Flexible energy systems Leveraging the Optimal integration of EVs deployment Wave

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Deliverable 3.3

Technological components to enable data driven markets for electromobility

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List of Acronyms

Acronym	Meaning
AI	Artificial Intelligence
API	Application Programming Interface
BAL	Blockchain Access Layer
BSP	Balance Service Provider
CBP	Crowd Balancing Platform
CCA	Conditional Connection Agreement
CEF	Common European Facilities
CIM	Common Information Model
CPO	Charger Point Operator
DEP	Data Exchange Platform
DER	Distributed Energy Resource
DSO	Distribution System Operator
EV	Electric Vehicle
FR	Flexibility Register
FSP	Flexibility Service Provider
IDS	International Data Space
IDSA	International Data Space Association
IT	Information Technology
LMO	Local Market Operator
P2P	Peer-to-peer
PGUI	Power Grid User Interface
PV	PhotoVoltaic
RAM	Reference Architectural Model
TSO	Transmission System Operator
V1G	Vehicle-1-Grid
V2G	Vehicle-to-Grid
VGI	Vehicle Grid Integration

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Executive Summary

The deliverable addresses the data-driven ecosystem around the electromobility sector, highlighting how the data sharing and availability plays a key role for the digitalisation of the energy systems and the implementation of innovative services based on V1G and V2G integration.

The document explores the importance of Data Space concept and analyse the most relevant initiatives and projects taking into account the important results which can be exploited for be implemented in EV ecosystem, facilitating the interoperable cooperation and integration of EV stakeholders and their existing environment in a trusted a secure way.

The Data Space concept and its application in the EV ecosystem is then contextualized in the FLOW scope, of which the possible use cases, the actors involved, and the data exchanged were analysed, identified and reported.

Starting from collected results, a specific list of components and technologies was identified and described for implementing a FLOW Data Space based architecture, in order to facilitate the enabling of the data-driven market in the electromobility sector.

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1. Introduction

Data-driven technologies and architectures can empower the energy sector for driving the digital transformation and unlocking the full potential of the energy transition in a rapidly evolving landscape.

In particular, the Data Space plays a crucial role in addressing and resolving data related issues in EV related technologies (V1G and V2G).

1.1. Purpose and Scope of the document

This document aims to identify the most proper technologies for implementing a data-driven ecosystem for electromobility sector, focusing on the results of Data Space initiatives and projects and contextualizing them in the FLOW scope.

The results is a detailed document on relevant data-driven use cases, which describes involved actors, discusses interoperability aspects, and introduces the core technologies for implementing a FLOW Data Space architecture.

1.2. Task 3.3

Task T3.3 aims to ensure that EV ecosystem entities are prepared to join the future of energy data sharing and develop some technological components implementing the data-driven market mechanisms which are compliant with the concept of Data Space architecture. These components and technologies should leverage both on the work done in the relevant H2020 projects, as well as on the most relevant Data Space initiatives like IDSA and GAIA-X, with a view to design a personalized e-mobility centered architecture based on a cross-stakeholder perspective.

1.3. Outline of the deliverable

Chapter 2 of the document analyse the Data Space concept, most relevant initiatives, and project outcomes.

Chapter 3 analyses the FLOW Demo Use Cases and Platforms from a data-driven perspective, identifying the energy stakeholders involved in the different data-exchange, the data models, standards, and interoperability mechanisms.

Chapter 4 take into accounts all the insights and results of the analysis conducted in the previous chapters and provides a list of core technologies and components for implementing a data-driven technological for electromobility sector. It also proposes a high-level FLOW Data Space Architecture.

Finally, Chapter 5 concludes this document.

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2. Data Space and Data Driven ecosystem

2.1. Introduction to Data Space

Data spaces are flexible and open IT infrastructures that enable trustful and transparent use of decentral organised data according to previously defined scopes of use while guaranteeing the full sovereignty of the actors involved. They are based on a federal organisational principle.

Data spaces create equal framework conditions for the sovereign exchange of data. This also means that every actor can benefit from the use of the data in the same way.

The main objectives of the Data Space implementation are:

- **Value creation**, New data-based applications, business models and collaboration.
- **Self-determination**, Control over the subject matter, scope, duration and actors in the context of data sharing.
- **Efficiency,** Data exchange takes place exclusively for a specific purpose.

In order to implement the main objectives, the data space implementation leverages on 5 main building characteristics:

- **Decentralisation**, Centralised structures are avoided in favour of decentralised solutions.
- **Federation and interoperability**, Interaction of actors within a data space as well as across data space is promoted.
- **Sovereignty**, Control over one's own data and its use is always guaranteed.
- **Trust**, Technologies, control mechanisms and unique digital identities contribute to building trust. High data quality also promotes trust.
- **Transparency**, Digital identities and the traceability of data-based operations promote transparency.

2.2. Main initiatives and Reference Architectures

In the last years, the Data Space concept arose in the research landscape, with very relevant associations and industry clusters pushing for it also from the ICT sector.

The main relevant, considered during this analysis were IDSA [1] and GAIA-X [2]. These initiatives are providing new reference architectures, framework, roles.

In addition, the BRIDGE Data Exchange Reference Architecture, which in its new version (DERA 3.0), leverages a lot in the Data Space concept and architectures, was also taken into account.

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2.2.1. IDSA

The International Data Spaces Association (IDSA) is a non-profit organization established by a collaboration of business, political, and research entities. It aims to develop and implement a Reference Architecture Model (RAM) for secure data spaces and sovereign data sharing on a European and global scale. With over 130 diverse members, the IDSA aims to create a universal standard for data exchange across industries.

At its core, IDS functions as a Virtual Data Space leveraging established technological standards and governance models. It aspires to facilitate secure data exchange within a trusted Business Ecosystem. By doing so, IDS becomes the backbone for developing Smart Service Business Processes while empowering participants to unlock the full value of their data. IDSA drives this vision by articulating and implementing a new reference architecture that guarantees security, sovereignty, and trust. This Reference Architecture Model interconnects data clouds, enterprises, business applications, and Internet of Things (IoT) devices, establishing a cohesive IDS ecosystem. The linchpin in this ecosystem is the IDS Connector, a dedicated software component (described in Ch. 2.2.1.4), functioning as an intermediary between participating entities.

2.2.1.1. Key Features, requirements, and principles

The IDS prides itself on several **distinctive features**:

- **Sovereignty of Data Assets**: Owners retain control by setting individualized usage policies governing data access and utilization.
- **Security of Data Exchange**: A robust protection layer ensures data security, particularly during its exchange.
- **Decentralized Organization and Federated Architecture**: IDS amalgamates all endpoints utilizing an IDS connector, eliminating the necessity for centralized data management or governance. This approach presents an alternative architectural design compared to both centralized data management concepts and decentralized data networks lacking shared rules.
- **Governance and Shared Rules**: In the absence of a central supervisory authority, data governance principles evolve as shared rules, delineating rights and obligations for effective data management, derived from user requirements.
- **Network of Platforms and Services**: IDS acts as a bridge connecting data providers and users. Entities ranging from companies to individual IoT entities like vehicles, machines, and equipment can function as data providers.
- **Scaling and Network Effects**: IDS facilitates data services for secure exchange and seamless data linking. Its decentralized nature enables scalability without reliance on a central authority, fostering network effects through increased data availability across diverse ecosystems.
- **Openness**: Driven by user input and participative development, the International Data Spaces initiative operates under the umbrella of the International Data Spaces Association.
- **Trust Protection**: Participants in IDS must rely on the identity verification of data providers and users, ensured through mandatory software certification. IDS also offers specialized connectors featuring extended encryption for secure data exchange.

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For the IDS to succeed, specific **strategic requirements** need fulfilment:

- **Trust**: Trust forms the bedrock of the ecosystem, mandating evaluation, and certification of all participating entities by trusted authorities.
- **Security and Data Sovereignty**: Rigorous evaluation and certification of technical components ensure security. Data owners dictate usage restrictions for data transfers.
- **Ecosystem of Data**: IDS's decentralization approach negates the need for centralized data storage, ensuring that data remains with respective owners until transferred to trusted third parties.
- **Comprehensive Data Source Description**: Thorough descriptions of data sources are mandated to maintain clarity and transparency.
- **Integration of Domain-Specific Data Vocabularies**: Usage of domain-specific vocabularies aids in data annotation and description.
- **Real-time Data Search Services**: Facilitation of quick and efficient data discovery and retrieval.
- **Standardized Interoperability**: IDS connectors act as technological components ensuring seamless communication and interaction.
- **Value-Adding Apps**: Integration of IDS connectors with business applications offers a myriad of services atop data exchange processes, including data processing, format alignment, exchange protocols, and analytics.
- **Data Markets**: IDS enables the provision of clearing mechanisms, billing functions, domain-specific broker solutions, and marketplaces, along with information regarding usage restrictions and legal aspects.

The IDSA steers its goals guided by **specific principles**:

- **Open Development Process**: The IDSA operates as a non-profit organization open to all participants adhering to common work principles.
- **Re-Use of Existing Technologies**: Emphasis is laid on leveraging and reusing established technologies and standards wherever feasible.
- **Contribution to Standardization**: IDSA aims to establish an international standard by supporting standardized architecture stacks.

2.2.1.2. IDS Refence Architectural Model (RAM)

At the core of IDSA's mission lies the Reference Architecture Model (RAM) - a meticulously designed framework that outlines the structure, interactions, and functionalities within the International Data Spaces ecosystem. The RAM [3] serves as a guiding blueprint, offering a systematic approach to designing and implementing secure data spaces, ensuring compatibility, interoperability, and trust among diverse stakeholders.

In compliance with common system architecture models and standards (e.g., ISO 42010, 4+1 view model), the Reference Architecture Model uses a five-layer structure expressing various stakeholders' concerns and viewpoints at different levels of granularity as illustrated in Figure 1.

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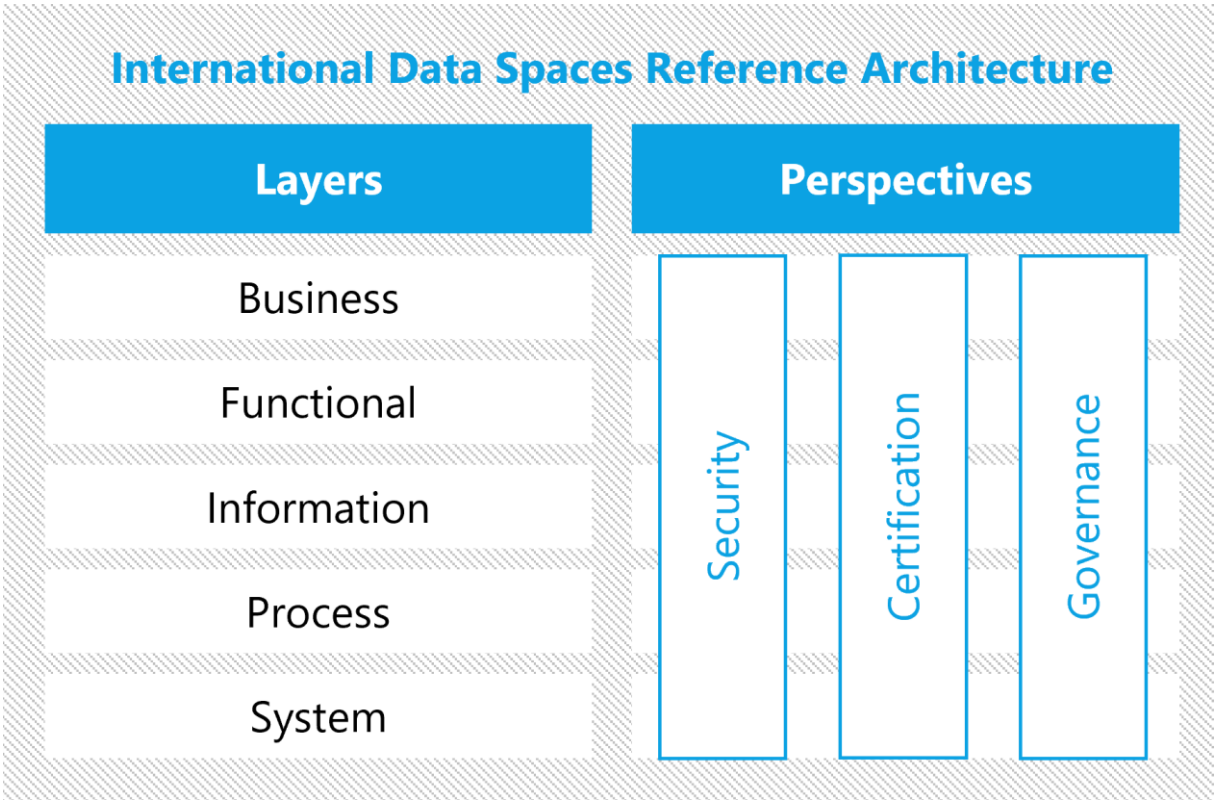

Figure 1. IDS Reference Architecture Model conceptual schema.

The general structure of the Reference Architecture Model is illustrated in the figure below. The model is made up of five layers:

The Business Layer specifies and categorizes the different roles which the participants of the International Data Spaces can assume, and it specifies the main activities and interactions connected with each of these roles.

The Functional Layer defines the functional requirements of the International Data Spaces, plus the concrete features to be derived from these.

The Information Layer defines a conceptual model which makes use of linked-data principles for describing both the static and the dynamic aspects of the International Data Space's constituents.

The Process Layer specifies the interactions taking place between the different components of the International Data Spaces; using the BPMN notation, it provides a dynamic view of the Reference Architecture Model.

The System Layer is concerned with the decomposition of the logical software components, considering aspects such as integration, configuration, deployment, and extensibility of these components.

In addition, the Reference Architecture Model comprises three perspectives that need to be implemented across all five layers:

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- Security
- Certification
- Governance

2.2.1.3. IDS Components

The technical components part of the IDS Reference Architecture are shown in Figure 2.

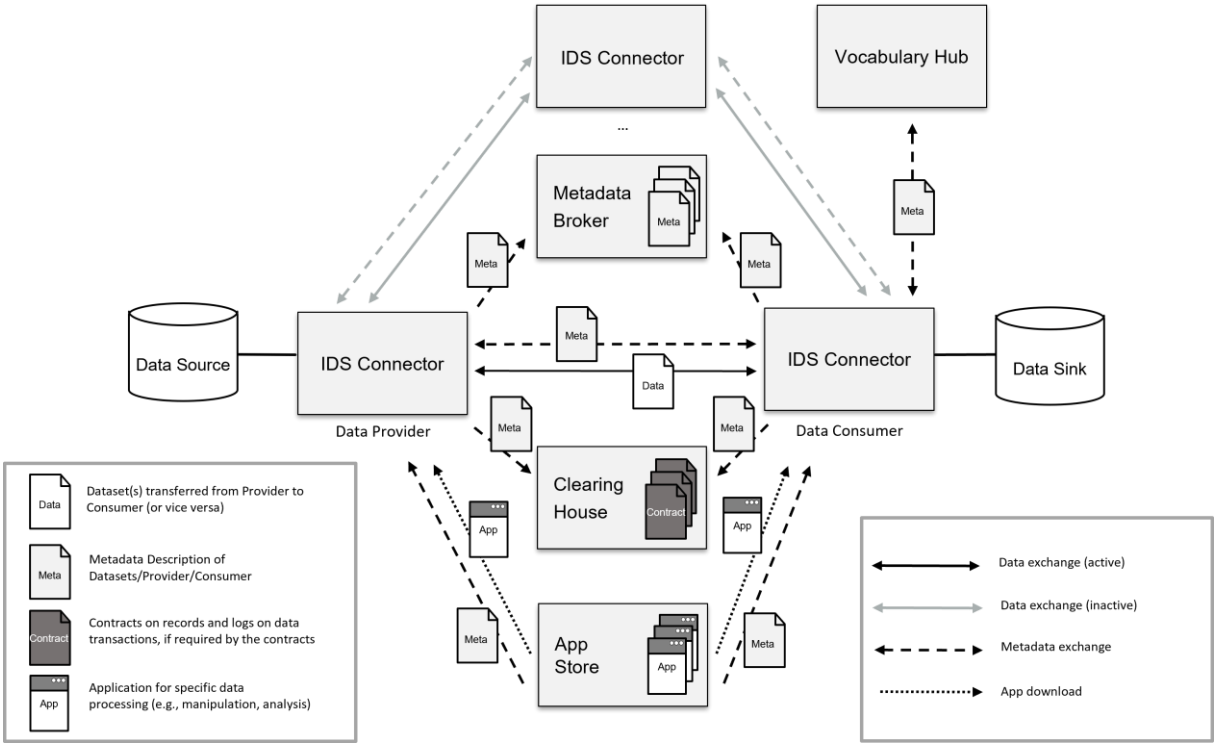

Figure 2. IDS Reference Architecture core components.

The IDS Reference Architecture consists of the following core components:

- the Identity Provider
- the IDS Connector
- the App Store and Data Apps
- the Metadata Broker
- the Clearing House
- the Vocabulary Hub

A distributed network like the International Data Spaces relies on the connection of different participants where IDS Connectors or other core components are hosted (an IDS Connector comprising one or more Data Endpoints). The IDS Connector is responsible for initiating a data exchange from and to the internal data resources and enterprise systems of the participating organizations and the International Data Spaces. It provides metadata to the Metadata Broker as specified in the IDS

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Connector self-description, e.g., technical interface description, authentication mechanism, and associated data usage policies. Usage Contracts can be transferred via the IDS Connector to the Clearing House to ensure trust. Also, the data transfer can be logged at the Clearing House for trust reasons, or for clearing reasons. Vocabularies can be interpreted by getting more details from the Vocabulary Hub. Additional IDS Apps can be downloaded to the IDS Connector to run operations on the data.

2.2.1.4. IDS Connector

International Data Spaces as a distributed network relies on the connection of different member nodes where Connectors or other core components are hosted. The Connector is responsible for the exchange of data or acts as a proxy in the exchange of data, executing the complete data exchange process from and to the internal data resources and enterprise systems of the participating organizations. The Connector provides metadata to the Broker, which include description of the technical interface, authentication mechanism, exposed data sources, and associated data usage policies. Data is transferred between the Connectors of the Data Provider and the Data Consumer (peer-to-peer network concept).

There are different types of Connector implementations, based on different technologies and depending on what specific functionality is required regarding the purpose of the Connector. Two fundamental variants are the Base Connector and the Trusted Connector as they differ in the capabilities regarding security and data sovereignty. Connectors can be further distinguished into External Connectors and Internal Connectors:

An **External Connector** executes the exchange of data between participants of the International Data Spaces. The International Data Spaces network is constituted by the total of its External Connectors. Each External Connector provides data via the Data Endpoints it exposes. Applying this principle, there is no need for a central instance for data storage. An External Connector is typically operated behind a firewall in a specially secured network segment of a participant (so-called “Demilitarized Zone”, DMZ). From a DMZ, direct access to internal systems is not possible. It should be possible to reach an External Connector using the standard Internet Protocol (IP), and to operate it in any appropriate environment. A participant may operate multiple External Connectors (e.g., to meet load balancing or data partitioning requirements). External Connectors can be operated on-premises or in a cloud environment.

An **Internal Connector** is typically operated in an internal company network (i.e., a network which is not accessible from outside). Implementations of Internal Connectors and External Connectors may be identical, as only the purpose and configuration differ. The main task of an Internal Connector is to facilitate access to internal data sources in order to provide data to External Connectors.

Connector Architecture

The Connector Reference Architecture shown in Figure 3 uses application container management technology to ensure an isolated and secure environment for individual data services which offer an API to store, access or process data. Any data pre-processing (e.g., filtering, anonymization, or analysis) should be performed by Internal Connectors. Only data intended for being made available to other participants should be made visible through External Connectors.

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Data Apps are bundled as container images for simple installation by application container management. Using an integrated index service, the Broker manages the data sources available in the International Data Spaces and supports publication and maintenance of associated metadata. Furthermore, the Broker Index Service supports the search for data resources. Both the App Store and the Broker are based on the Connector architecture in order to support secure and trusted data exchange with these services.

