informations (consumption) are not publicly available. They can be upon pseudonimization. Carbon footprint data is not public but shared for the sake of research activities by Electricitymaps. Other data sources (transparency platform) are publicly available.</td></tr>
<tr><td colspan="2">Expected impact: 1000+ end users are benefitting from the Flexi feature in a real life environment. D/R service is available for 120 single end users (participating to the initiatives and benefitting from both HW - washing machines, dishwashers- and SW -demand response service within the Planet App.</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: Money savings can be applied but need to rely on price information not available for now.</td></tr>
<tr><td rowspan="2">Capacity to integrate with 3rd parties</td><td><u>Yes/No</u>: Yes,</td></tr>
<tr><td>Supporting ToU (once the market will be mature), Flex services (same as the previous one) and/or Renewable Energy Communities if constituted, providing with otpimized overlap between production and consumption (sector coupling - implicit flexibility)</td></tr>
<tr><td colspan="2">Consumer segment: 3 large scale social housing settlements in Milano, counting more than 1000 single housing units</td></tr>
<tr><td colspan="2">Replicability across EU: Yes</td></tr>
<tr><td colspan="2">Time to deliver: Bottlenecks for operativity are related to SW stability.</td></tr>
<tr><td colspan="2">Origin: Market Party</td></tr>
</table>

## GREEK PILOT

<table>
<tr><td colspan="2">Name: AUEB-RC</td></tr>
<tr><td colspan="2">Country: Greece</td></tr>
<tr><td colspan="2">Functionalities: Within the Energy App, users were provided with a comprehensive 24-hour forecast of energy consumption recommendations sourced directly from the grid. This forecast was detailed on an hourly basis, highlighting specific times when it would be beneficial to either ramp up or scale down electricity usage. Such guidance was aimed at assisting users in adjusting their consumption patterns to enhance the overall stability of the local and national electricity grid.</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td><u>Passive vs. Active</u>: Passive (Consumers had the freedom to decide whether to follow the daily recommendations at their discretion).</td></tr>
<tr><td><u>Level of granularity and timeliness</u>: The recommendations were refreshed daily, offering users hourly detailed guidance on managing their energy consumption.</td></tr>
<tr><td>Type of meter of other device used: For the Greek pilot's other use cases not covered by WP13, smart meters were employed.</td></tr>
<tr><td><u>Open/Closed data</u>: Data derived from the smart meters, which is proprietary to the companies (and the consumers) that installed these devices and manage the IoT cloud platforms, is closed source. For the majority of these companies, this dataset represents a valuable asset for future exploitation.</td></tr>
<tr><td><u>Cloud-based vs. localized</u>: Data is collected at the edge and forwarded to the cloud for storage and further processing.</td></tr>
<tr><td><u>Access and exchange conditions</u>: The data generated by smart meters is proprietary, owned by both the consumers and the companies responsible for their installation and the operation of cloud IoT platforms. Access to this data is granted to project partners under strict conditions, defined in a data usage agreement that restricts any exploitation of the data beyond the project's scope without explicit permission from the data owners. Despite these ownership and access controls, the data is processed with privacy-preserving measures: it is anonymized to ensure that no personal information is stored or exchanged. Additionally, energy consumption data is pseudonymized, linking it to arbitrary home IDs, thereby maintaining data confidentiality while in transit or at rest. These protocols are in place to safeguard the data and comply with data protection standards.</td></tr>
<tr><td colspan="2">Expected impact: The use case successfully engaged 145 users via the developed mobile app, encouraging them to modify their consumption habits in line with recommendations to enhance grid stability.</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: The primary motivation for consumers was the sense of contributing to the public good by aiding in the stabilization of the energy system and lowering their CO2 emissions.</td></tr>
<tr><td rowspan="2">Capacity to integrate with 3rd parties</td><td><u>Yes/No</u>: The application has the potential to leverage Time-of-Use (ToU) tariffs, enabling it to provide consumers with economically incentivized recommendations that encourage more efficient energy use.</td></tr>
<tr><td>DSO, Retailer, Aggreggator, ESCO</td></tr>
<tr><td colspan="2">Consumer segment: Primarily designed for households, the scope could extend to include building managers.</td></tr>
<tr><td colspan="2">Replicability across EU: In its initial form, the use case can be replicated throughout Europe, utilizing TSO data from ENTSO-E to offer recommendations to consumers. Expanding the use case to incorporate the capabilities of smart meters and ToU tariffs requires overcoming certain obstacles, including the current status of the energy market with respect to demand-side flexibility, the adoption of ToU tariffs, and the deployment of smart meters.</td></tr>
<tr><td colspan="2">Time to deliver: The UC could be implemented in less than 6 months provided that most of the required components have been already implemented within the Interconnect project.</td></tr>
<tr><td colspan="2">Origin: public/market party/SO – The use case was executed by a collaborative consortium comprising ICT SMEs, a university, a retailer, and a Distribution System Operator (DSO).</td></tr>
</table>