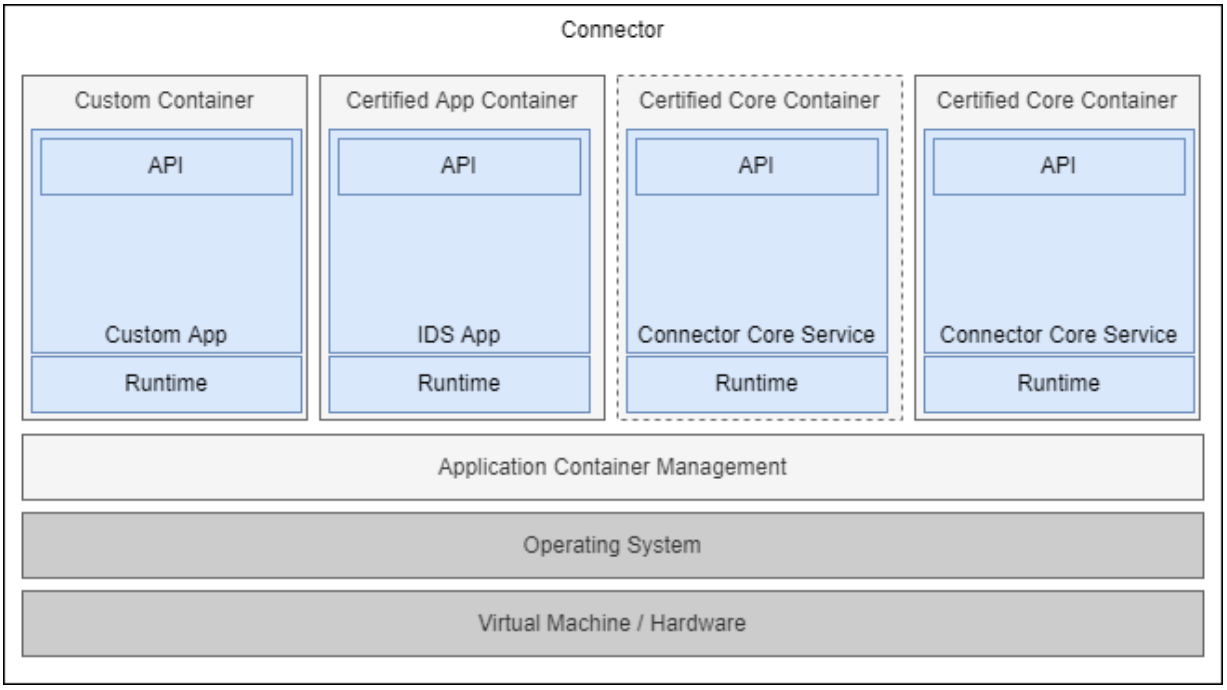

Figure 3. IDS Connector Architecture.

2.2.2. GAIA-X

The GAIA-X initiative, launched in 2019, is driven by the firm belief in propelling the development of a sustainable and innovative data economy within Europe. As a project initiated by and for Europe, GAIA-X aims to establish unified requirements for a European data infrastructure, emphasizing openness, transparency, and connectivity among European nations and beyond. Engaging representatives from multiple European countries and international partners, the project encourages further collaboration, inviting participation for collective development.

At its core, GAIA-X seeks to propose the next generation of a European data infrastructure—a secure, federated system ensuring the highest standards of digital sovereignty while fostering innovation. The initiative embodies an ambition to cultivate an open, transparent digital ecosystem where data and services are shared within a foundation of trust.

2.2.2.1. Architectural Overview

The GAIA-X architecture [4] represents a response to challenges facing the European digital economy, addressing issues such as decentralized processing locations, lack of sovereignty over stored data, and

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sector-specific data spaces. Its core architectural principles underscore openness, transparency, interoperability, federation, authenticity, and trust.

Aligned with its vision and objectives, GAIA-X operates based on key technical guidelines:

- security-by-design,
- privacy-by-design,
- federation enablement,
- user-friendliness,
- machine-processability
- semantic representation.

These principles ensure compliance with the GAIA-X vision while establishing a robust, adaptable framework.

The Gaia-X Architecture, shown in Figure 4, enables Data and Infrastructure Ecosystems using the elements explained in the Gaia- X Conceptual Model, the Gaia-X Operational Model and the Federation Services together with the Gaia-X Trust Framework.

An Ecosystem is an organizing principle describing the interaction of different actors and their environment as an integrated whole, like in a biological ecosystem. In a technical context, it refers to a set of loosely coupled actors who jointly create an economic community and its associated benefits.

Gaia-X proposes to structure a Data Ecosystem and an Infrastructure Ecosystem, each with a different focus on exchanged goods and services. Despite each of them having a separate focus, they cannot be viewed separately as they build upon each other, i.e., they are complementary.

The Gaia-X Ecosystem consists of the entirety of all individual Ecosystems that use the Architecture and conform to Gaia-X requirements. Several individual Ecosystems may exist (e.g., Catena-X in the automotive sector) that orchestrate themselves, use the Architecture and may or may not use the Federation Services open source software.

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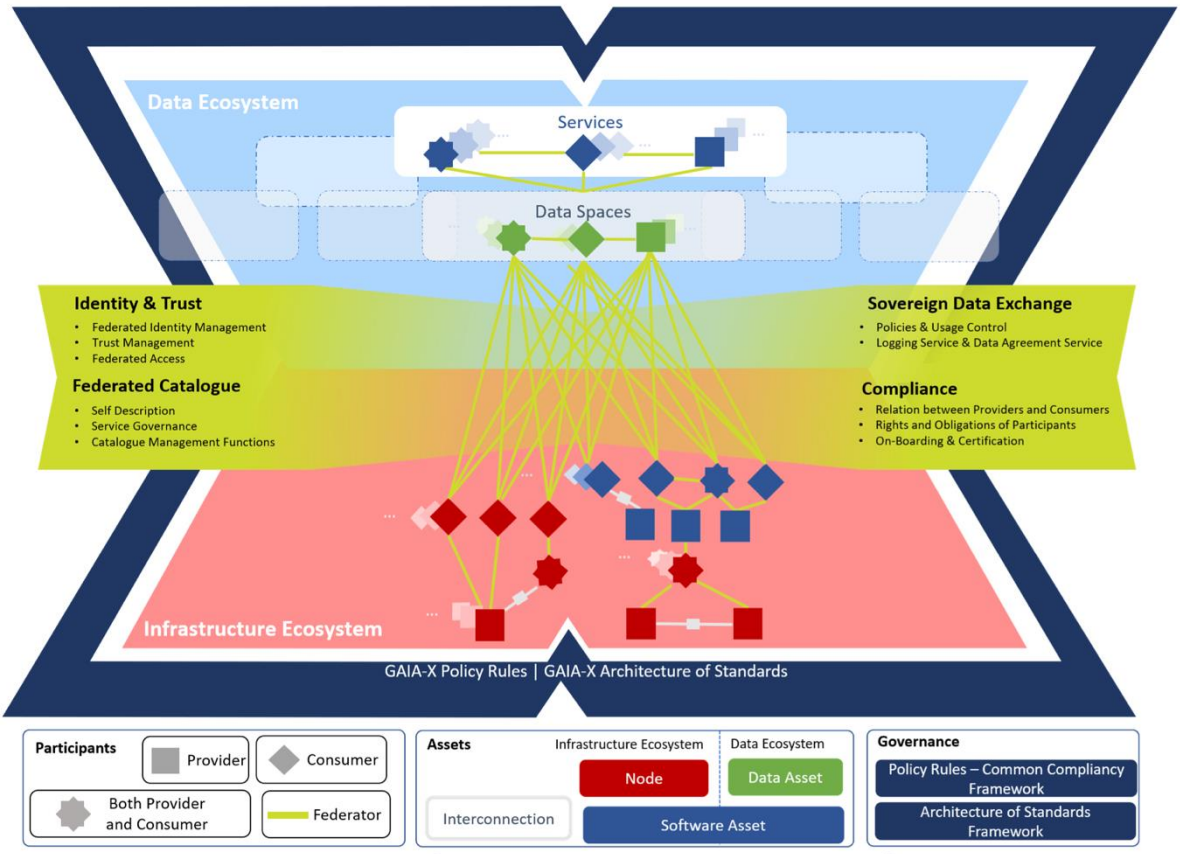

Figure 4. GAIA-X Ecosystem Architecture.

2.2.3. BRIDGE

BRIDGE [5] was introduced by the European Commission in 2016 as an EU initiative aiming to enhance cooperation and consolidate findings across research & innovation projects centered on smart grids, energy storage, islands, and digitalization of the energy system funded under the Horizon 2020 program. This initiative operates through four primary Working Groups—Data Management, Business Model, Regulation, and Customer Engagement—which compile reports and propose recommendations to the European Commission regarding various themes pertinent to the future of the energy sector.

In April 2021, the Data Management WG, focusing on both technical and non-technical aspects concerning stakeholder data exchange handling, released a report outlining an EU data exchange reference architecture [6]. Multiple BRIDGE projects contributed to this report. The reference architecture, aligned with the Smart Grid Architecture Model (SGAM), defines foundational elements essential for inter-domain exchanges. Its purpose is to facilitate cross-domain and cross-border interoperability, empowering existing and future projects in this pursuit.

The escalating growth of distributed renewable energy generation and energy storage systems, coupled with an anticipated surge in active customer engagement in demand response and electric

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mobility, presents several challenges to prevailing planning and operational methodologies of system operators. An imperative aspect in transitioning towards an energy shift is integrating demand flexibility services from these new assets and players into the energy market. This incorporation is crucial for addressing technical issues and ensuring resilience, efficiency, and reliability in modern electricity grids. This evolution anticipates bringing flexibility products—inclusive of those from residential consumers—to the forefront of system operation, thereby facilitating market adoption.

Both traditional retail procedures and emerging flexibility services demand accessible data and information exchange among a diverse array of stakeholders, networks, systems, devices, applications, and components. The cooperation and data exchange among existing and new systems are vital to enable present, evolving, and future energy services. Establishing a common European reference architecture serves as a pivotal driver toward committing to demand flexibility, allowing utility coordination across national borders and diminishing market entry barriers.

Designating interoperable data exchange solutions forms a cornerstone in defining a reference architecture. Diverse solutions—bilateral point-to-point arrangements, data hubs/warehouses, and data exchange platforms—exist alongside each other. The interoperability of these solutions necessitates comparability, appropriate standardization, and governance. Apart from decentralized solutions, platform-oriented solutions (hubs, DEPs) have recently emerged across Europe to streamline processes, enhance data quality, and ensure minimal delay, primarily in retail markets. Recent initiatives, guided by the Clean Energy Package and other relevant directives, emphasize the active inclusion of end-users in both retail and wholesale energy markets, intensifying the demand for data exchange among all stakeholders. An integrated data exchange architecture is pivotal in the global energy system, signalling a convergence of wholesale and retail markets.

2.2.3.1. Bridge DERA (Data Exchange Reference Architecture)

In July 2023, the third version of Data Exchange Reference Architecture – DERA 3.0 was released by BRIDGE Data Management Working Group [7].

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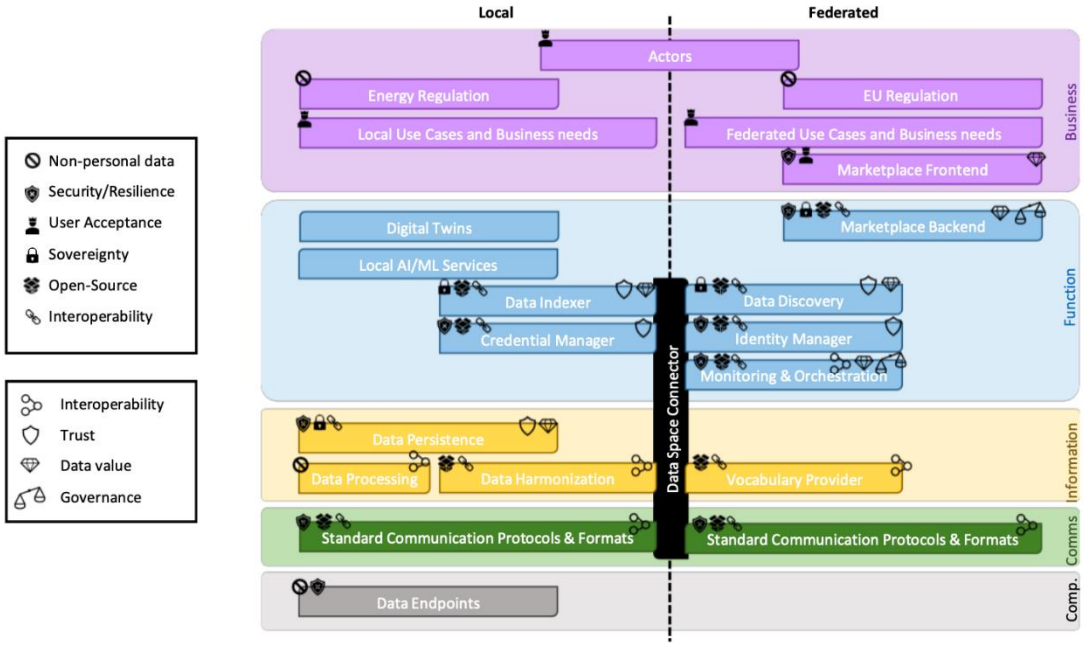

Figure 5. BRIDGE DERA 3.0.

This third version of the architecture (Figure 5) is based on the following objectives:

- Compared to the previous version of BRIDGE DERA (v. 2.0) fewer and **more high-level modules** are presented;
- **The Data Space concept** arose in the research landscape, with very relevant associations and industry clusters pushing for it also from the ICT sector (such IDSA and GAIA-X). These initiatives are providing new reference architectures, framework, roles. DERA 3.0 tries to match also these new inputs, while keeping the essence of energy-related requirements as described in DERA 1.0 and 2.0.
- DERA 3.0 provides the link towards DESAP (**Digitalising the energy system - EU action plan** [8], launched in October 2022). Including related requirements such as:
    - Non-personal data. Availability of non-personal/anonymised energy data (including protection, confidentiality and sovereignty requirements).
    - Security/Resilience. Cybersecurity and data protection.
    - User Acceptance. Reach consumer acceptance and empowerment. o Sovereignty.
    - EU data sovereignty principles:
        - Data to flow within EU across sectors;
        - Access/es fair, practical and clear;
        - Trustworthy data governance;
        - Open approach to international data flows, based on EU values;
        - Data shared focused and containing essential elements for services;
        - Non-essential data stored and processed locally.
    - Open Source. Open-source solutions, open standards and data models, APIs.
    - Interoperability. Interoperable cross-sectoral solutions.

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It is important to highlight the DERA 3.0 (in line with what was included also in DERA 1.0) differentiates between Local platforms and Federated Data Space stacks. They are both connected through a piece of software named Data Space Connector, allowing the interconnection and data exchange.

A **Data Space Connector** allows different IT systems/platforms and data using applications to connect and share data with each other. This can be useful for integrating data from different sources, or for allowing multiple applications to access the same data without having to duplicate it in multiple places. Data space connectors typically use standardised protocols to facilitate the transfer of data between different systems. This can help to ensure that the data remains consistent and accurate across all of the connected systems. Beyond trustworthy and interoperable data exchanges, it can provide a seamless service utilization.

The **Local side** of the architecture refers to (most likely already existing) data platforms, either from individual actors (e.g., the data platform from a Retailer) or groups of actors (e.g., the data platform of an Energy Community) or energy market/system as whole (e.g., the Data Hub of metering data, the Flexibility Register, the SCADA, the ECCo SP platform from ENTSO-E and Transparency Platform from ENTSO-E). Those platforms are already capturing and persisting own data, which is usually inputted to local services for tailored applications. The data space connector should be incorporated to these (pre-existing) platforms to enable identification, data harmonisation and brokerage towards Data Spaces.

The **Federated Data Space** part of the architecture refers to where data is indexed, making it discoverable and providing a sort of marketplace for trading both data and data services. In order to do so, the Data Space will rely on multiple actors and data platforms (the previously described ones) federating through the Data Space Connectors and offering their data under pre-recorded policies.

The Figure 6 below shows how the concept of federated and local platorms are matched into the BRIDGE DERA.

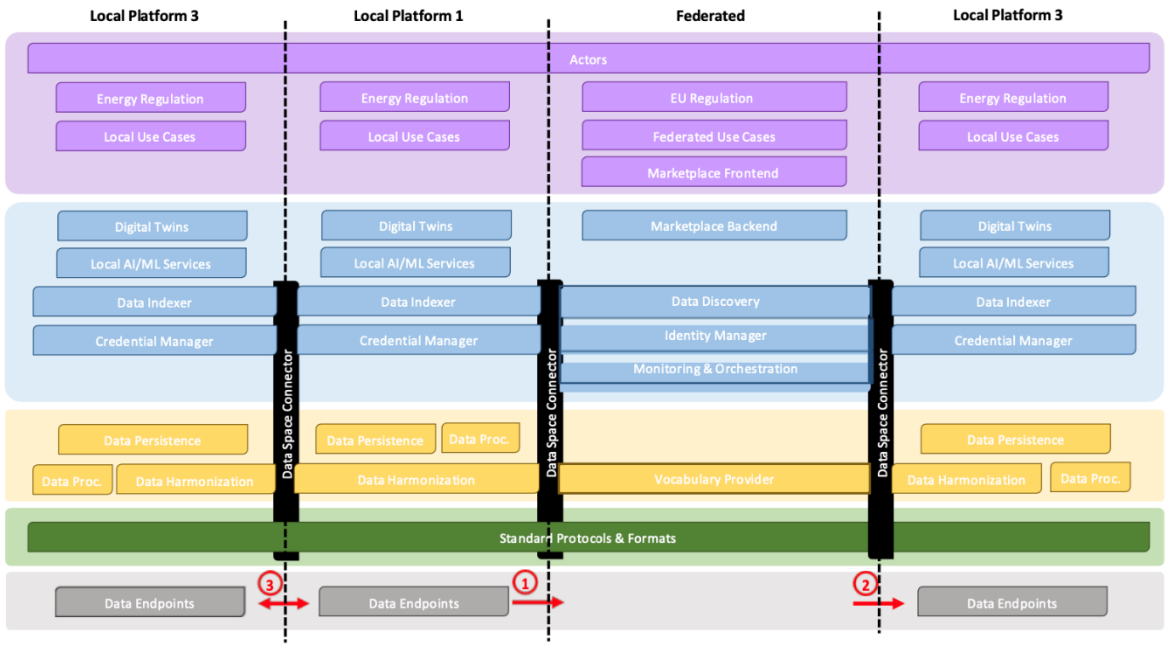

Figure 6. BRIDGE DERA 3.0 implementation in local and federated platforms.

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2.3. Relevant projects outcomes

Among the several projects that in recent years have introduced and elaborated the concept of Data Space and data driven architecture in the energy context, the projects that have the most relevance in the design of the FLOW specifications have been selected.

These projects are not only relevant to the FLOW project but provide a technological basis that can be investigated and exploited for the implementation of these concepts within the project and their verticalization in the electromobility context.

2.3.1. OneNet

The project OneNet (One Network for Europe) provides a seamless integration of all the actors in the electricity network across Europe in order to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure [9].

The key elements of the project are:

- Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers.
- Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe.
- Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

In the context of data-driven architecture, the OneNet Reference Architecture represents a very innovative solution that leverage on IDS reference model and FIWARE interfaces, bring to a hybrid solution using both the standard models for implementing the OneNet Decentralized middleware and the OneNet Connector. The usage of IDS Connector and FIWARE Context Broker ensures a high level of standardization, interoperability, scalability and reuse of OneNet solution.

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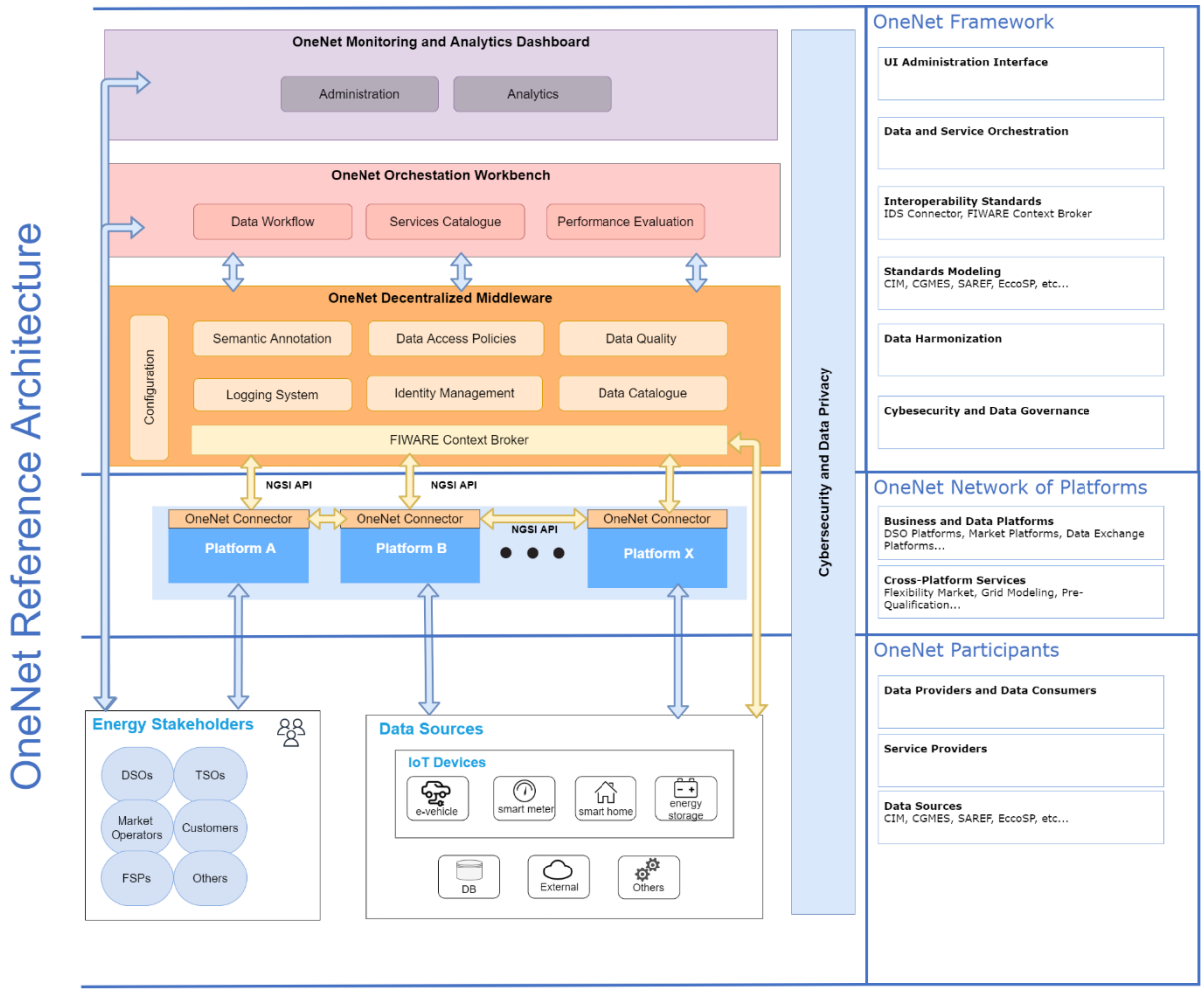

Figure 7. OneNet Reference Architecture.

The OneNet Reference Architecture, shown in Figure 7, consists of three logical layers:

OneNet Participants

Any kind of actor involved in the OneNet ecosystem. Can be divided into data source, data provider, data consumer and service provider.

OneNet Network of Platforms

Any Platform (e.g., DSO platforms, Market platforms, DEPs) able to connect with the OneNet Middleware using the OneNet Connector.

It aims to be a P2P fully decentralised ecosystem for interoperability. In the OneNet Network of Platforms, two systems (OneNet Participants) can interact directly with each other, without intermediation by a third party.

OneNet Framework

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The core of the OneNet Architecture. It consists of three main components:

- OneNet Decentralized Middleware
- OneNet Orchestration Workbench
- OneNet Monitoring and Analytics Dashboard

2.3.1.1. OneNet Participants: Data Sources and Business Actors

The bottom layer of the OneNet Reference Architecture, the OneNet Participants layer includes the Business Actors and Data Sources.

The Business Actors are named according to their business role, and this can be DSO, TSO, Market Operator, FSP, Customer or others possible Energy Stakeholders. Due to the focus of the architecture in the Data exchange, these actors are classified following a data-driven set of roles such as Data Owner, User, Consumer, Provider, and others.

The following data-driven Business Actors and Roles were identified in OneNet:

- Data Provider is a specific OneNet participant that provide data to the system. To submit metadata to a Broker, or exchange data with a Data Consumer, the Data Provider uses software components (OneNet connector) that are compliant with OneNet Framework. To facilitate a data request from a Data Consumer, the Data Provider should provide proper metadata.
- Data Consumer receives data from a Data Provider. From a business process perspective, the Data Consumer is the mirror entity of the Data Provider; the activities performed by the Data Consumer are therefore similar to the activities performed by the Data Provider. Before the connection to a Data Provider can be established, the Data Consumer can search for existing datasets in a data catalogue.
- Service Provider is a specific OneNet participant that provides services or tools. The Service Provider registers its services in the OneNet Framework in order to be used, integrated and tested within any cross-platform integration or orchestration process.

The Data Sources refer to all the assets that produce or process data. These can be sensors, actuators, gateways, edge computing nodes and they can come from various energy sectors like electric mobility, energy storage and residential energy monitoring.

This layer is connected with the OneNet Network of Platforms layer since it represents the source of data for all the business and data platforms, as well as any integrable services or applications. It could be also directly connected to the OneNet Framework, since based on needs and requirements, there may be a need to integrate a data source directly into the OneNet Framework, using the OneNet Middleware and its interoperability mechanisms based on the FIWARE architecture and on the FIWARE Orion Context Broker.

Furthermore, the business actors will have the possibility to access the Orchestration Workbench for the evaluation and testing of apps, tools and services and the OneNet Monitoring Dashboard for exploiting monitoring and analytics features offered by the OneNet Framework.

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2.3.1.2. OneNet Network of Platforms: Business and Data Platforms, Application, Services

The OneNet Network of Platforms layer focuses on the integration of external platforms, such as DSO platforms, Market platforms and other data exchange platforms into the OneNet Framework. This integration is to be made regardless of the technology of these platforms in order to remain platform-agnostic. From a technical point of view, the term platform means any software environment (e.g., applications, services or tools) able to connect with the OneNet Middleware using the OneNet Connector.

The main goal of this layer is to create a P2P fully decentralised system for interoperability. In such an infrastructure, two systems (OneNet Participants) can interact directly with each other, without intermediation by a third party. The results of this fully decentralised approach will create the OneNet Network of Platforms.

The more important component included in this layer is the OneNet Connector, described in Ch.2.3.1.3.

2.3.1.3. OneNet Framework

The OneNet Framework is the core of the OneNet Architecture. It consists of three main components: the OneNet Decentralized Middleware (including OneNet Connector), the OneNet Orchestration Workbench and the OneNet Monitoring and Analytics Dashboard.

OneNet Decentralized Middleware and OneNet Connector

The OneNet Decentralized Middleware is main component of the OneNet Framework which enable the creation of the data space ecosystem. It implements some crucial centralized features for setup the data space and provides central information to the OneNet Participants. In particular in the OneNet Decentralized Middleware are implemented:

- Identity Management
- Data Catalogue and Data source discovery
- Vocabulary Provider

The OneNet Connector is a specific instance of the OneNet Decentralized Middleware, to be deployed inside each platform environment. It allows an easy integration and cooperation among the platforms, maintaining the data ownership and preserving access to the data sources. The OneNet Connector is essential for connecting and integrating a platform within the OneNet ecosystem.

The OneNet connector has been developed following a decentralised approach, ensuring the necessary scalability for the near real-time data integration and management enabling multi-country and multi-stakeholder near real-time decision-making services.

The OneNet connector is based on IDS connector concept and follows all the IDS specifications and requirements. The Broker included in the OneNet Connector is implemented using the FIWARE Orion-LD Context Broker.

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The FIWARE context Broker offers the FIWARE NGSI APIs and associate information model (entity, attribute, metadata) as the main interface for sharing data by the OneNet Participants. Data Providers can use the FIWARE APIs to publish or to expose the data they offer, and Data Consumers can retrieve or subscribe (to be later notified) to the data offered.

OneNet Orchestration Workbench

The OneNet Orchestration Workbench [10] is the component able to orchestrate and evaluate the performance and scalability of the cross-platform services that will be integrated and implemented in the OneNet System.

Any OneNet Participant and in particular the Service Providers will be able to test and evaluate its own service exploiting the OneNet Orchestration Workbench, that allows to integrate data coming from the OneNet Middleware and to implement a data pipeline orchestration.

From a functional perspective supports the integration and the evaluation of the performance and scalability of the AI, IoT and Big Data cross-platform services for market and grid operations.

The OneNet Orchestration Workbench allows to integrate data coming from the OneNet middleware and the interaction with the service providers which are able to register and evaluate their own services, implementing services orchestration, data pipeline and evaluation schema.

The OneNet Orchestration Workbench also include:

- Job Scheduling;
- App/Service registry and discovery;
- Error/Retries management; and
- SLAs tracking, alerting and notification.

OneNet Monitoring and Analytics Dashboard

The OneNet Monitoring and Analytics Dashboard [10] is the component that offers a GUI for facilitating the OneNet Participants in the management, monitoring and analytics of the data exchanges.

The OneNet Monitoring and Analytics Dashboard is the main User Interface that allows the access to the OneNet Participants for monitoring and data analytics features, as well as for the OneNet Administrators for configuration and administration tools.

The main features of the OneNet Monitoring and Analytics Dashboard are:

- administrative and configuration tools;
- easy integration with the OneNet Orchestration Workbench and OneNet Middleware;
- data-analytics dashboard;
- monitoring and alerting dashboard for data processes and platform integrations; and
- user-friendly selection of data sources and services from the catalogues.

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2.3.2. Platone

Platone project proposes an innovative approach for supporting the DSOs and other involved stakeholders in the energy transition phase. Platone aims to support the observability of the network and the exploitation of the flexibility for solving both the volatility of renewable energy sources and the less predictable consumption patterns [11].

The Platone solution consists of a layered set of platforms to meet the needs of system operators, aggregators and end users, named Platone Open Framework.

The Platone Open Framework aims to create a fully replicable and scalable system that enables distribution grid flexibility/congestion management mechanisms through Peer-to-peer (P2P) market models involving all the possible actors at many levels (DSOs, TSOs, customers, aggregators). The key components for an open framework are a secure shared data management system, standard and flexible integration of external solutions (e.g. legacy solutions), and openness to external services through standardized open application program interfaces (APIs). The Platone Open Framework offers a two-layer platform and innovative components which implement all the characteristics mentioned above.

As already declared in introduction, one of the main goals of the Platone Project is to create an open framework that is:

- Open, to be extended and integrated with external services providing standard interfaces
- Flexible, in terms of integration with already existing external solutions (e.g. legacy platforms)
- Secure, for data handling, using blockchain technology for data certification and integrity and for data interoperability, using standard communication protocols and following the data security and data privacy best practices

The Platone Open Framework is completely open-source and consists of three core platforms [12]:

- Market Platform enables the creation of an open energy marketplace creating the ecosystem for a rapid roll out among DSOs and for a large involvement of customers in the active management of grids and in the flexibility markets.
- DSO Technical Platform ensures an easy integration of external systems both at data level and service level.
- Blockchain Access Layer allows the integration of data coming from the physical infrastructure adding a further level of security and trustworthiness to the framework, exploiting the blockchain and smart contracts technologies.

The Figure 8 represents the reference architecture of the Platone Open Framework.

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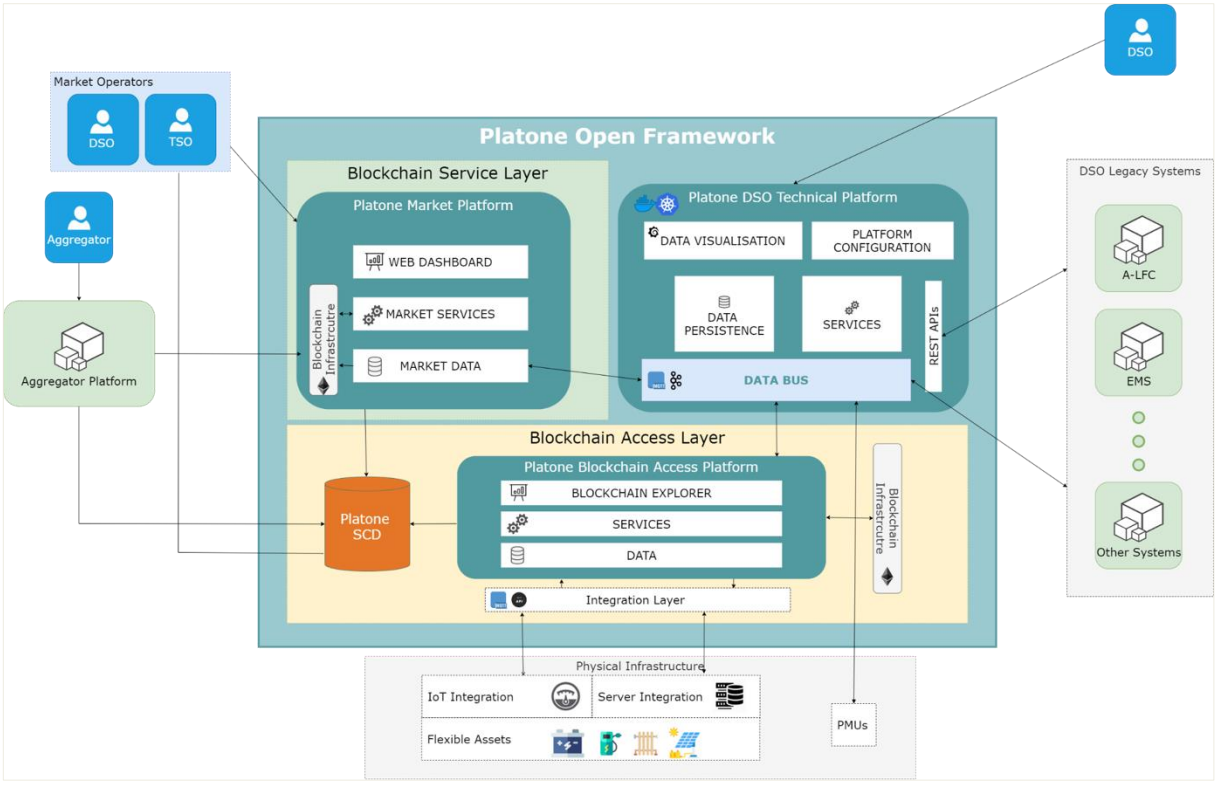

Figure 8. Platone Open Framework Architecture.

In the context of the FLOW project is important to analyse more in detail one of the three main platform of the Platone Open Framework, the DSO Technical Platform.

2.3.2.1. Platone DSO Technical Platform (SOGNO)

The Platone DSO Technical Platform is a plug-and-play microservices-based platform for data-driven control system capable of hosting different micro services aiming at simplifying e.g., the grid monitoring or market interactions for a DSO.

The DSO Technical Platform should respond to specific technical and operational requirements, including:

- High availability
- Scalability both horizontally and vertically
- Flexibility and modularity
- Centralized monitoring and logging
- Reduced operational cost

Figure 9 illustrates the architecture of the Platone DSO Technical Platform.

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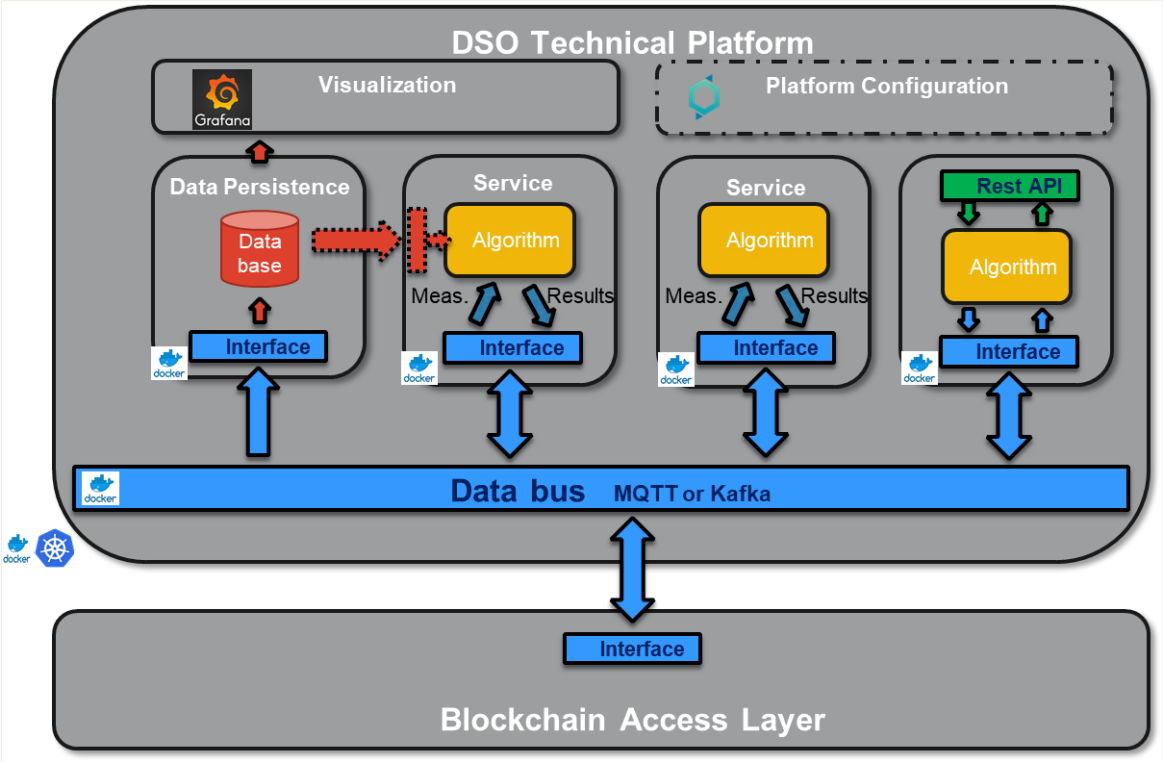

Figure 9. Platone DSO Technical Platform Architecture.

Databus

The databus is the core component of the DSO Technical Platform and is implemented as an MQTT message broker. The first release of the platform uses the RabbitMQ [20] message broker with an MQTT plugin. The databus is accessible for all services within the platform and can also be exposed to outside the cluster for integration of external devices, platforms or services. It shall be used for asynchronous transfer of streaming data from field devices (e.g. PMUs) or setpoints.

Services

All services are able to connect to the Databus and may provide individual RESTful APIs as an interface for other services or to be exposed to external clients (users or systems). All services for the platform are deployed in Docker containers and restricted to the usage of the specified communication protocols. The programming languages are not specified to allow a wide flexibility for service developers.

API Gateway

The API Gateway is responsible for routing API requests from clients (i.e. users or external systems) to the related services while ensuring authentication, authorization, and security policies. Besides, data transformations on the transfer. The first release of the DSO Technical Platform uses the basic functionality of the Kubernetes ingress reverse proxy.

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In order to provide a long-term sustainability and maintenance of platform, the Platone DSOTP results was included in the Linux Foundation Energy within the SOGNO project.

The SOGNO [13] project goal is to create plug-and-play, cloud-native, micro-services to implement innovative data-driven monitoring and control systems. It aims to simplify the life of distribution utilities by enabling them to optimize their network operations through open source to deliver cost-effectively, and seamless, secure power supply for their customers. SOGNO introduces the idea of grid automation as a modular system in which components can be added through time. This is in opposition to classical monolithic solutions.