## DUTCH PILOT

| **Name: Eklok** | |
|---|---|
| **Country: Netherlands** | |
| Functionalities: The Eklok application will provide end-users a clock like interface on their mobile phones, and additionally also provide this schematic in the form of a physical clock on large public buildings and squares. The clock will recommend via a color scheme to avoid or delay energy consumption based on predicted time slots where an abundance of renewable energy (solar/wind) occurs or when there is a shortage (typically occurring when EV's are charged). | |
| **Type of data, access and exchange** | Passive vs. Active: Active |
| | Level of granularity and timeliness: hourly recommendations, 24 hours in advance of the actual time of observing |
| | Type of meter of other device used: Stedin's own grid elements provide actual usage data, which will be combined with Stedin's AI predicted near future local grid levels. |
| | Open/Closed data: closed data – however may be used by 3rd parties after agreement and technical alignment. |
| | Cloud-based vs. localized: localized solution for data gathering. Actual front end applications (to mobile app providers) may run in a cloud environment. |
| | Access and exchange conditions: to be agreed on with Stedin, in principle the data is not publicly accessible and there is no intention to change this in the near future. |
| Expected impact: to be measured to state any quantifiable benefit. | |
| **Incentives/engagement mechanism:** The engagement strategy towards consumers is mostly to increase awareness by educating the population through a friendly approach on both smartphones as well as visuals in the public space by means of displays on buildings. Stedin has limited possibilities through regulation to add a direct financial incentive, as a DSO in the Netherlands may in now way have a commercial impact directly or indirectly obtained through energy consumption and production. | |
| **Capacity to integrate with 3rd parties** | Yes/No: Yes |
| | Stedin has a partner for mobile app development: Technolution. |
| **Consumer segment:** residential areas with frequent congestions**.** | |
| **Replicability across EU:** Yes | |
| **Time to deliver: Estimated at** 2024/2025 | |
| **Origin:** DSO | |

## BELGIAN PILOT

| **Name: BE CERF demo** | |
|---|---|
| **Country:** Belgium | |
| **Functionalities:** Recommendation to increase/decrease consumption at selected timeslots. | |
| **Type of data, access and exchange** | Passive vs. Active: Active and passive. |
| | Level of granularity and timeliness: **Granularity:** the current Recommenders provide recommendations with 1 granularity of 1 hr, but this is easy to change. **Timeliness:** Day-Ahead or Intra-Day: a new optimization is done every 15' based on the latest available recommendation. |
| | Type of meter of other device used: EV Charging Infrastructure and whitegoods |
| | Open/Closed data: The ElectricityMaps data source (input for VITO's carbon intensity based Recommender) is closed and access permission to this was negotiated/agreed with them for the purpose of the CERF pilots. The ENTSO-E TP data source (input for INESC's Recommender) is open. VITO created the requires SSAs for both data sources to connect them to the SIF. |
| | Cloud-based vs. localized: Cloud |
| | Access and exchange conditions: Carbon intensity-based recommendations from the VITO Recommender can be made publicly available as long as the required data access to the ElectricityMaps service is possible. An agreement for continued acess beyond the timeline of the Interconnect project is yet to be agreed. The recommendations can be used at own risk, without support guarantees unless explicitly agreed otherwise. |
| **Expected impact:** The demo scope is limited to the Thor Park with a single 'user' being the facility manager that is responsible for the EV smart charging i.e. minimizing charging cost (employees charge for free) and maximizing charging satisfaction (requested charging needs must be met).<br>**Measured demand response impact** i.e. impact of changing consumption profile in line with received recommendations compared to the baseline plan depends on many factors but will be monitored and logged to enable reporting. | |
| **Incentives/engagement mechanism:** Depends on the Recommender that is used. When using the VITO carbon intensity based Recommender the business case is to reduce building (EV charging) emissions without compromising charging satisfaction and with no or a limited impact on the charging cost for the facility manager. But other Recommenders could be selected to support other business cases. | |
| **Capacity to integrate with 3rd parties** | Yes/No: in principle yes, although some issues may arise depending on the exploitation model and the tools to be integrated (i.e., recommender) |
| **Consumer segment:** All | |
| **Replicability across EU:** Very Replicable | |
| **Time to deliver:** Quickly implementable if the concepts of Semantic Interoperability and SSAs are understood. | |