SOGNO facilitates network operators in the transition to a modular microservices-based control center software solution. The vision is to integrate today's SCADA systems with SOGNO and then to gradually move functionalities into microservices. As a result, SOGNO is not in opposition to classical solutions, but it can be seen as an add-on that supports a flexible growth of the automation architecture. This allows operators to adapt faster with components that can be updated independently from each other while recognizing the "brown field" that most utilities continue to operate in. SOGNO provides system operators and automation software developers a pathway to the future through an open-source framework that exposes open APIs that plug-in new automation functions, while supporting industry standards such as CIM IEC61970.

SOGNO enables automation functions to be developed as components of the core project, as new functionality contributed upstream, or as separate projects that are compatible with the interfaces defined in SOGNO.

Automation functions are run as containerized microservices that communicate with other services using, for example, a message broker or HTTP. Since the microservices are decoupled, users can select the SOGNO services that fit their use case and easily integrate them with their own platform or run the entire SOGNO suite and integrate their own functionalities as microservices.

SOGNO packages these services to be readily used within Kubernetes, either in a cloud environment or at the edge using a lightweight Kubernetes distribution.

With the integration of real-time simulation, the SOGNO project supports seamless integration of development, testing, and deployment. New automation functionalities can be developed and thoroughly tested against a virtual real-time representation of the power system before deployment.

The Figure 10 below, represents the core concept of SOGNO.

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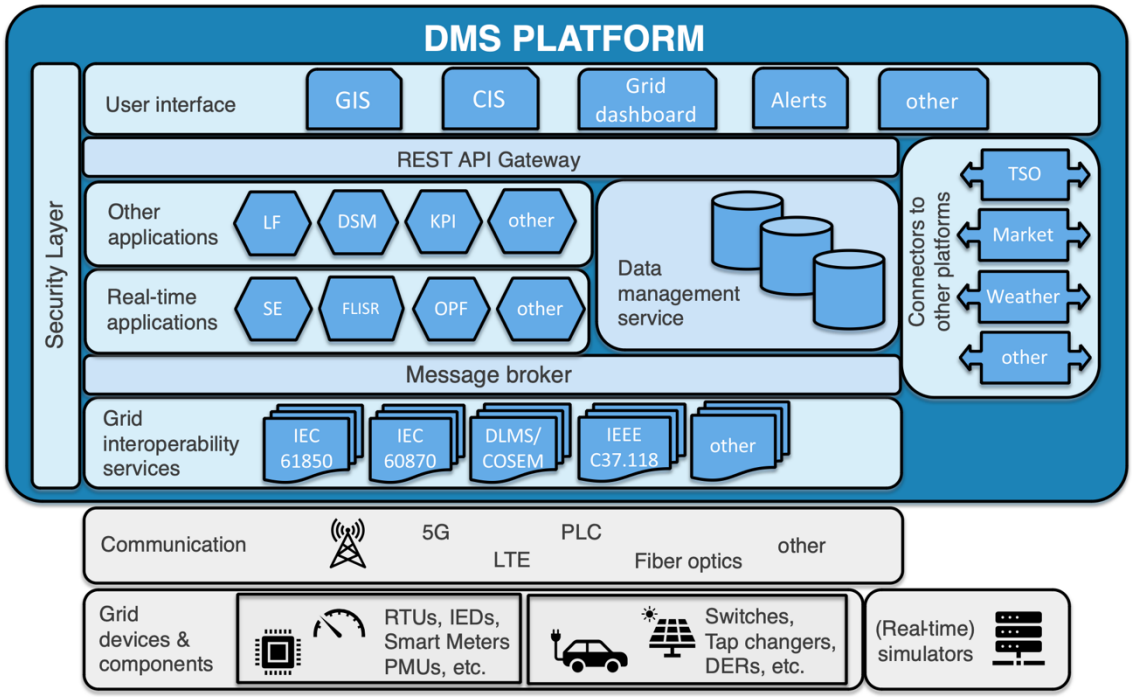

Figure 10. SOGNO Platform Architecture [13].

2.3.3. OPEN DEI

The main goal of the OPEN DEI project is to support the alignment of Reference Architectures, Open Platforms and Large-Scale Pilots in Digitising European Industry.

Following the digital transformation strategy, a particular priority comes out: the need to create a common methodology for data platforms based on a unified architecture and a well defined set of standards. The OPEN DEI project focuses on “Platforms and Pilots” to support the implementation of next generation digital platforms in four basic industrial domains and one of the is the Energy domain [14].

The energy system is facing an important transition from the present single-carrier, fossil-based status towards an integrated, low-carbon and market-based one.

Due to the increasing complexity, there is an urgent need to unlock smart technologies and services to ensure secure, reliable, resilient, accessible and cost-efficient solutions.

In the next future, the Integrated Energy Systems (IES) will consist of four inter-connected and inter-related layers:

- The market layer, to allow for exchanges between market players (generators, aggregators, consumers and any other player).

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- The communication layer, to support the vertical and horizontal integration of energy systems and the relaying of information with the market.
- The physical system layer, which consists of automated energy infrastructures (generation, power conversion, storage and networks) designed to meet citizen needs.
- The digital infrastructure layer, which supports network operations to manage the integrated energy systems with higher levels of automation.

This complexity requires higher levels of operational excellence with the adoption of disrupting technologies to foster data sharing and data-driven innovation. In this context OPEN DEI evaluated and proposed reference platforms that will constitute the basis of the four IES layers.

Particular attention has been done to the open-source platforms such as the FIWARE framework, which provides open-source software components, easy adoptable and that can be assembled together with other third-party platform components.

The amount of data exchanged between different domains and levels of the energy systems is continuously increasing and requires effective measures to be managed.

Following OPEN DEI insights, the following key elements need to be fulfilled for supporting interoperable data exchange:

- Data model/Semantics: definition of an appropriate data model beyond a single sector is a key ingredient for interoperability.

- Data Sovereignty: the ability of a data owner to define what a third party is allowed to do with his data.

- Security: systems must be immune to cyber-attacks even under strong growth of IoT and rapid changes in digital technologies and decentralisation.

- Open API: closed solutions will not create a real open and competitive market. Open APIs offer the perfect bridge between private infrastructure spaces.

All these aspects and building blocks clearly reflect the Data Space concept described so far. In this context, OPEN DEI provided some important outcomes described in the white paper “Data Space for Energy, Home and Mobility” [15].

The paper highlights how data models, ontologies and standards are crucial for implementing an energy data space, analysing the most relevant use cases and projects.

Among them, the most relevant case study for the Data Space in the electromobility sector is EEBUS which will be described more in detail in Ch. **Error! Reference source not found.**.

The analysis of the relevant use-cases provided some important outcomes that can be exploted for the definition of data-exchange use cases and specification for electromobility sector.

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In particular the following case studies was identified

Energy sector: Flexibility products for the energy markets

It includes flexibility for the grid operators (grid support), flexibility for the BRPs (portfolio optimisation), but also flexibility for the local communities (e.g. collective self-consumption) or for its own interests (individual self-consumption).

Energy sector × Mobility & transports sector: Smart charging & V2G

It includes optimization of energy cost, reduction of connection impact, optimization of the contractual power, valorisation of the storage capacity.

In addition, a first set of datasets to be exchanged and related standards and data models were identified. A subset of these information relevant for FLOW scope is reported in Table 1 below.

Table 1. OPEN DEI relevant data set and standards for energy and electromobility sector.

Sector	Data Exchanged	Standards/Data Models
Energy	• Grid & topology • Energy & power • Flexibility function • Metering & tariff	• IEC CIM (incl. CIM-Market) • FlexOffer • IEC 61850 • USEF • OpenADR • DLMS/COSEM • SAREF4ENER
E-Mobility	• Mobility / transport • Charging contract	• OCPI • OCPP • IEC 63110 • IEC 63119 • IEC 63382

2.4. Data-driven approach in electromobility sector

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Electric vehicles (EVs) have sparked a paradigm shift in transportation, not just for their environmental benefits but also for their potential to interact with the electric grid. Two significant concepts in this realm are Vehicle-to-Grid (V2G) and Grid-to-vehicle (V1G) technologies.

V2G technology transforms EVs from mere consumers of electricity to active participants in the energy ecosystem. It enables bidirectional flow, allowing EVs to not only draw power from the grid but also return excess energy back to it. This bidirectional energy exchange creates a dynamic relationship between electric vehicles and the grid.

On the other hand, V1G primarily involves the unidirectional flow of energy from the grid to the vehicle. It focuses on EVs drawing power from the grid for charging purposes without sending energy back.

In both the scenarios, data collection and utilization play a fundamental role, and it is important to identify which kind of information need to be exchanged for implementing innovative digital services for electromobility sector.

In V2G scenarios for example Information on charging behavior, battery health monitoring, grid demand, supply patterns, and financial transactions between EV owners and grid operators forms the backbone.

Data concerning charging infrastructure usage, user behavior related to charging routines, energy consumption tracking, and operational efficiency comprise the critical components of V1G data.

In this context, the Data Space concept can be essential for maximizing the potential benefits of V2G and V1G technologies within the broader context of electric vehicle integration.

The Data Space concept can be applied in the following use cases:

- **Grid Stabilization**: Utilizing EVs to stabilize the grid during peak demand or supply shortages by feeding surplus power back into the system.
- **Demand Response**: Adjusting EV charging/discharging schedules to align with fluctuating grid needs.
- **Renewable Energy Integration**: Using EVs as storage units for excess renewable energy, contributing to a more sustainable energy mix.
- **Charging Infrastructure Optimization**: Analysing data to optimize the placement and capacity of charging stations.
- **Enhanced User Experience**: Leveraging data to predict optimal charging times or locations, thereby improving the overall experience for EV owners.
- **Load Management**: Efficiently distributing charging loads across the grid to prevent strain during peak periods.

The Data Space can support these processes by establishing standardized protocols, ensuring data security and trust, fostering collaboration, adhering to regulatory frameworks, and leveraging analytics for optimization. It can act as the backbone for efficient and transparent data exchange among diverse stakeholders, contributing to the successful integration and operation of V2G and V1G systems.

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2.4.1. Mobility Data Space

The Mobility Data Space (MDS) [16] is a data marketplace where equal partners from the mobility sector can exchange data. The data provider remains the owner of the data at all times and can autonomously decide whether and with which participant to enter into data exchange. The goal is to create a cross-company data economy in order to realize and further develop innovative, environmentally and user-friendly mobility concepts. In doing so, the MDS brings together companies, organizations and institutions: those that want to monetize their data treasures and those that need data for innovative mobility solutions, but in many cases also to create a win-win situation for mutual benefit through a targeted exchange. For this purpose, the MDS creates the framework for a trusting cooperation.

With the objective of making mobility safer, more efficient and more environmentally friendly, the MDS is funded by the German Federal Ministry of Digital Affairs and Transport (BMDV), and is therefore a neutral and trustworthy partner to pave the way for a networked and secure data infrastructure in Europe that complies with European values such as data protection, data sovereignty and interoperability.

The MDS is based on a data protection-friendly approach that aims to facilitate data exchange between partners without the MDS or any third party storing or analyzing the data. Only the data description (metadata) is made available to all participants. Data is transferred directly between partners via the Eclipse Data Space Components (EDC) connector, which means that data sovereignty remains with the partners involved. Decentralized data storage is made possible in this way. In addition, the MDS offers a Connector-as-a-Service (CaaS), a browser-based service from MDS partners that participants can use on demand.

The Mobility Data Space implemented several use cases [17] and offers many relevant datasets in its data catalogue, among them those relating to electromobility are reported below [18].

Table 2. Electromobility Data Offering in Mobility Data Space.

Data Product	Description	Data Supplier
Forecast data for renewable energies	Forecast data for renewable energies (PV, wind) for Germany in temporal and spatial resolution as required by users	Research institute
Charging point	Geographical information on charging points worldwide	Data aggregator
State of charge and range of electric car	State of charge and remaining range of a specific electric vehicle with personalised consent.	Car manufacturer
Power consumption and charging demand	Display of electricity consumption in a geographical area or measurement of charging potential in that area.	Car manufacturer
Tank level	Fuel level and remaining range of the vehicle	Car manufacturer
Charging status		Car manufacturer
Status of charging plug connection		Car manufacturer
Fuel tank range		Car manufacturer
Tank level	Absolute and relative fuel level	Car manufacturer
Remaining electric range in km		Car manufacturer

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Charging station register	The data on publicly accessible charging infrastructure in Germany reported by the Federal Network Agency as part of the Charging Column Ordinance (LSV) can be accessed. In addition, the charging stations of the city of Reutlingen are integrated, since these were collected by the city itself, this data is very accurate.	Public sector
Charging Station Data Baden-Württemberg	The Federal Network Agency publishes the data reported on the publicly accessible charging infrastructure in Germany as part of the Charging Column Ordinance (LSV).	Public sector
Public Fast Charging Timeseries for Electric Vehicles	This dataset provides a realistic and representative hourly charging power time series over one year for 100 electric vehicles (EVs) charging in public with a power of 150 kW. The time series includes daily driving patterns such as commuting to work, recreational activities, and weekend activities for a car situated in a metropolitan area. In addition, the dataset accounts for seasonal effects, such as temperature effects on consumption, and holiday travel. Different spatial types and other aggregation levels higher time resolutions and varying charging power are available.	Research institute
Home Charging Timeseries for Electric Vehicles	This dataset provides a realistic and representative hourly charging power time series over one year for 100 electric vehicles (EVs) charging at home with a power of 11 kW. The time series includes daily driving patterns such as commuting to work, recreational activities, and weekend activities for a car situated in a metropolitan area. In addition, the dataset accounts for seasonal effects, such as temperature effects on consumption, and holiday travel. Different spatial types and other aggregation levels higher time resolutions and varying charging power are available.	Research institute
Public Charging Timeseries for Electric Vehicles	This dataset provides a realistic and representative hourly charging power time series over one year for 100 electric vehicles (EVs) charging in public with a power of 11 kW. The time series includes daily driving patterns such as commuting to work, recreational activities, and weekend activities for a car situated in a metropolitan area. In addition, the dataset accounts for seasonal effects, such as temperature effects on consumption, and holiday travel. Different spatial types and other aggregation levels higher time resolutions and varying charging power are available.	Research institute
Workplace Charging Timeseries for Electric Vehicles	This dataset provides a realistic and representative hourly charging power time series over one year for 100 electric vehicles (EVs) charging at work with a power of 11 kW. The time series includes daily driving patterns such as commuting to work, recreational activities, and weekend activities for a car situated in a metropolitan area. In addition, the dataset accounts for seasonal effects, such as temperature effects on consumption, and holiday travel. Different spatial types and other aggregation levels higher time resolutions and varying charging power are available.	Research institute
EV Vehicle Profiles Data (EVP)	Electric Vehicle Profiles (EVP) data includes up to one year of trips for each of the electric vehicles. (Including battery electric vehicles (BEV) and plug-in hybrid electric vehicles	Automotive Supplier

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	(PHEV). Extended metrics on battery capacity, available range, energy consumption (total and per road type), fuel consumption (for plug-in hybrids only), ambient temperature, idling time and others are provided.	
EV Charging Events Data (EVCE)	Electric Vehicle Charging Events data includes all charging events taking place in a specific region/location over a given period, for EVs, comprising battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV). Most relevant metrics as charging duration, start/end battery level, start/end range, ambient temperature, or even energy consumption and vehicle usage before the charging event are provided as well.	Automotive Supplier
Electric Vehicle Status	Get remote access to all relevant charging data of a vehicle.	Car manufacturer
Energy Data	Use data from cars to optimize power grids and charging infrastructure.	Car manufacturer
Fuel Status	Determine the fuel level and the remaining distance of connected vehicles remotely.	Car manufacturer

2.4.2. EEBUS

As EVs consume significant amounts of power, it is important to integrate them into an energy management system to coordinate the charging process with other consumers, such as heat pump, and producers, such as photovoltaic system (PV). This will help optimize cost and sustainability.

The increased power demand of EVs will be challenging for the power grid. As the number of EVs is continuously and rapidly increasing, it is important to balance consumption and production by energy management systems. This will ensure the EV can be charged by a stable grid condition within the limits set by the owner. Furthermore, the batteries of EVs can, in the future, also be used to stabilize the grid.

To address the needs of this scenario, EEBUS [19] has developed a comprehensive architecture for influencing the behaviour of a customer installation at the grid connection in a coordinated manner. This approach is independent of the devices employed and the direction of power flow. This architecture serves as an essential base for the digitalisation of the energy transition.

In particular, for the electromobility scenario, EEBUS proposes the SPINE [20] toolbox, with corresponding data models and functionalities, to address the following use cases [21]:

- **Coordinated EV Charging**. Relying on the energy broker, the consumption of an EV is guided through incentives. Additionally, the energy guard, a specific device that monitors the energy consumption, avoid overload situations during charging. The EV will inform the energy guard and broker about its actual energy demand. This information enables the energy guard and energy broker to provide the maximum power limitation, and to tailor its incentives to the energy demand of the EV.
- **Overload Protection by EV Charging Current Curtailment**. To avoid an overload situation, the energy guard continuously monitors the power consumption through the according

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measurement points. It will immediately initiate curtailing of the charging power of the EV if a potential overload at the corresponding circuit breaker is detected.

- **Optimization of Self-Consumption during EV Charging**. Optimizing the consumption of self-produced energy (e.g., PV energy), via the Customer Energy Manager (CEM), during the EV charging process.
- **EV Charging Electricity Measurement**. Monitoring the power consumed by the EV charging process to enable the CEM to evaluate the charging power and react accordingly.
- **EV Charging Summary**. The energy broker continuously monitors the percentage value of the used energy source, as well as the energy costs of the current charging session. During, or at the end of the charging process, the Electric Vehicle Service Equipment (EVSE) can request a charging summary.
- **EV Commissioning and Configuration**. This process is needed as basis for the deployment of further use cases in the EV charging process.
- **EVSE Commissioning and Configuration**. The EVSE usually serves as gateway that transmits the necessary information between the CEM and the EV.

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3. Definition of FLOW Data-driven ecosystem

3.1. FLOW platforms and technologies

As described in Ch.1, the main goal of T3.2 is to define a subset of use cases and specification for data sharing and exchange across the EV ecosystem entities.

After the definition of the EV-centered data-driven ecosystem and data space and in addition to the electromobility data-driven use cases and data-exchange scenarios described in Ch.2, a set of use cases from the FLOW pilot was identified.

In order to identify these use cases two main activities were conducted:

- Identification of platforms and technologies as part of the EV ecosystem
- Definition of data sharing processes in the EV-centred ecosystem and design of the use cases

The first preliminary step was implemented collecting information about platform, components and technologies from FLOW pilot partners, in order to evaluate from a business and technical perspective the specifications and the needs of each pilot architecture.

The most important information about technical components and platform were collected using a generic architectural template, which was shared with the demo partners. The template can be found on *Annex 1 – FLOW Components Business and Technical Requirements - Template.*

Below is reported the list and detail of the platforms and technologies identified so far. Since this activity was performed in advance compared to the Pilot Use Case definition and consolidation, this list could be updated on a later stage in the project and refined during the implementation and integration phase.

Table 3. Italian Demo – DSO Blockchain Access Layer.

Partner	Areti
WP and Task reference	WP7 - T7.2 - Rome Demo
Responsible	Areti – Gabriele Fedele
WP and Task reference or FLOW Demo reference	WP7 - T7.2 - Rome Demo
Business Requirements	
Objective	Improve observability of the network and enable electric vehicles to provide flexibility services to electrical grids.
Actors:	DSO, EV User, BSP
Platform/software component involved in delivering the functionality:	PGUI, DSO TP, Aggregator Platform, Flexibility Register

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Is the technical documentation of the platform/software available	No
Opportunities	To be evaluated
User/Consumer:	DSO for observability and BSP to take part in the flexibility market
Data specification:	The owner of the data is the EV end user
Threats:	To be evaluated
Implementation Challenges:	Removing barriers to access retail flexibility services and improving the observability including low voltage customers (under 55 kW)
Technical Requirements	
Name of Component/Service:	DSO Blockchain Access Layer
Type	Service
Functionality	
Input Connections & Interfaces	BAL receives inputs from PGUI
Output Connections & Interfaces	BAL sends the certified outputs to the Flexibility Register
Software Requirements/Development Language	To be defined
Hardware Requirements	To be defined
Status of the development of the component	Partially developed and deployed in the Platone project, the starting TRL is 6

Table 4. Italian Demo - DSO Technical Platform.

Partner	Areti
WP and Task reference	WP7 - T7.2 - Rome Demo
Responsible	Areti – Gabriele Fedele
WP and Task reference or FLOW Demo reference	WP7 - T7.2 - Rome Demo
Business Requirements	
Objective	Management of the procurement of local flexibility services and TSO/DSO coordination for global flexibility services.

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Actors:	TSO, DSO, BSP
Platform/software component involved in delivering the functionality:	Equigy, Flexibility Register, Light Node
Is the technical documentation of the platform/software available	No, to be defined
Opportunities	DSO
User/Consumer:	DSO
Data specification:	DSO (Grid Data), End Users (Metering data and flexibility services activation commands)
Threats:	Cybersecurity, GDPR
Implementation Challenges:	Removing barriers to access retail flexibility services, improving the observability including low voltage customers (under 55 kW), and guaranteeing the safety of the distribution grid.
Technical Requirements	
Name of Component/Service:	Component: DSO Technical Platform Services: Define the flexibility needs, dynamic grid assessment and TSO/DSO coordination
Type	Both component and service.
Functionality	Define the flexibility needs, dynamic grid assessment and provide TSO/DSO coordination
Input Connections & Interfaces	DSO TP receives data from the flexibility register and the CBP
Output Connections & Interfaces	DSO TP sends outputs to the CBP and the Light Node
Software Requirements/Development Language	To be defined
Hardware Requirements	To be defined
Status of the development of the component	To be defined

Table 5. Italian Demo - Flexibility Register.

Partner	Areti

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WP and Task reference	WP7 - T7.2 - Rome Demo
Responsible	Areti – Gabriele Fedele
WP and Task reference or FLOW Demo reference	WP7 - T7.2 - Rome Demo
Business Requirements	
Objective	Create a unique and shared database to collect DERs data
Actors:	DSO, BSP
Platform/software component involved in delivering the functionality:	CBP, DSO Technical Platform, Aggregator Platform, Block Chain Access Layer
Is the technical documentation of the platform/software available	No
Opportunities	The whole electrical system
User/Consumer:	TSO, DSO, BSP
Data specification:	DSO and end user
Threats:	Cybersecurity, GDPR, data retention and requirements
Implementation Challenges:	Removing barriers to access retail flexibility services and improving the observability including low voltage customers (under 55 kW)
Technical Requirements	
Name of Component/Service:	Component: Flexibility Register Service: Share flexibility data, improve the observability of the grids
Type	Both component and service
Functionality	Gather the data from the DERs, store, arrange and manage them. Sharing the data with authorized stakeholders.
Input Connections & Interfaces	Flexibility Register receives data from DERs (through the Light Node if any), DSO, Aggregator Platform
Output Connections & Interfaces	Flexibility Register sends outputs to the DSO, CBP and Aggregator Platform
Software Requirements/Development Language	To be defined
Hardware Requirements	To be defined
Status of the development of the component	Partially developed and deployed in the Platone project, the starting TRL of 5

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Table 6. Italian Demo - Energy Services Platform.

Partner	Enel X Way
WP and Task reference	WP7 T7.2 – T7.3
Responsible	Enel X Way Srl, Davide De Michino
WP and Task reference	WP7 T7.2 – T7.3
Business Requirements	
Objective	The e-mobility revolution, from one side is a big opportunity to decarbonize the world of transportation, but, from the other, is opening new challenges to grid operators (both TSOs and DSOs) that need to manage on their grids not a big increases of demand but a hard-predictable and widely-distributed power peaks from charging infrastructures. This, together with the increase of distributed generation (mainly PV and storage system) obliges grid operators to re-think the future of the grids, moving to old "dummy" ones, to more and more "smart grids". Technology as Vehicle Grid Integration (VGI) can also help TSOs and DSOs to face the EV revolution as "an opportunity more than a problem".
Actors:	VGI can be deployed when different actors properly interact and exchanges their needs, their availability and the related data. These actors are: the system operator (whether it's the DSO or the TSO), the aggregators, the CPO and the MSP and finally the end-user. The CPO is responsible to properly manage the charging session in response of the request of flexibility and for doing that it interacts with the aggregator, the MSP and the end-user.
Platform/software component involved in delivering the functionality:	EvOS (charging station management system): it interacts with the charging station, the energy management platform and the end-user mobile app (B2C) or the Web Dashboard (B2C) Energy Services Platform: it's the energy management platform, it optimizes the charging profile, it interacts with EvOS and the aggregator's Flex Platform (Enel X flexibility platform).

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	Mobile App (Enel X Way app): mobile app that interacts with the user to allow public charging and manage the household's charging point installed at home
Is the technical documentation of the platform/software available	The documentation of the above mentioned platform is available but it is not public.
Opportunities	The primary services that can be provided to the grid are energy arbitrage, frequency regulation, voltage support, and congestion management. The grid operators will be paying for the service offered by the aggregator. The flexibility provider who optimizes the charging profile and interacts with the end-user will take a share of the benefit received by the aggregator from the grid operator. This benefit will be partially distributed also to the end-user allowing to use the flexibility of its EV.
User/Consumer:	The end-user is the EV driver that allows Enel X Way to manage its charging session to extract value from his/her flexibility
Data specification:	**User data** **EV data** **Charger Data** **Electricity Market/Grid data** Some user data are protected by GDPR and can't be exchanged with the aggregator. All the other data are exchanged with the aggregator as aggregated unless they are needed in a different way to participate to the established flexibility program.
Threats:	-Regulatory market -Use cases vs technology architecture (service performance, latency) -Market barrier (access cost) -Cyber security -Minimum user remuneration not met
Implementation Challenges:	No implementation challenges
Technical Requirements	
Name of Component/Service:	Energy Services Platform (Component)
Type	Component

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Functionality	Energy Services Platform provides both local energy management solution and grid aggregation services.
Input Connections & Interfaces	INPUT: • aggregated demand response event from the Aggregator platform via OpenADR protocol • Charger and EV data (status, telemetry, SoC) from EvOS • User preferences from the mobile App (B2C) /Web Dashboard (B2B)
Output Connections & Interfaces	OUTPUT: • Charging session scheduling to the charger via EvOS • Flexibility service deployment to the user via mobile App (B2C) /Web Dashboard (B2B) • Telemetry data for performance/settlement evaluation to the Aggregator platform
Software Requirements/Development Language	
Hardware Requirements	Cloud based solution: no ad-hoc hardware need to be installed locally
Status of the development of the component	The component is already existing, eventual adaptation to fit WP7 target architecture need to be evaluated.

Table 7. Italian and Spanish Demo - FlexCore/VPP Manager, Flexible Asset Interface.

Partner	Enel X S.r.l., Stefano Rosolia
WP and Task reference	WP 7, Task 7.2 and 7.3
Responsible	Enel X S.r.l., Marco Artina
WP and Task reference	WP 7, Task 7.2 and 7.3
Business Requirements	
Objective	System operators are nowadays facing new technical challenges due to the unpredictable nature of renewable energy generation

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	assets and Electric Vehicles (EVs) charging stations. In the context of improving the continuity of service, new tools and capabilities are needed for the grid operators to manage the available local resources when flexibility is required, including aggregation/VPP. New, distributed energy resources (DERs) of varying types/technologies and sizes are growing in their installed capacity and increasingly have the potential and ability to interact intelligently with the grid. This is incredibly complex for the grid operator to manage, whose primary goal is to ensure a stable grid for electricity consumers. DERs', such as an aggregation of EVs', ability to provide grid services is an emerging opportunity that can only grow with the support of grid operators, who need to fully understand the impact of DERs' participation in grid services. The goal of this works is to help grid operators understand risks and benefits of having EVs and aggregations EVs will interact with the grid. The aggregator monitors the system and coordinates transactions on behalf of the EV operator following grid operator requests, local system frequency, or varying market prices.
Actors:	Actors: aggregator (VPP manager), grid operators (DSO/TSO), and EV operator (CPO). The aggregator acts as a VPP manager and is responsible for monitoring the system and coordinating transactions on behalf of the EV operator following requests issued by grid operators, local system frequency or varying market prices. The EV operator is responsible for directly monitoring EVs enrolled in the program and reports the collected data to the aggregator.
Platform/software component involved in delivering the functionality:	FlexCore/VPP Manager, Flexible Asset Interface
Is the technical documentation of the platform/software available	The protocol for connecting the EV component to Flexible Asset Interface is OADR.

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Opportunities	The primary services that can be provided to the grid are energy arbitrage, frequency regulation, voltage support, and congestion management. The grid operators will be paying for the service offered by the aggregators.
User/Consumer:	The beneficiary of the aggregation capability is the grid operator. The grid operator has an interest in supporting the development financially. The added value is to contribute flexible loads to the grid operator to manage its network using flexible resources connected to it. On the other side, the owners of the EV chargers may also benefit from a payment from the grid operator for volunteering their assets and responding to the grid needs. The aggregator receives the payment from the grid operator and re-distributes it to the EV operators based on the performance of the EV chargers.
Data specification:	We require legal discussions and guidance to answer these questions, because the data rights may depend on the specific region in question. In some regions, for example, the specific asset data, including status and device energy usage, is owned by the asset owner.
Threats:	Lucrative market conditions A defined regulatory framework with minimum technical requirements for charging infrastructures is necessary to enable them to provide the services. The regulation has to be defined to guarantee access to a broader market, so that is up to the aggregator to select the most suitable market, shifting the perspective from the single physical assets to the aggregated virtual asset. Moreover, valuable market remuneration is necessary to create a business case promoting participation in scale.
Implementation Challenges:	The service has not been implemented since there are many complex stakeholders, and this hasn't been the lowest-cost way to participate in serving the grid... Challenges are spread among regulators, system operators, aggregators and EV operators. Technical alignment between the aggregator and EV operators must be in place with clearly defined implicit and explicit financial incentives.
Technical Requirements	
Name of Component/Service:	FlexCore/VPP Manager, Flexible Asset Interface
Type	Component

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Functionality	• FlexCore handles the bidding functionalities and collects the dispatch instructions from the grid operators • VPP Manager defines the optimal configuration of the virtual assets can be dispatched to meet the dispatch instruction • Flexible Asset Interface is the communication layer between FlexCore and Energy Services
Input Connections & Interfaces	• FlexCore: grid operator, VPP Manager • VPP Manager: FlexCore, Flexible Asset Interface • Flexible Asset Interface: Flexible Asset Interface, Energy Services
Output Connections & Interfaces	• FlexCore: grid operator, VPP Manager • VPP Manager: FlexCore, Flexible Asset Interface • Flexible Asset Interface: Flexible Asset Interface, Energy Services
Software Requirements/Development Language	TBD
Hardware Requirements	No hardware requirements from the aggregator point of view.
Status of the development of the component	• FlexCore: already developed – TRL 9 • VPP Manager: to be developed from scratch – TRL 1 • Flexible Asset Interface: TRL 5

Table 8. Italian Demo - Crowd Balancing Platform.

Partner	Terna
WP and Task reference	5.5 – 7.2 (to be better clarified)
Responsible	Terna, Alessio Siviero
WP and Task reference or FLOW Demo reference	5.5 – 7.2 (to be better clarified)
Business Requirements	

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Objective	Facilitate the penetration of DERs into existing wholesale energy and balancing markets. The core functions of the CBP are the provision of a secure data exchange tool and the validation of transactions between market players aiming at increasing the level of acceptance that system operators have in using distributed small scale flexibility assets. The CBP is established to support flexibility procurements without acting as a market platform where transactions are cleared. The platform facilitates aggregators and other stakeholders along the flexibility user journey without interacting directly with the downstream layer of field device' owners. The assets' flexibility is contracted by the aggregator which in turn uses the platform as the market front end access point. Especially in contexts of distributed flexibility the CBP also hosts the relevant DSOs with which the TSO must establish the proper coordination mechanism to unlock DSO connected assets. The DSO as platform user fulfils the role of assets validation responsible and data provider as it is the party that gathers commercial data to be used for settlement of commercial transactions.
Actors:	Equigy: JV by Tennet, Swissgrid, Terna and APG, provides and develops the platform. TSO: defines the business requirements for the integration of TSO systems and other market platforms. DSO: Enables distributed resources to flexibility resources provision by guaranteeing the resources availability, provides the necessary measurements flow BSPs: Integrate with CBP in order to better manage market processes and interactions with the grid operators, with the aim to increase the market potential by reducing the cost per resource.
Platform/software component involved in delivering the functionality:	Crowd Balancing Platform (CBP)

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Is the technical documentation of the platform/software available	Not available.
Opportunities	CBP is developed by Equigy as a service tool freely available to the participating operators. The development in terms of business and economic requirements is managed by Terna for the project purposes.
User/Consumer:	Actors in the energy value chain (TSOs, DSOs, BSPs, other commercial actors) are users of the platform – potentially also OEMs, directly providing data from their assets through IOT can be users of the platform.
Data specification:	Not specified yet.
Threats:	Not identified yet.
Implementation Challenges:	Platform implementation has to follow careful definition of use cases to be tested. Implementation follows first the definition of a business requirement document by the TSO where functional specification of new features, corresponding to identified processes/use case to be developed, is made. Equigy then produces a technical document explaining the more technical details regarding how the requested developments will be performed on the CBP (sort of a "technical specification" Equigy will follow during the development phase). Parallelly, an "implementation guideline" is also produced (a combination of business+technical requirements but for the other actors involved) in order to guide the implementations on the involved actors interfaces/platforms to perform the identified use-case.
Technical Requirements	
Name of Component/Service:	Crowd Balancing Platform can be classified as a "market intermediary platform" as it provides enabling services (e.g., asset registration and prequalification, etc) to SOs and FSPs that facilitate procurement.
Type	Component

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Functionality	The CBP is positioned along the entire flexibility user journey: from registration of flexibility assets to settlement of transactions. In the following, a high-level description of the "full" user journey the CBP can be deployed for is given, with the aim to provide more insight on the platform possibilities. Development of CBP functionalities, such as the ones described below, follows after a clear definition of use-cases and process requirements, as previously explained. Being the front end for flexibility providers, the CBP can be the tool aggregators use to qualify their assets and portfolios. Aggregators register their asset pools on the platform in order to participate in the Ancillary Services market. The prequalification process is very TSO-specific as requirements change among countries. Though different approached exist this section of the user journey requires the aggregators to provide technical and generic details of assets in order to gather consistent data records for the final purpose of performing a technical qualification test which ultimately determines whether the pool is fit for purpose or not. When the assets pool is correctly registered and qualified for flexibility provision based on TSO requirements then the aggregator can proceed by placing a bid in the market. In this regard, CBP might be a bid manager giving the TSO the chance to review the bids on-platform and determine an acceptance notification by which the TSO itself sends an activation signal for service delivery purposes. The platform can also be deployed with less process integration being used as a forwarder of bids information, which would be in this case processed off-platform, and of activation signals. In any case the activation, i.e.: the interaction with the field, may or may not be on the platform action perimeter. Based on market clearing the TSO sends an aggregated activation signal with is then dispatched by the aggregator to its portfolio with requirements

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	specified by the national network code. Either way the TSO's market systems won't be taken over by the CBP as it fulfils the role of the facilitator not that of the marketplace. The delivery of services in a market-based environment must always be validated against available commercial measurements. Currently, in all involved countries, the regulatory framework provides that the aggregator shall make available measurements at pool level in order for the TSO to validate the delivery of requested services based on product and market specific requirements. Aggregators' measurements are compared with commercial data provided by DSOs in order to proceed to transaction settlement. The platform leverages a distributed environment opening to the possibility of directly connecting to a third party provider of assets' measurements being it the OEM or a generic MSP. In this case the measurements flows would be gathered by the CBP for validation purposes against aggregated data. When the delivery is validated the settlement of transactions is carried out. The CBP does not define the remuneration of the flexibility providers and does not settle with the flexibility provider. Settlement is done via the normal market processes. The presence and form of penalties are in line with the market rules in each country adopting the platform. Equigy does not define the penalties for failure to deliver flexibility nor does it charge penalties to market parties. This is in sole responsibility of the contracting party (TSOs and in the future potentially DSOs).
Input Connections & Interfaces	As per the functionalities described, the CBP can acquire input by and forward output information to the actors involved (e.g., BSP can register its assets on the CBP, CBP forwards BSP bids to TSO market platform, etc.).

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	The CBP exploits an integrated infrastructure of APIs (Application Programming Interface) allowing the platform to connect with its users, while leaving to the users' systems their own business operativity.
Output Connections & Interfaces	As per "Input connections & interfaces"
Software Requirements/Development Language	Not relevant
Hardware Requirements	Not specified
Status of the development of the component	Platform is already in industrial operation phase in the countries where it is adopted and for the use cases envisioned. Additional developments can leverage on the developments already done for similar use cases.

Table 9. Spanish Demo - DERMS Platform.

Partner	e-Distribución
WP and Task reference	WP 7, Task 7.3
Responsible	e-Distribución, Miguel Pardo
WP and Task reference or FLOW Demo reference	WP 7, Task 7.3
Business Requirements	
Objective	Provide a tool to the DSO (DERMS Platform) that can manage the available flexibility resources to solve congestions in the distribution network. The increasing number of the DERs in the distribution network and the massive deployment of the EV chargers make this tool necessary to address the problem of the congestion in the distribution networks.
Actors:	DER (In the Menorca demonstration V2G Chargers) will provide the service to solve the congestions. The CPO will manage the V2G Chargers and will communicate with the aggregator to participate in the congestion market. The DSO will estimate their flexibility

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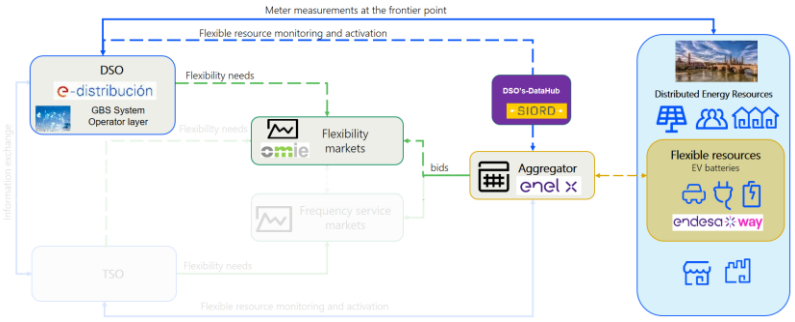
	needs to solve the congestion. The congestion flexibility market that will determinate which DER will solve the congestions. 
Platform/software component involved in delivering the functionality:	DERMS Platform
Is the technical documentation of the platform/software available	The documentation of the Platform is not yet available.
Opportunities	The DSO is paying for the service. The benefit of the service is that the DSO will avoid congestions in its network that can cause supply issues to the network users.
User/Consumer:	The user of the feature is the DSO. The DSO pays the tool. The added value is to contribute to the DSO to manage its network using flexible resources connected to its network.
Data specification:	The owner of the data is the DSO. The data is sensitive.
Threats:	The incentives to the DER/aggregators are not enough to participate in the flexibility market and in consequence, there are not enough resources to provide the service.
Implementation Challenges:	The service has not been implemented since the challenge hasn't arisen in the past. Implement the new features to manage flexibility in the DSO existing IT tools.
Technical Requirements	
Name of Component/Service:	DERMS Platform (Component)
Type	Component
Functionality	DERMS platform which has four main modules: Long term planning, Day ahead DSO, Intraday operation DSO and Observability. Each of these modules is in charge of a range of functionalities that are described below.