# OPEN CALL PILOTS

## AI4CS

<table>
<tr><th colspan="2">Name: AI4CS</th></tr>
<tr><td colspan="2">Country: Croatia</td></tr>
<tr><td colspan="2">Functionalities: AI4CS - AI for Charging Stations project tested a mobile app that guides EV owners to public charging stations, based on their forecasted availability and the Grid information coming from the Interoperable Recommender. It will suggest the charging station which will be available and a timeslot that the Interoperable Recommender has indicated as appropriate to use for the Grid stability. The objective was to help the users get good customer experience and also help the Grid from peak loads plus shift consumption when the energy mix is greener. It was carried out in Croatia with the Charging Station Network of Hrvatski Telekom. More than a hundred of their users used the pilot app for more than a month and used its recommendations and guidance.</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td>Passive vs. Active: Active. Recommendations are included in the scheduling process of the EV station reserve.</td></tr>
<tr><td>Level of granularity and timeliness: Access to daily recommendations provided by through the interoperability framework.</td></tr>
<tr><td>Type of meter of other device used: N/A</td></tr>
<tr><td>Open/Closed data: Public TSO data provided by through ENTSO-E portal.</td></tr>
<tr><td>Cloud-based vs. localized: Cloud</td></tr>
<tr><td>Access and exchange conditions: Generated recommendations data is provided through the Interoperabiltiy framework, whose access is provided to project partners in the consortium (including OC participants)</td></tr>
<tr><td colspan="2">Expected impact: Inclusion of recommendations in the service pipeline provided by AI4CS in the charing station service.</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: Contribution to public welfare.</td></tr>
<tr><td>Capacity to integrate with 3rd parties</td><td>Yes/No: Yes</td></tr>
<tr><td colspan="2">Consumer segment: More than a hundred of users of Charging Station Network of Hrvatski Telekom.</td></tr>
<tr><td colspan="2">Replicability across EU: Very replicable</td></tr>
<tr><td colspan="2">Time to deliver: quickly implemented as long data is available.</td></tr>
<tr><td colspan="2">Origin: public/market party/SO – N/A</td></tr>
</table>

## SAVINGSFOOTPRINT

| **Name: SavingsFootproint / R8 Energy OU** | |
|---|---|
| **Country:** Lithuania, Latvia, Estonia | |
| **Functionalities:** footprint calculation and recommendations to encourage behavioural change towards improved energy efficiency and addressing the grid needs. | |
| **Type of data, access and exchange** | Passive vs. Active: Passive recommendations sent to end users. |
| | Level of granularity and timeliness: Recommendations are sent for the next day. Data granularity is high and goes to individual smart meters. |
| | Type of meter of other device used: Smart meters. |
| | Open/Closed data: Data is closed for smart meters. Open data sets used for market status (Estonian data hub Elering for DSO level data, Baltic transparency platform for TSO level data). |
| | Cloud-based vs. localized: Cloud |
| | Access and exchange conditions: Smart metering data is sensitive and access is subject to writen consent collected from consumers. DSO is private but not paid and TSO level data are publically available and subject to policies listed on the corresponding webpages. |
| **Expected impact:** A set of 15-15-15 KPIs were proposed to be evaluated based on the end-customer survey:<br>• KPI #1: 15% monetary savings of on-site energy costs.<br>• KPI #2: 15% decrease of on-site energy net consumption.<br>• KPI #3: 15% of GHG reduction on on-site energy consumption<br>These KPI targets should be compared to business-as-usual scenario on annual basis. | |
| **Incentives/engagement mechanism – See above** | |
| **Capacity to integrate with 3rd parties** | Yes/No: Yes |
| | (e.g., banks, fuel retailers) |
| **Consumer segment**: Separation of two customer segments was made, while revenues would be mostly collectable from third party service providers and less likely directly from households: 1. Direct interaction with households who are primarily in the role of non-paying users – B2C; 2. Indirect interaction with households through third party service providers (e.g., banks, fuel retailers) – B2B2C. | |
| **Replicability across EU:** Currently the integration works with data hubs specific to Baltic countries. However, the recommendation logic and footprint calculation could be replicated with other national and regional data sources. They already work with ENTSO-E TP meaning that pan-Europe replication is possible. | |
| **Time to deliver:** UC is being piloted as part of the OC2. | |
| **Origin:** public/market party/SO – SME | |