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	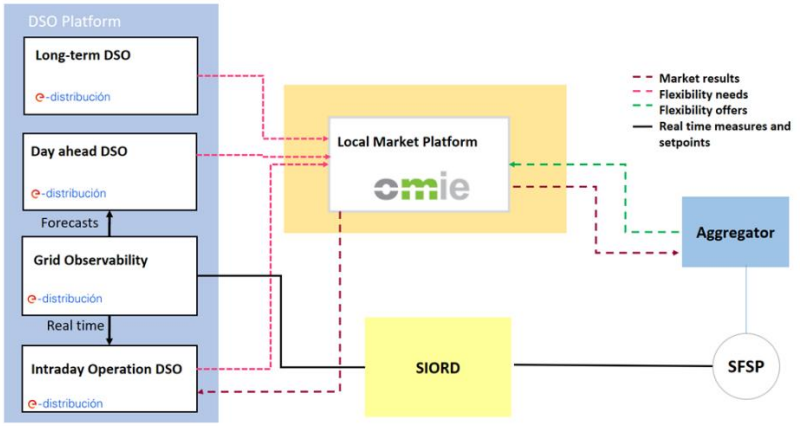 **Long-term DSO** This module considers the procurement of flexibility from FSP as an alternative of the existing planning methodology based in copper investments. This module is in charge of sending the needs of distribution networks to the market platforms. **Day ahead DSO Local congestion management** This module is responsible for estimating the expected congestions on the distribution network in order to send the requirements to the local market platform. The module operates at day ahead timeframe. **Intraday Operation DSO** The intraday operation module is in charge of checking the results computed in the market clearing and estimate the expected congestions on the distribution network in the real-time timeframe. **Observability** This module is related to the grid's operation. It includes the forecasting, metering and checking of activation functionalities, which are essential for the correct operation.
Input Connections & Interfaces	Inputs: - e-Distribución SCADA – API - Flexibility market – API - SIORD Platform – (TBC)
Output Connections & Interfaces	Outputs: - Flexibility market – API - SIORD Platform – (TBC)
Software Requirements/Development Language	- Programming Language: Pyhton
Hardware Requirements	The DERMS Platform. Considering that the workstation will have to deal with multiple task in parallel, high requirement operations (running Optimal Power

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	flow algorithms, running machine learning algorithms…) a high performance workstation has been considered. The workstation considered to host the DERMS Platform has the following characteristics: - Intel Core i9-9900,(8 Core HT, 16MB Cache, 3.1GHz, 5.0GHz Turbo w/UHD Graphics 630) - 32GB 2x16GB DDR4 2666MHz UDIMM Non-ECC Memory - 512GB PCIe NVMe Class 40 M.2 SSD
Status of the development of the component	- The DERMS Platform is partially developed. Starting TRL 4-5.

Table 10. Danish Demo - Use Case 1.

WP and Task reference	**T7.4, USE CASE 1**
Responsible	DTU – Mattia Secchi
Deadline	M46 – May 2026
Business Requirements	
Objective	To be able to control the maximum charging current for the 12 outlets in DTU's Building 325 parking lot.
Actors:	Spirii – bills the EV owners through their application (CPO/EMSP) DTU's Campus Service – provides the software interface. DTU – calculates the optimal charging setpoints.
Platform involved in delivering the functionality:	DTU Campus Service (CAS) software interface.
Opportunities	The software interface is being provided for free by CAS for internal use in DTU. The main benefit is being able to "smart charge" on stations that have no built-in functionality for that purpose.
User/Consumer:	The consumer of the feature is the EV owner that charges his/her car through the Spirii application.

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Data specification:	The owner of the data is DTU's Campus Service. The data is not sensitive because it is anonymized (DTU does not know who charged in a particular timeframe), the owner of the data is DTU, which is going to use it for scientific purposes.
Threats:	The software interface could be hacked and allow access to unauthorized personnel. The use of ICT secured DTU laptops and protected communication channels will ensure the data is safe.
Implementation Challenges:	DTU has never worked with these specific EV chargers (EVLink by Schneider Electric), and the energy measurement devices are currently missing (need to be installed).
Technical Requirements	
Name of Component/Service:	Campus Service Software Interface for EVLink Chargers
Type	Component
Functionality	The component is a software interface between the EV charging stations in DTU's Lyngby Campus (Building 325) and Spirii's (CPO) front-end software management system for the stations. The software interface will work between the CPO's front-end and the EV charging station, deploying OCPP 1.6, and setting a maximum current value to be absorbed by the station for a specific time frame, based on the setpoint sent by DTU.
Input Connections & Interfaces	Inputs: 1) **Outlet status (occupied/available)**, from the EV station; 2) **Max. current setpoint**, from DTU's optimization algorithm;
Output Connections & Interfaces	Outputs: 1) **Max. current setpoint**, to EV station; 2) **Outlet status**, to DTU's optimization algorithm;
Software Requirements/Development Language	Not defined
Hardware Requirements	Not defined

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Status of the development of the component	The component has already been developed for other chargers and would need to be adjusted for Schneider Electric's EVLink stations. TRL 4-5.

Table 11. Danish Demo - Use case 2.

WP and Task reference	**T7.4 – USE CASE 2**
Responsible	Mattia Secchi
Deadline	M46 – May 2026
Business Requirements	
Objective	To develop a platform to establish conditional connection agreements (CCAs) between the Distribution System Operator (DSO) and a Charging Point Owner/Operator (CPO), and regulate the max. charging power of two sites based on the total available capacity.
Actors:	Spirii – charging point operator (CPO/EMPS). Radius – Distribution System Operator, owns the transformer. DTU – calculates the optimal available transformer capacity to be "booked" by the CPO and regulates the max. power at the two demo sites.
Platform involved in delivering the functionality:	Zaptec Pro API for parking lots, data measurement service from the energy meter at the transformer (owned by the DSO, Radius).
Opportunities	The platform will be created by DTU's researchers using FLOW's project money for working hours to test the CCA functionality.
User/Consumer:	The consumer of the feature is Spirii, the CPO that operates the two analysed charging hubs.

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Data specification:	The owner of the transformer data is Radis (not part of the FLOW project) and is accessible to DTU for scientific purposes only.
Threats:	At present, no concerns appear to be possible.
Implementation Challenges:	There was no meter installed at the secondary substation (transformer), hence no real-data measurements were available. The penetration of EVs and charging hubs usage are not high enough to justify the creation of a CCA. In the future, no matter the size of the transformer, there transformer overloads could happen, due to the high synchronization of the EV charging process at the same hours.

Technical Requirements

Name of Component/Service:	CCA Platform
Type	Service
Functionality	The service is a platform connecting the DSO (Radius) to the charging point operator (Spirii), in order to allow the creation of CCAs based on short-term forecasts or real time measurements of the transformer at the secondary substation. The platform will receive information from the transformer at the secondary substation, and from the charging hubs, to smartly allocate capacity based on the number of connected EVs, and the transformer loading level.
Input Connections & Interfaces	Inputs: 1) **N/N-1 grid condition**, from the DSO. 2) **Transformer loading level** (current, voltage, power factor) from the DSO (Radius), or short-term forecast from DTU/Radius. 3) **Number of connected cars at the two charging hubs**, from Zaptec chargers' API.
Output Connections & Interfaces	Outputs: 1) **CCA capacity**, to Spirii/DSO. 2) **Charging hubs setpoints**, to the Zaptec API controlling the EV stations.

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Software Requirements/Development Language	Not defined
Hardware Requirements	Not defined
Status of the development of the component	The service has only been theorized, and CCAs were proven to be beneficial for the system. TRL2-3.

Table 12. Danish Demo - Use Case 3.

WP and Task reference	**T7.4 – USE CASE 3**
Responsible	DTU – Mattia Secchi
Deadline	M46 – May 2026
Business Requirements	
Objective	Allowing for a flow of information to go from DTU's Syslab facility, through EATON's Energy Management System, until Spirii's Advanced Dynamic Load Management platform.
Actors:	Spirii – bills the EV owners through their application (CPO/EMSP) DTU's Campus Service – allows Spirii to operate the charging stations. DTU's Syslab – collects renewable energy production readings and/or grid frequency measurements. EATON – finds the optimal setpoint for the EV chargers to activate the flexibility service.
Platform involved in delivering the functionality:	EATON's Energy Management System, Spirii's Advanced Dynamic Load Management platform.

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Opportunities	The service would be useful for the Charging Point Owner (DTU's Campus Service) to decrease its CO2 emissions or unlock an additional revenue stream through the provision of frequency services.
User/Consumer:	The consumer of the service is the Charging Point Owner, DTU's Campus Service.
Data specification:	The owner of the charging data is DTU's Campus Service, while the two input signals of renewables production and grid frequency are owned by DTU's Syslab. The data regarding EVs is anonymous, while the renewable energy production and grid frequency are to be used for scientific purposes by DTU, hence they should not be disclosed.
Threats:	The platform could be hacked, and data streams could be accessed by unauthorized people. The use of ICT secured laptops and protected data transmission channels/storage locations will protect the data.
Implementation Challenges:	This is the first time an attempt is made to have EATON's EMS and Spirii's ADLM communicate. Data communication delays and incompatibilities are the main implementation challenges we foresee.

Technical Requirements

Name of Component/Service:	Spirii-EATON-DTU Grid Services Platform
Type	Service
Functionality	The platform allows for the communication between DTU's Syslab measurement devices, Spirii's ADLM platform for chargers control, and EATON's EMS for optimal chargers' operation. Based on either a renewable production or a grid frequency signal from DTU's Syslab Facilities, EATON's EMS will elaborate an optimal charging setpoint for the EVs connected to Spirii's station. This setpoint will then be sent to the stations via Spirii's ADLM, unlocking grid frequency services or renewable-based charging.
Input Connections & Interfaces	Inputs to EATON's EMS:

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	1) **RES production/grid frequency**, from DTU' Syslab; 2) **Number of connected EVs**, from Spirii's ADLM; Inputs to Spirii's ADLM: 1) **Number of connected EVs**, from Zaptec Chargers API; 2) **Optimal EV charging schedule**, from EATON's EMS.
Output Connections & Interfaces	Outputs from EATON's EMS: 1) **Optimal EV charging schedule**, to Spirii's ADLM; Outputs from Spirii's ADLM: 1) **Optimal EV charging schedule,** to Zaptec Chargers API.
Software Requirements/Development Language	Not defined
Hardware Requirements	Not defined
Status of the development of the component	The component has only been theorized and is based on a set of assumptions that will be checked during 2024. TRL 1-2.

Table 13. Danish Demo - Use Case 4.

WP and Task reference	**T7.4 – USE CASE 4**
Responsible	DTU – Mattia Secchi
Deadline	M46 – May 2026
Business Requirements	
Objective	To be able to smart charge the EVs of a number of residential users who own their charging station, based on a price signal resulting from a combination of the spot market electricity price and additional fees.
Actors:	Spirii – bills the EV owners through their application (CPO/EMSP) DTU – calculates the optimal charging setpoints.

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Platform involved in delivering the functionality:	Zaptec GO Chargers API.
Opportunities	The service would be provided to the users by Spirii for free, and would allow an additional reduction of the EV owners charging bill.
User/Consumer:	The consumer of the feature is the EV owner that charges his/her car through the Spirii application.
Data specification:	The owner of the data are the residential customers, and DTU does not know their identity, but is in communication with them through Spirii's customer service.
Threats:	The data transmission between DTU's optimisation algorithm and Zaptec's API could be hacked and allow access to unauthorized personnel. The use of ICT secured DTU laptops and protected communication channels will ensure the data is safe.
Implementation Challenges:	It has always been problematic to find a number of residential EV owners that would like to participate in the trial. Moreover, the same strategy was being tested in public parking places, on the same type of chargers, and provided good results. Hence, the extension to the residential space.
Technical Requirements	
Name of Component/Service:	Eco Charging Mode
Type	Service
Functionality	The idea is to smart charge the EVs in a few residential locations throughout the Copenhagen region, based on the price signal set by the EV utility. The service covers some specific hours of the day, to be defined by analysing the historical consumption timeseries, and entails the communication of the status of the EV charging station (occupied/not occupied) to DTU, who runs a scheduling based on the cost to charge in the following hours. The optimal schedule is then sent to the charger via the Zaptec Go API, and a maximum current limit is set to minimise the charging cost.

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Input Connections & Interfaces	Inputs: 1) **Outlet status (occupied/not occupied),** from the Zaptec API (charging station). 2) **Electricity cost,** from electric utility chosen by the residential customer.
Output Connections & Interfaces	Outputs: 1) **Max. current setpoint**, to EV station.
Software Requirements/Development Language	Not defined
Hardware Requirements	Not defined
Status of the development of the component	The service has been successfully tested in public charging locations (curbside chargers), so it needs to be tailored to the new location (residential). TRL 5-7.

3.2. Use Cases for data exchange across EV stakeholders

3.2.1. Italy

Italian Demo, which will take place in Rome, aims to deploy a complete turn-key innovative solution enabling the massive smart charge/V2G services implementation, maximizing the benefits for all stakeholders, including TSO, DSO, CPOs, Mobility Service Provider (MSP), Aggregators and EV drivers.

The demo investigates how the electrical system, and all involved stakeholders, can take benefit from massive spread of EV charging. Thanks to a comprehensive partnership including TSO, DSO, CPO, Aggregator, RTO and EV drivers, the demo deploys a comprehensive set of solutions for a range of services in a coordinated manner.

This set of solutions includes the components described in Ch 3.1:

- Flexibility Register
- DSO Technical Platform
- Crowd Balancing Platform (CBP)
- FlexCore/VPP Manager
- Energy Services Platform
- EvOS (charging station management system)
- End-user apps (e.g., Enel X Way app)

In the preliminary version of the Italian Demo use cases, all these platforms must interact with each other for implementing EV-driven services.

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Analysing the specifications provided about the platforms in terms of data, input and output, it was possible to identify a preliminary list of data to be exchange among the platforms in order to implement these services.

The Table 14 below summarize the list of data exchange and possible actors/platform involved.

Table 14. Data exchange use cases - Italian Demo.

Data Provider	Data Consumer	Exchanged Data	Service
EV User (BAL + FR)	DSO/TSO	Metering Data	Observability
EV User (BAL + FR)	DSO/TSO/Aggregator	Metering Data	Flexibility Market
DSO (DSOTP)	BAL	Flexibility Activation	Flexibility Market
EV User (User App)	CPO	User Data	Charging Scheduling
EvOS	CPO	EV Data	Charging Scheduling
EvOS	CPO	Charger Data	Charging Scheduling
DSO	CPO	Grid Data	Charging Scheduling
CPO	EvOS	Scheduling Data	Charging Scheduling
CPO	Aggregator	Metering Data	Settlement
CPO	EV User	Flexibility Activation	Flexibility Market
DSO/TSO	FlexCore	Dispatch instructions	Flexibility Market
DSO/TSO	FlexCore	Bids	Flexibility Market

In the context of the Italian Demo, a key role in the data-driven ecosystem and data exchange is played by the Crowd Balancing Platform (CBP) components which act as an orchestrator among the control platforms adopted by actors involved in EV charging and management chain.

The CBP developed by a group of TSOs including TERNA, is a blockchain digital tool, based on open API infrastructure to support the grid energy balancing by guaranteeing that all flexibility transactions are tracked in a secure and unchangeable register. CBP provides a transversal framework involving relevant stakeholders through which small resources provide flexibility to the ancillary services market, promoting efficient coordination among the stakeholders, reliable transactions validation between market players and grid operators and settlement.

In FLOW, CBP will be improved in T5.5, including new services and enabling the effective interaction with multiple platforms owned by mobility and system operators.

In this context, the CBP will act as an orchestrator in the Data Space ecosystem and through a Data Space Connector will act as interfaces to allow synchronisation and data exchange.

In the Figure 11 below, a schema of data exchange and orchestration using CBP is represented.

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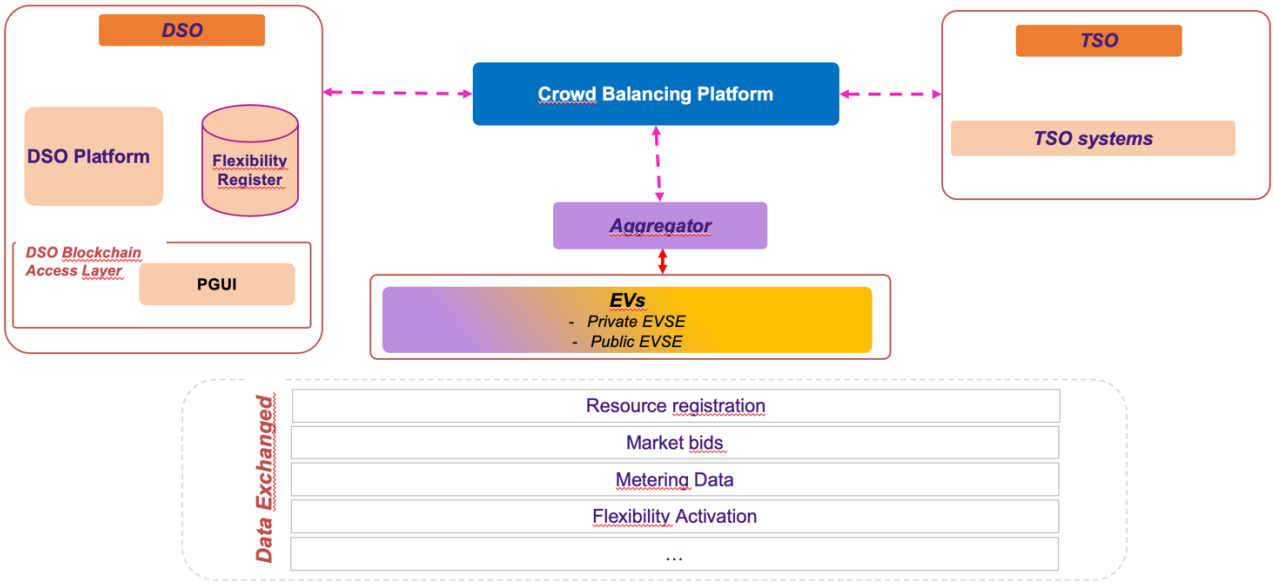

Figure 11. Italian Demo - Data exchange use cases based on CBP orchestration.

3.2.2. Spain

The demo in Menorca focuses on the provision of EV based Flexibility Services (henceforth EV-FSs) in the typical context of a small island in the Mediterranean Sea. The situation is that of a small grid entirely operated by the DSO that faces high seasonality both in the RES production as well as in load demand as consequence of the touristic season. The grid is already operated close to its technical limits in several parts of the island, where V1G and V2G charge points will be installed and operated.

In this context, the two most important *business requirements* that EV-FSs must address are (1) support the integration of newly installed RES capacity and (2) mitigate congestion issues at the distribution level.

Focussing on the provision of the Flexibility Service to the DSO, it is possible to draw the backbone ICT architecture that supports all the information exchanges and the two Use Cases needed for the actual service provision:

- Use case 1 (UC1): FS service procurement on the Local Market Operator platform.
- Use case 2 (UC2): FS activation – after market clearing.

Similarly to the list for the Italian demo (par. 3.2.1), and with reference to the analysis in par. 3.1, the demo in Menorca requires the following platforms/modules:

- Flexibility Register – module on the DERMS and OMIE platforms
- DSO Technical Platform – DERMS platform
- Energy Services Platform – OMIE Local Market Operator platform (LMO)

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- FlexCore/VPP Manager – the Aggregator, or Flexibility Service Provider (FSP) platform
- EvOS (charging station management system) – the Flexibility Resource (FR) platform

The information exchanges and the use cases discussed below expect the DSO and the LMO to have previously agreed on the technical definition of a particular Flexibility Service and that the DSO was able to qualify the V1G/V2G Charge Points to meet the technical requirements for the service provision.

ACTORS/PLATFORMS and roles in the FS provision

Distribution System Operator (DSO)

- *not discussed here* - defines the FSs available on the LMO and qualifies the FSPs
- UC1 – sends flexibility needs to the LMO platform
- UC1 - qualifies the FS bids received from the LMO platform
- UC2 – sends the FS activation signal to the FSP

Local Market Operator (LMO)

- UC1 - receives the DSO flexibility needs and publish the FS auction on its LMO platform
- UC1 - sends the FS bids to the DSO for qualification
- UC1 - clears the FS market after the DSO qualification

Flexibility Service Provider (Aggregator):

- UC1 - send their FS bids to the LMO platform
- UC1 - receive the market clearing signal from the LMO
- UC2 - receive the FS activation request from the DSO
- UC2 - send the load balance request to the FR/CPO

FR/CPO:

- Sends meter data to the DSO and to the FSP
- receives and execute the load balance command from the FSP

USE CASE 1 (UC1): Flexibility Service procurement on the Local Flexibility Market

The sequence diagram of the Flexibility Service contractual procurement on the Local Market Operator platform is reported in **Figure 12**. Briefly:

1. as soon as the DSO identifies short-term grid criticalities (expected in following 2 to 5 days, and prior to the settlement of the European Wholesale day-ahead markets), it sends the FS auction parameters to the LMO, which in turn opens a dedicated auction.
2. After receiving the best bids from each different FSPs, the LMO forwards them back to the DSO for the final technical qualification.

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a. The DSO chooses the ones which are technically suitable to solve the issue and informs back the LMO, which chooses the optimal offer from the economic standpoint and clears the market. As can be seen, this Use Case does not involve the actual Flexibility Resources (ie the CPO), but all the information exchanges are kept between the DSO, the LMO and the FSPs.

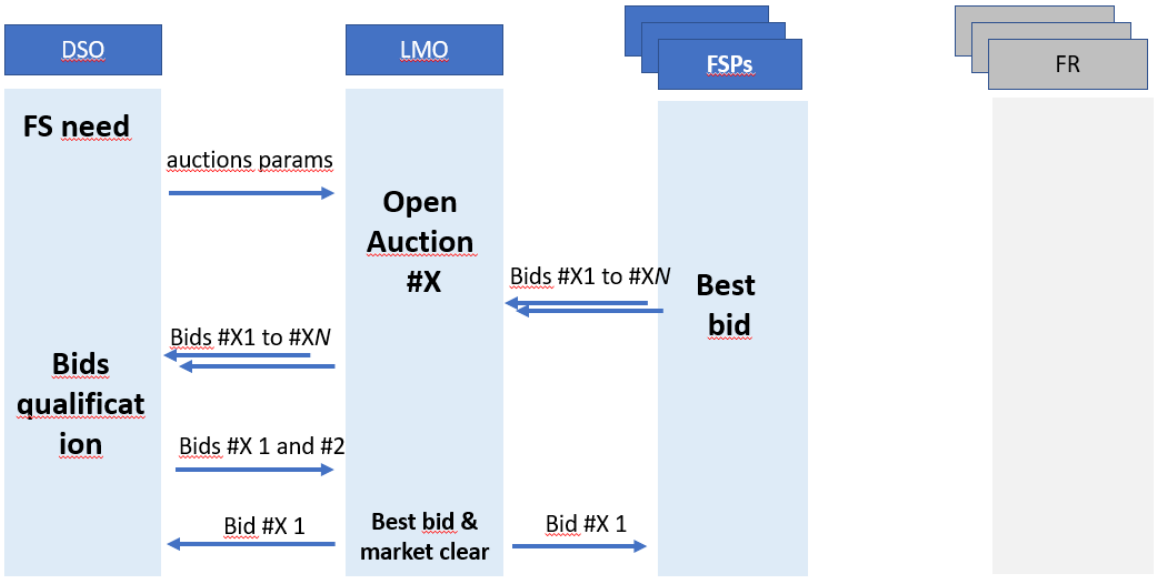

Figure 12. Sequence Diagram of the Flexibility Service procurement on the Local Market Operator platform.

USE CASE 2 (UC2): Flexibility Service activation – after market procurement

The sequence diagram of this Use Case is illustrated in **Figure 13**. Briefly, after UC1 the DSO is entitled to ask for the activation of the Flexibility Service that was previously contracted. In this case the LMO is not involved in the information exchanges and the DSO directly sends the activation signal to the Flexibility Service Provider, which in turn sends the proper control commands to the V1G/V2G Charge points (or *Flexibility Resources*). It is important to note that the communication between the DSO and the FSP is not limited to the provision of the flexibility service, but at all times the FSP is responsible to send meter data to the DSO in order to let the DSO run the real-time load forecasts/simulations and know if the contracted FS is still technically feasible, since the service was contracted at least one day before.

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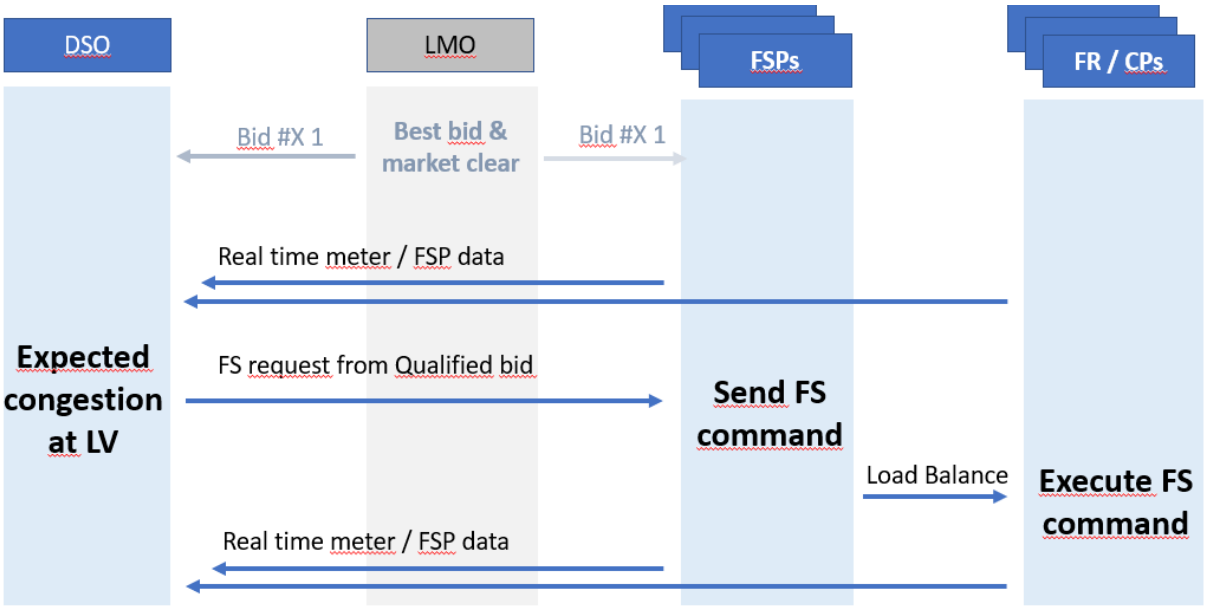

Figure 13. Sequence Diagram of the Flexibility Service activation after market procurement.

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3.2.3. Denmark

The Danish demo will execute four distinct use cases, deploying them to various locations: DTU Main Campus, Lyngby (Usecase-1), Adolph Steens Alle (Usecase-2), DTU Risø Campus, Røskilde (Usecase-3), and residential charging scenarios (Usecase-4) in collaboration with Spirii. The primary objective is to implement charging control mechanisms that optimize the charging cost of Electric Vehicles (EVs) for enhancing both technical and economic benefits for stakeholders. These stakeholders include campus entities, the general public, and residential EV users. Interaction will occur among EV users, Charging Point Operators (CPOs), parking lot aggregators, Distribution System Operators (DSOs), Wind/PV plant operators, and residential house owners.

Technical benefits encompass the provision of ancillary services such as frequency regulation, peak-load consumption reduction, and leveraging renewable energy sources. Economic benefits involve charging cost optimization and increasing parking lot benefits, including incentives. Key interactive components in these use cases involve EV users, aggregators, CPOs, DSOs, and Transmission System Operators (TSOs). The software platform partners include DTU CAS software, Spirii ADM, Zaptec APIs, and EATON's EMS, offering various service solutions, including:

- Grid-constrained emissions minimization (centralized).
- Dynamic transformer capacity allocation for different EV charging clusters.
- Maximizing Renewable Energy Source (RES) exploitation and Frequency Containment Reserves (FCR-n) provision (collaboration between Spirii ADM and EATON's EMS).
- Maximizing RES exploitation and FCR-n provision (cooperation between Spirii ADLM and EATON's EMS).
- Cost-based smart charging in a fixed time period.

The Danish Demo aims to develop an interactive software platform enabling seamless interaction among stakeholders to implement EV flexibility services effectively. The developed platform will analyse the specifications of different input and output data to facilitate interaction among participating stakeholders. Considering the stakeholders and their interactions, a preliminary list of data exchange requirements among platforms has been identified for the effective implementation of these services and are presented in Table 9.

Table 9. A representation of the different actors and their data exchange among the four use cases - Denmark Demo.

Use Case	Data Provider	Data Consumer	Exchanged Data	Service
Use Case 1	EV User	DTU CAS Software	User Data	Observability
	EVSE (Status)	DTU CASE Software	Status Data	Observability
	CPO	DTU	Consumption Data	Observability
	TSO	DTU CAS Software	Electricity mix	Flexibility Market
	Spirri	DTU CAS Software	Energy timing	Scheduling
	DTU	DTU CAS Software	Max Current Setpoint	Control

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Use Case 2	EV User	Zaptech API	User Data	Observability
	Zaptec API	DTU	Consumption Data	Observability
	CPO	DTU	Control Data	Control
	Radius DSO	DTU	Constraints	Regulation
	Grid	DTU	Real-time Load	Observability
	DSO Database	DTU	Forecasting Load	Observability
	DTU	Zaptech API	Current Setpoint	Control
Use Case 3	Spirii ADLM	Zaptec Charger	EV Schedule Data	Scheduling
	Zaptec Charger	DTU SysLab	Consumption Data	Observability
	Zaptec Charger	Spirii ADLM	EVSE Status Data	Observability
	Wind/PV Plant	DTU	RES Production Data	Observability
	Spirii ADLM	EATON's EMS	EVSE Status Data	Observability
	Spirii Database	EATON's EMS	Charging time	Scheduling
	EATON's EMS	Spirii	EV Schedule	Scheduling
	DTU SysLab	EATON's EMS	RES Production	Observability
Use Case 4	EV User	Zaptech Charger	User Data	Observability
	Zaptech Charger	Zaptech API	Status/Consumption	Observability
	Zaptech API	Zaptech	Setpoint	Control
	CPO	DTU	Enable Control	Control
	Spirii Database	DTU	Charging Time	Scheduling
	Electricity Providers	EV Users	Bill	Market

Use Case 1: In the implementation of the Denmark Demo, the following functional components are identified for Use Case 1 at DTU Main Campus, Lyngby, involving smart charging with 12 chargers of 22 kWh each and is shown in **Figure 14**.

Actors and Roles:

1. EV users connect to the chargers.
2. The CAS software interfaces with the DTU chargers.
3. Spirii CPOs provide control charging.
4. TSO provides electricity data.
5. Spirii Database supplies charging schedule timing information**.**

Dataflow and System Functionality:

1. EVs connect to the chargers through DTU's CAS Software interface, where EV user data is collected for observability and charging services provision.
2. DTU chargers collect electricity data, charging timing schedule data, and electricity consumption data from TSO, Spirii Database, and Spirii CPOs.

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3. Spirii utilizes the CAS Software interface to collect the consumption data of the EVs.
4. DTU controls the charging of EVs through setpoints (scheduling) via the CAS Software platform.

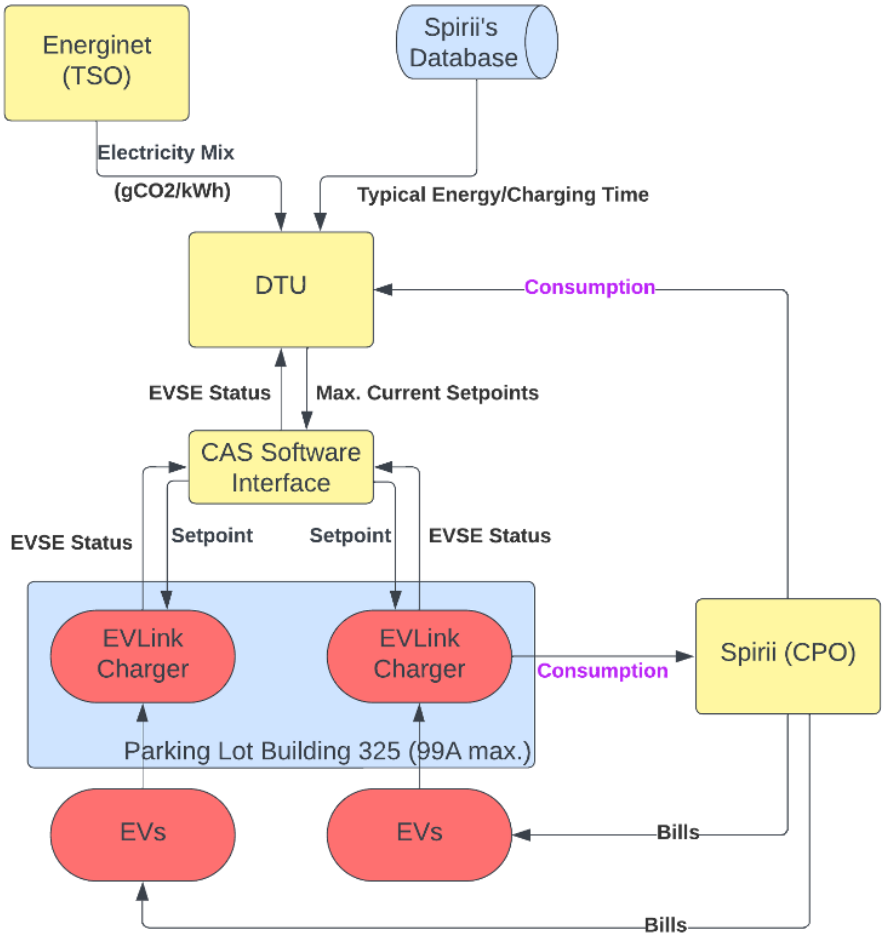

Figure 14. Use case 1: DTU Main Campus, Lyngby smart charging with 12 chargers of 22kWhs.

Use Case 2: Cluster Charging of EVs with DTU and Zaptech API in Adolph Steens Alle Shared Charging Space and is presented in Figure 8.

Actors and Roles:

1. EV users connect to the Zaptec chargers through the Zaptec API.
2. The Zaptec API serves as the interface between EVs and DTU.
3. The DSO and Spirii CPOs are connected with DTU to provide updates.
4. The grid or DSO data is collected by DTU for controlling the charging of connected EVs.

Dataflow and System Functionality:

1. DTU collects real-time grid load data from LV/MV transformers or forecasted load from the DSO database to comprehend the grid load for optimal control of EVs charging load.

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2. Network constraints are provided by Radius DSO, and CPOs offer the control mechanism to DTU.
3. DTU sends a setpoint scheduling mechanism to EVs through the Zaptec API, while the same Zaptec API updates DTU on EVs' charging consumption.

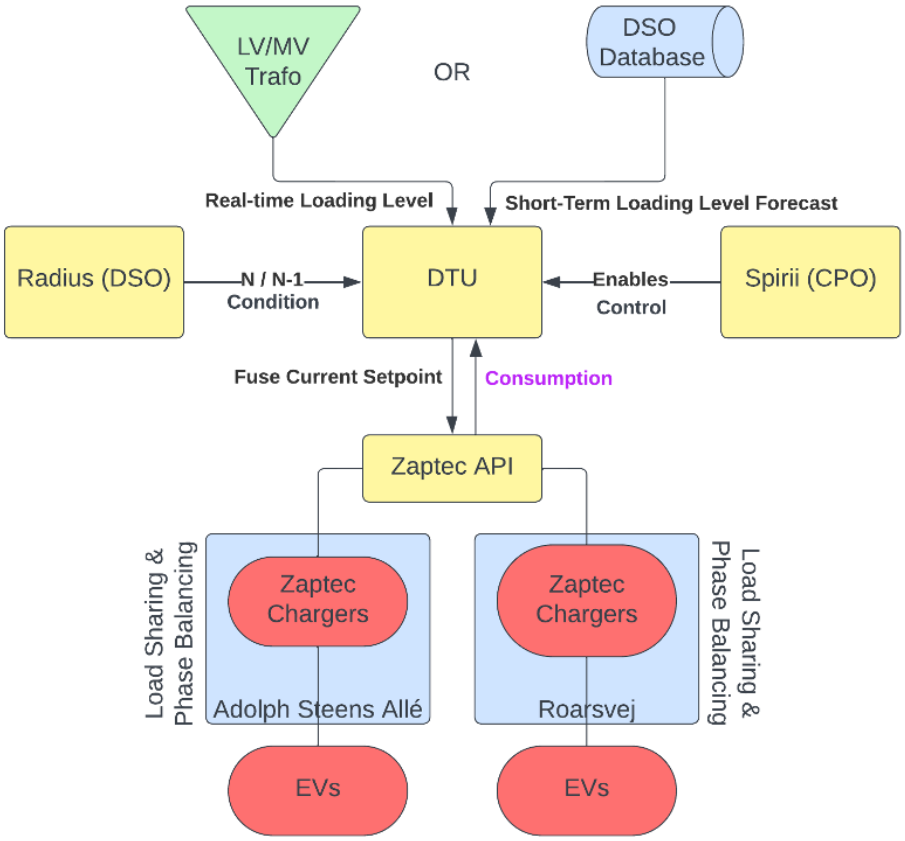

Figure 15. Use case 2: Cluster Charging of EVs with DTU and Zaptech API in Adolph Steens Alle Shared Charging Space.

Use Case 3: Maximizing Renewable Energy Sources (RES) Exploitation at DTU Risø Campus, Røskilde, through Collaboration Between DTU and EATON and is visualized in **Figure 16**.

Actors and Roles:

1. Zaptec chargers connect to DTU's Syslab to update EV charging consumption.
2. Wind/PV plants connect to DTU's Syslab to update RES production.
3. DTU's Syslab connects to EATON's for updating RES production.
4. Spirii database sends charging timing to EATONs.
5. EATON's connect to Spirii to send EV scheduling.
6. Spirii ADLM gets the charging updates and provides them to EATON.

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Dataflow and System Functionality:

1. DTU collects real-time grid load data from LV/MV transformers or forecasted load from the DSO database to comprehend the grid load for optimal control of EVs charging load.
2. Network constraints are provided by Radius DSO, and CPOs offer the control mechanism to DTU.
3. DTU sends a setpoint scheduling mechanism to EVs through the Zaptec API, while the same Zaptec API updates DTU on EVs' charging consumption.

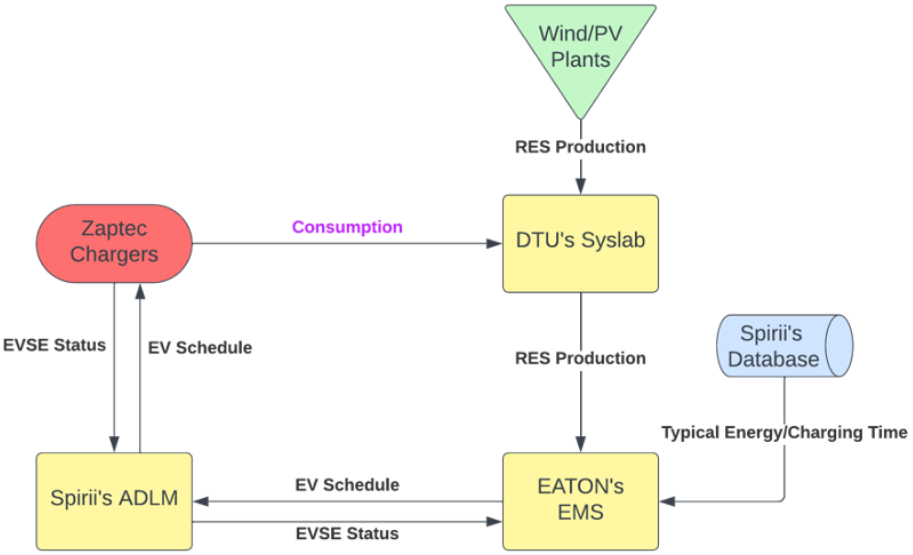

Figure 16. Use case 3: Maximizing the RES utilization in the DTU and EATONs collaboration scenarios.