# EMPOWERING CONSUMERS THROUGH STIMULI

<table>
<tr><th colspan="2">Name: Empowering Consumers Through Stimuli / Easy Smart Grid GmbH</th></tr>
<tr><td colspan="2">Country: Germany</td></tr>
<tr><td colspan="2">Functionalities: In OC 2 a previously developed energy community was integrated into the SAREF-CERF context. In this energy community, demand side flexibility from heat pumps and household appliances is activated and guided by a local "stimulus" representing the instantaneous value of energy (high represents energy import, low represents energy export from the community). During the project, we SAREFized parts of this functionality, particularly the import of grid state and stimuli derived therefrom and merged these stimuli with the already existing one. Thus, demand side flexibility not only maximizes local value of energy self-consumpotion, but also provides grid-supportive flexibility for the DSO and TSO. We thus worked on the objective of SAREFization (bringing this functionality to the SIF/CERF environment) and extension of demand side flexibility use to various (local and remote) stimuli).</td></tr>
<tr><td rowspan="6">Type of data, access and exchange</td><td><u>Passive vs. Active</u>: Passive</td></tr>
<tr><td><u>Level of granularity and timeliness</u>: At the one hand, the data is highly granular, providing temporal resolution of seconds and spatial resolution of grid connection points. It does so in real-time. On the other hand, it is highly compressed, representing just the value of energy, expressed as a dynamic tariff. Therefore, extremely high performance is combined with extremely low complexity and cost. This is possible by applying a novel. patented technology: It uses grid physics for aggregation, transporation and closing the information/control loop.</td></tr>
<tr><td><u>Type of meter of other device used</u>: Smart meters were used to measure grid states and export the required data</td></tr>
<tr><td><u>Open/Closed data</u>: The data used for stimulus generation reflect grid status. While is is avaraged over an area and therefore does not represent private data, it is closed and only used to create the stimulus which again is used to efficiently operate the energy community</td></tr>
<tr><td><u>Cloud-based vs. localized</u>: Data concerning stimuli is used and stored at grid edge. Some devices such as household appliances are accessed via a cloud service (home connect)</td></tr>
<tr><td><u>Access and exchange conditions</u>: The data is sensitive as it represents information on the state of the electric grid. While for the project experiment this was used without extended protection )(other than reverting to historic data(, the intention is to only use it locally in the future, not feeding it to higher grid levels, and therefore protecting it.</td></tr>
<tr><td colspan="2">Expected impact: extend the existing project with 23 households and their appliances in numbers, but integrate them into the CERF and SAREF perspective. Allow to access and use other services (user interaction, forecasts) already available there. Extend the community by providing stimuli for explicit support of DSO/TSO operation.</td></tr>
<tr><td colspan="2">Incentives/engagement mechanism: We target involving more users by reducing barriers of acceptance (simplicity, automation, no publication of their private data, increasing value to them and the general public by more renewables and lower energy cost, and to the grid operators by contribution to stability, reduced extension needs, and higher resilience.</td></tr>
<tr><td>Capacity to integrate with 3rd parties</td><td><u>Yes/No</u>: Yes, it supports financial incentives (fair and transparent allocation, only small reduction by unavoidable system or contract complexity)</td></tr>
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| | |
|---|---|
| | Any 3rd party can be integrated: If a financial stimulus representing their needs is added, flexibility will support their needs |
| **Consumer segment:** Previously developed energy community | |
| **Replicability across EU:** Use of dynamic tariffs has been prescribed by Eruopean regulation, can universally be used. Also, the technical requirements on smart meter and associated infrastructure are extremely light, so the method can be adapted to and applied without restrictions. | |
| **Time to deliver:** Quick as long as data is available. A demo is in progress. | |
| **Origin:** public/market party/SO – The use case was developed jointly by an NGO (working towards decarbonization of a community) and an SME proposing a suitable technology to achieve this. | |

## DSO-FLEX

| **Name: DSO Flex** | |
|---|---|
| **Country:** Denmark and France | |
| **Functionalities:** DSO Flex integrates with existing energy infrastructure to enhance grid resilience and promote efficient energy use. It supports peer-to-peer energy trading within localised low-voltage microgrids, thus facilitating active participation of energy consumers in the market and contributing to energy efficiency. | |
| **Type of data, access and exchange** | Passive vs. Active: (Passive) Integrates and utilizes transformer load, thermal data, building energy consumption data, and grid-interactive asset data to provide recommendations/prompts. |
| | Level of granularity and timeliness: High granularity and timeliness with data streaming at 1-minute intervals optimized from 1-second data collection intervals. |
| | Type of meter of other device used: Utilizes advanced metering infrastructure including sensors and nodes installed in substations and various grid-interactive assets. |
| | Open/Closed data: Employs an open data schema compatible with SAREF standards, ensuring interoperability and open access to data. |
| | Cloud-based vs. localized: Implements a cloud-based approach for data integration and analytics, ensuring scalability and remote management capabilities. |
| | Access and exchange conditions: Data sharing underpinned by secure API integrations, ensuring controlled access and exchange with third-party analytics providers. |
| **Expected impact:** Enhances grid stability, facilitates efficient energy management, supports the transition to decentralized energy systems, and promotes sustainability through increased use of renewable energy sources. | |
| **Incentives/engagement mechanism:** Provides economic incentives for energy conservation and production, supports predictive maintenance, and enables peer-to-peer energy transactions to optimize both supply and demand. | |
| **Capacity to integrate with 3rd parties** | Yes/No: Yes |
| | Integrates with third-party services like AI-Energy, Center Denmark, and various DSOs including Trefor and Konstant through standardized APIs and data models. |
| **Consumer segment:** Targets industrial, commercial, and residential sectors, with a focus on enhancing operations for large energy consumers and grid operators. | |
| **Replicability across EU:** The app works seamlessly with existing energy systems, thanks to standardized data sharing protocols. | |
| **Time to deliver:** The timelines for deployment are coordinated with ongoing user engagement and iterative testing, leading to refined and ready-to-implement solutions for smart grids. | |
| **Origin:** SME | |

## FLEXTRADE

| **Name: FlexTrade** | |
|---|---|
| **Country:** Slovenia | |
| **Functionalities:** Peer-to-peer energy trading and flexibility sharing based on analytics-based optimization; basic consumption key performance indicators are provided to users that can be used to improve the user's self-consumption and self-sufficiency | |
| **Type of data, access and exchange** | Passive vs. Active: Combination of active (community manager sets automation for members) and passive (community manager takes actions and consumers can chose to react). |
| | Level of granularity and timeliness: Near real time with DSO interface. DSO level data and smart meters. |
| | Type of meter of other device used: Smart meter and custom IoT hardware. |
| | Open/Closed data: Combination of open and closed. For closed data there is license and specific agreement with DSO and aggregators. |
| | Cloud-based vs. localized: Cloud |
| | Access and exchange conditions: Using public from ENTSO E and private from DSO and communities. |
| **Expected impact:** Use by community managers across Slovenia and beyond. | |
| **Incentives/engagement mechanism:** Improving grid stability. Improving community impact and savings. | |
| **Capacity to integrate with 3rd parties** | Yes/No: Yes |
| | With DSOs, retailers and energy community managers. |
| **Consumer segment:** a community formed within one balance responsible party (BRP) and a distribution system operator acting as a beneficiary of flexibility services | |
| **Replicability across EU:** At the moment it is specific for national DSOs. Following InterConnect SIF compliance and usage of InterConnect DSOi replicability within other pilots could be established. | |
| **Time to deliver:** Serving 30 users. | |
| **Origin**: SME | |

## SINERGY+

| | |
|---|---|
| **Name:** Sinergy+ | |
| **Country:** Spain | |
| **Functionalities:** application that allows the end-users to automate existing systems (i.e., lighting, HVAC, etc.) to comply with grid signals and optimize the energy consumption to reduce energy costs and the carbon footprint. | |
| **Type of data, access and exchange** | Passive vs. Active: Active: data gets retrieved from existing sensors and other IoT devices and control actions are triggered into actuators. |
| | Level of granularity and timeliness: variable data granularity according to the device or system considered |
| | Type of meter of other device used: metering via sensing devices and systems to be installed within home automation |
| | Open/Closed data: data is made available to the consumers for their assessment and engagement; APIs are available for access to the system information/status. |
| | Cloud-based vs. localized: Combination of cloud based systems with IoT edge devices |
| | Access and exchange conditions: Data is restricted to customer access, compliant to GDPR. Integration of data from energy service providers to produce optimal operation |
| **Expected impact:** sets of end-users in Spain. Ability to support other markets where the company has operation. | |
| **Incentives/engagement mechanism:** energy reduction opportunities; CO2 footprint reduction; optimization of energy costs. | |
| **Capacity to integrate with 3rd parties** | Yes/No: Yes |
| | The platform is able to include other automation systems.<br>It can connect to the retailing platforms for price information retrieval |
| **Consumer segment:** clusters of residential consumers that can operate in flexibility markets and implement demand response strategies. It can also provide local grid services. | |
| **Replicability across EU:** potential to explore the replication across the EU | |
| **Time to deliver:** Serving currently more than 45 customers. | |
| **Origin: SME** / market party | |