Use Case 4: Residential Charging of EVs Based on Charging Cost and is shown in **Figure 17**

Actors and Roles:

4. EV users connect to Zaptec chargers, providing their input data.
5. DTU connects to Zaptec chargers through Zaptec APIs to control the charging of EVs.
6. Spirii database sends charging timing information to the DTU.
7. Spirii CPOs connect to the DTU, providing control mechanisms.
8. DTU interacts with Zaptec chargers through the Zaptec API platform.
9. Electricity providers provide cost and billing information to the DTU and EV users.

Dataflow and System Functionality:

10. Zaptec chargers are connected to the DTU, updating them with EVSE status and charging load consumption of EVs. The Zaptec API is also used to collect EV user data, which is then passed to the DTU for observability and charging decisions.

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11. DTU collects control information from Spirii CPOs and charging timing information from the Spirii database, while electricity cost information is collected from electricity providers.
12. DTU controls charging and sends setpoint scheduling commands to Zaptec chargers through the Zaptec API interface.
13. Electricity providers provide charging cost information to EV users and the DTU.

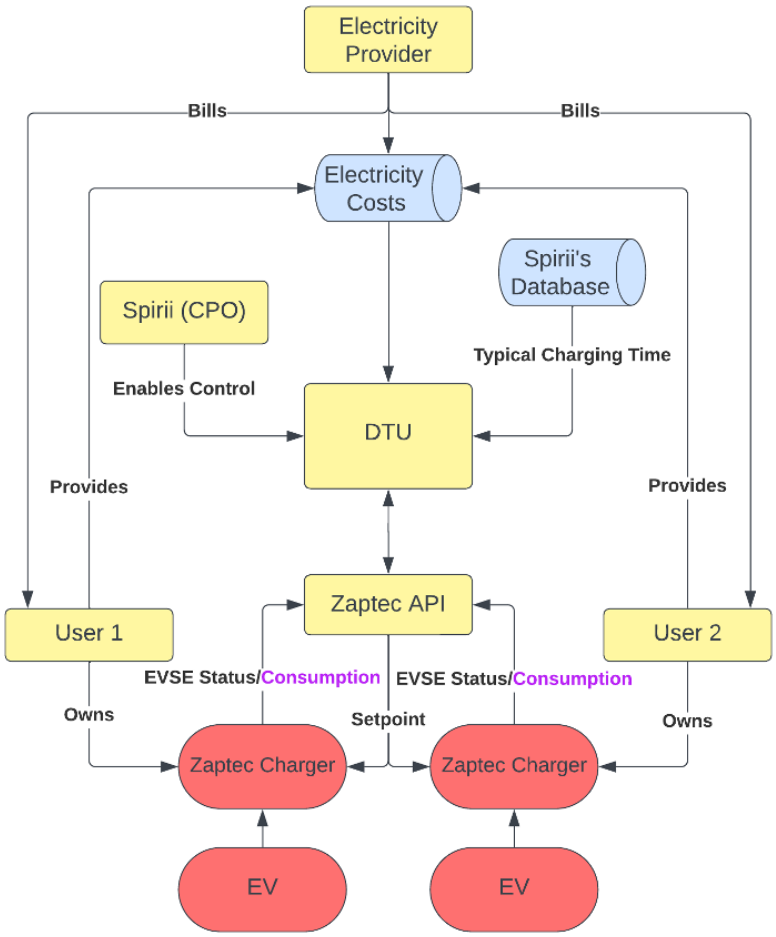

Figure 17. Use case 4: Residential charging of EVs based on the charging cost.

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4. Technologies and specifications for data sharing in the FLOW ecosystem

4.1. Technological Building Blocks

The main goal of the Data Space technical architecture is facilitating the sharing of data between different parties in a secure and trustworthy fashion.

The technological building blocks described in this chapter are crucial for the implementation of the technical architecture of a data space. They include core tools, middleware components and standardized interfaces (APIs).

Based on the analysis reported in Ch.**Error! Reference source not found.**, several data space technological components were already implemented and made available in several initiatives and projects. Starting from the requirements and expectation for data sharing within the FLOW ecosystem, the most relevant were identified.

4.1.1. Data Space Connector

The Data Space Connector is probably the key technological budling block for implementing a Data Space Architecture. Data Connectors are crucial to share data enabling secure and effective communication and exchange in data spaces.

A Connector is a tool to connect many data endpoints to increase the pool of available data and to accelerate the data economy. Connecting data connectors, data spaces become protected environments where participants can freely share data. Data sovereignty, transparency and fairness are ensured by adherence to a set of rules. Data connectors act as nodes in a Data Space and provide data sovereignty by design [22].

Following the Data Space analysis results described in Ch. **Error! Reference source not found.**, the Data Space Connector must implement:

- **end-to-end data exchange** process leveraging on standardized interfaces (APIs) and Broker for information flow and communication.
- trustworthy **data handling with policy enforcement** mechanisms and a common baseline for cybersecurity
- **data sources and data-driven services publishing and discovery mechanisms**, making use of common descriptions of resources, services, and participants. Such descriptions can be both domain-agnostic and domain-specific. They should be enabled by semantic-web technologies and include linked-data principles.

In the chapters below, are reported the technological components that addresses and implements all the main characteristic of a Data Space Connector.

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4.1.1.1. Broker

The Broker of a Data Space Connector is the main gateway of each Data Space Actor for accessing data exchange and provide data in the data-driven ecosystem.

Following CEF considerations [23] and OneNet project results, a Context Broker should be a core technical building block for enabling standardized interfaces for data exchange. Context Broker makes it possible to create interfaces that makes it easy for anyone to view and interpret data. Using the Context Broker, it is possible to share the context information you choose with third parties, enabling process improvements and innovation across the whole data value chain.

The most used Context Broker is the FIWARE Orion Context Broker.

FIWARE Orion Context Broker, which is the core component of the FIWARE platform and implements the Next Generation Service Interface NGSI standard to deploy the Publish/Subscribe architecture. In particular, the Orion Context Broker is one of the nine CEF building blocks [23], whose aim is to help to implement the most commonly needed digital capabilities among Europe. In addition to this, FIWARE is integrated onto the International Data Spaces [1].

In FIWARE framework, Orion Context Broker is a key service to ease the development and provisioning of smart and innovative applications that require context information and data stream management, processing and exploitation. The Orion Context Broker [24] is an HTTP Publish/Subscribe implementation—based on the NGSI standard—that enables management of the entire lifecycle of context information including updates, queries, registrations, and subscriptions. Orion Context Broker has been recognized as a CEF Building Block, which is one step forward on its path towards becoming a global standard for large-scale contextual information management. Orion allows defining a model of data (i.e., entity) to which publishers update values to be obtained by subscribers. Orion uses the NoSQL MongoDB database to store these entities and the last value recorded on them.

The evolution of the FIWARE Orion Context Broker is the Orion-LD Context Broker, which extend the NGSI standard for supporting Linked Data (LD) which is including entities relationships, property of graphs, and semantics. This revolution has been conducted under the ETSI CIM initiative and named NGSI-LD.

Orion-LD complies with 95% of the ETSI standards 1.2.1 specifications (excluding the temporal API).

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4.1.1.2. Usage and Access Control

This building block guarantees enforcement of data access and usage policies defined as part of the terms and conditions established when data resources or services are published (see 'Publication and Services Marketplace' building block below) or negotiated between providers and consumers. A data provider typically implements data access control mechanisms to prevent misuse of resources, while data usage control mechanisms are typically implemented on the data consumer side to prevent misuse of data. In complex data value chains, both mechanisms are combined by prosumers. Access control and usage control rely on identification and authentication.

Usage Control allow to define Usage Policies and Usage Enforcement. Each Data Provider can define usage control policies for their data, attached to the outbound data. Therefore, Data Space participants can be sure, that their data are treated according to their usage policies.

The Usage Control should address three aspects:

- Data Control Management, the Usage control should be able to apply all the defined policies to any data exchange interacting with the Data Space Connector and should allow the possibility to administrate the overall data access and usage control process.
- Policy Definition, Data Provider must be able to create at runtime its Data Usage Control policies, to be applied to different data exchanges. A policy specification dashboard should support the Data Provider in the process of policy specification.
- Policy Enforcement, the Policy Enforcement should be able to monitor, filter and mask data based on the predefined rules (e.g., anonymize personal data, remove specific information, send notifications and alerts). It should also be able to add additional enforcement rules based on external information like location, context and purpose.

4.1.1.3. Data Exchange APIs

This building block facilitates the sharing and exchange of data (i.e., data provision and data consumption/use) between data space participants.

The Data Exchange APIs are strictly linked with the Context Broker and must be responsible for implementing the complete end-to-end data exchange process leveraging on the standards (e.g., NGSI-LD), as well as for offering standardized interfaces for the integration of the external platforms and systems through the Data Space Connector.

This building block should also address data format and data models specifications, establishing a common format for data model specifications and representation of data in data exchange payloads for ensuring fully interoperability among participants.

In addition, the Data Exchange APIs should also ensure data provenance and traceability, tracing and tracking all the process of data provision and data consumption/use. This feature is strictly linked with the Clearing House building block and provides the basis for the logging of transactions and accountability.

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4.1.1.4. Data Catalogue and UI

This building block facilitates dynamic expansion of the data space. It supports the discovery of data sources and data-driven services.

It should incorporate publishing and discovery mechanisms for data resources and services, making use of common descriptions of resources, services, and participants. Such descriptions can be both domain-agnostic and domain-specific. They should be enabled by semantic-web technologies and include linked- data principles.

All these functionalities can be implemented in a dedicated UI of the Data Space Connector, facilitating the discovery and publishing of data sources as well as the participation on the Data Space.

It should also include capabilities for publishing data resources in a standard and well recognised way, possibly following already know Data Catalogue Vocabulary.

4.1.2. Clearing House (Logging system and accounting)

The **Clearing House** act as an intermediary that logs all activities performed during data exchange in the IDS ecosystem and it therefore provides clearing and settlement services for all financial and data exchange transactions.

Data in the Clearing House should be registered in an irrefutable way, in order to ensure the accounting access to and/or usage of data by different users. If dispute arises the Clearing House must be used as trusted third party to resolve this issue by providing secure and trusted logging system.

4.1.3. Identity Management

The Identity Management building block allows identification, authentication, and authorisation of stakeholders operating in a data space. It ensures that any Data Space Participant (organisations, platforms, and other actors) are provided with acknowledged identities, and that those identities can be authenticated and verified, including additional information provisioning, to be used by authorisation mechanisms to enable access and usage control. The IDM building block can be implemented on the basis of readily available IDM platforms that cover parts of the required functionality. Examples of open-source solutions is KeyCloak [ref] also used in OneNet solution or the FIWARE IM framework [ref]. Integration of the IM building block with the eID building block of the Connecting Europe Facility (CEF), supporting electronic identification of users across Europe, would be particularly important.

4.1.4. Data and Service Orchestration

Orchestration for services and data offers several benefits, particularly on contexts where many interconnected systems and services are present, such as a Data Space ecosystem.

Orchestration of data services are not mandatory in a Data Space concept but can bring many advantages:

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- Integration management: orchestration allows managing a data services interactions in a unique point.
- Resilience: an orchestration system can detect failures and automatically alert data services, thereby increasing the resilience of the system.
- Scalability: with orchestration, services can be easily scaled up and down based on demand, allowing for a flexible response to changes in workload.
- Monitoring: orchestration systems can provide monitoring tools that allow visualizing the status of the system and identifying issues proactively.

Data orchestration offers similar benefits, allowing for more efficient and effective management of data between different services and systems.

In particular, data orchestration is the organization and management of data between different systems and services distributed over a network. The objective of data orchestration is to ensure that data is readily available and easily accessible to the systems and services that require it. Additionally, it aims to maintain the consistency and integrity of the data.

In a Data Space architecture, for example, data orchestration can be used to ensure that data is available to all services that need it. Additionally, data orchestration can be used for efficient distribution of data, while optimizing the use of resources.

4.2. FLOW Data Space Architecture

Following the core technological building blocks and the data-exchange use cases and requirements identified so far, is possible to design a **high-level Flow Data Space Architecture** that can represent the creation of the enable data driven markets for electromobility.

This high-level architecture and concepts will be used and elaborated in T5.5 for the integration among the CBP and the other platforms.

4.2.1. Architecture and design

The result of all the analysis conducted so far highlighted how a Data Space architecture can provide several benefits on the integration of V2G and V1G technologies in electromobility sector.

The data-driven economy a key pillar for enabling these new technologies in a seamless way, ensuring a proper application in the already existing infrastructure and system.

For this reason, the approached suggested by the more relevant initiative on Data Space, of implementing a decentralized Data Space architecture over upon existing platforms, is for sure a disruptive solution.

In this context, analysing the possible use case in the electromobility sector for data exchange, is also important highlight how an orchestration system can play a key role on facilitating the integration of existing system in an interoperable and standardized way.

In the proposed architecture, shown in **Figure 18**, the decentralized Data Space approach and the CBP Orchestration approach are merged in a hybrid architecture.

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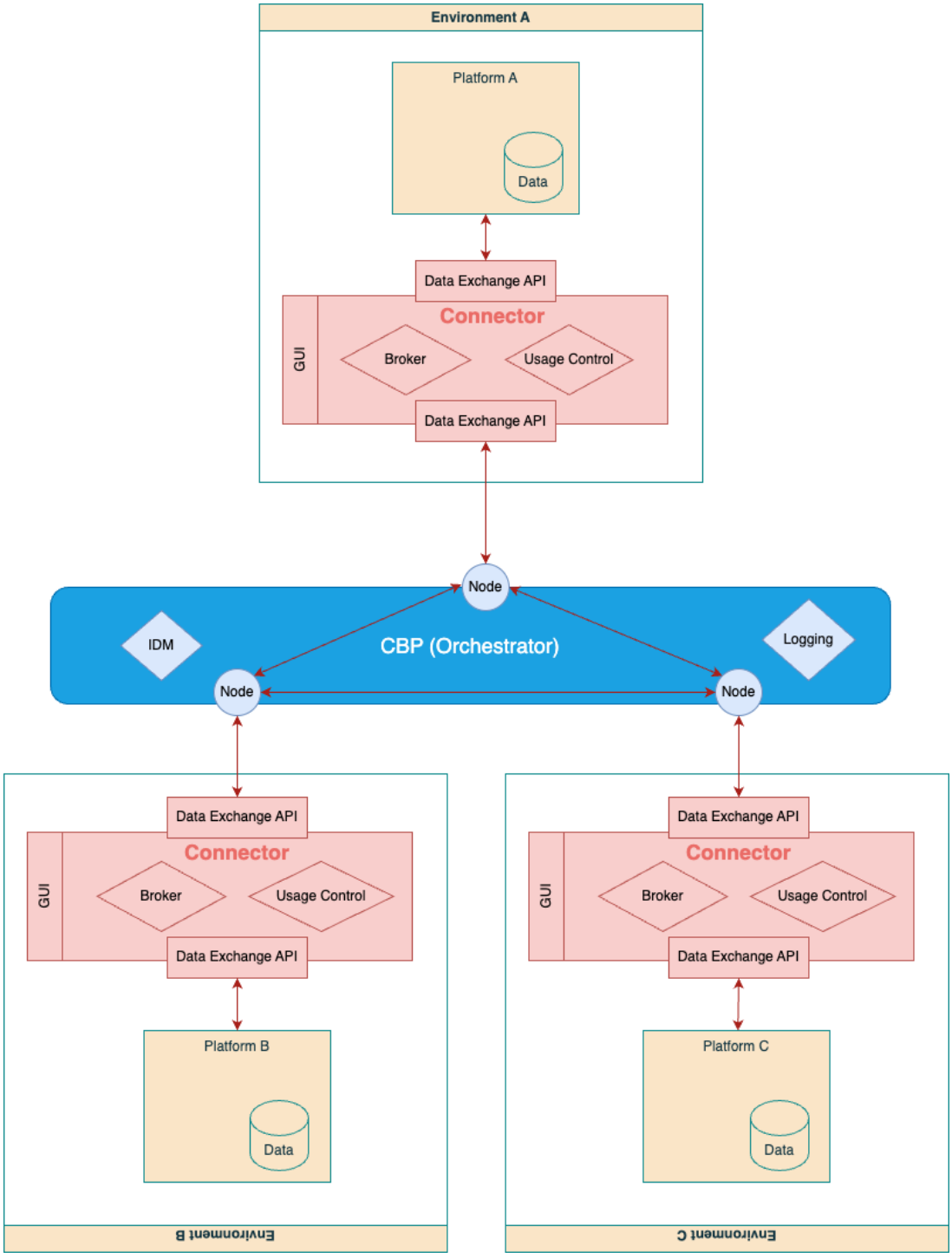

Figure 18. FLOW Data Space Architecture.

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The CBP act as a middleware in the FLOW Data Space Architecture, providing centralized features like Identity Management and Logging system, as well as an orchestrator, in which any Data Space Participant can register its own node and participate in Data Space ecosystem.

The Data Space Connector implements the decentralized mechanisms of the Data Space Architecture, ensuring a secure and trusted data exchange among all the Data Space Participants.

More in detail the Data Space Connector should include:

- **Data Exchange APIs,** for integrating the existing platforms services and data, as well for connecting the CBP nodes.
- **Context Broker**, for encapsulating the data payload in a standardized way, ensuring a high level of interoperability.
- **Usage Control,** for data access and usage management, providing the possibility to define new policies and control that the data exchanged is allowed correctly.
- **Graphical User Interface (UI),** for facilitating the configuration of the connector, accessing the Data and Service Catalogue and linking platform services and data in an easy way.

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5. Conclusions

In conclusion, the data space in the electromobility sector concerning V1G and V2G involves diverse aspects such as user behaviour, grid management, energy optimization, and infrastructure development. Efficient data handling and analysis are crucial for the successful integration and utilization of V2G and V1G technologies within the broader electric vehicle ecosystem.

An effective Data Space Architecture for electromobility sector can resolve data exchange issues by establishing standardized protocols, ensuring data security and trust, fostering collaboration, adhering to regulatory frameworks, and leveraging analytics for optimization. It acts as the backbone for efficient and transparent data exchange among diverse stakeholders, contributing to the successful integration and operation of V1G and V2G systems.

The preliminary versions of Use Cases elicited by Demo partners, do not give an exhaustive overview of what could be all the possible use cases relating to the data exchange, but they provide us with the first insights into how these interactions between several energy stakeholders are necessary and essential for the implementation of innovative EV based services.

The Data Space Architecture proposed in this document, try to meet these needs and integrates the most used approach in the Data Space projects, which provides a completely decentralized environment, an orchestration system.

The Orchestration system implemented using the Crowd Balancing Platform (CBP), in addition to implementing typical orchestration services, can also act as middleware in the FLOW Data Space architecture, providing centralized functionality such as identity management and logging system.

The results of this analysis and the FLOW Data Space Architecture will be consolidated and elaborated in T5.5, which will focus among other things, on the integration among the CBP and the other platforms.

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6. References

[1] https://internationaldataspaces.org
[2] https://gaia-x.eu
[3] https://docs.internationaldataspaces.org/ids-knowledgebase/v/ids-ram-4/introduction/1_1_goals_of_the_international_data_spaces/1_2_purpose_and_structure_of_the_document
[4] https://gaia-x.eu/wp-content/uploads/2022/06/Gaia-x-Architecture-Document-22.04-Release.pdf
[5] https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu
[6] https://ec.europa.eu/energy/sites/default/files/documents/bridge_wg_data_management_eu_reference_architcture_report_2020-2021.pdf
[7] https://op.europa.eu/en/publication-detail/-/publication/dc073847-4d35-11ee-9220-01aa75ed71a1/language-en/format-PDF/source-294051153
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560
[9] https://onenet-project.eu
[10] https://onenet-project.eu/wp-content/uploads/2023/09/OneNet_D6.4_v1.0.pdf
[11] https://www.platone-h2020.eu
[12] https://platone-h2020.eu/data/deliverables/864300_M12_D2.1.pdf
[13] https://lfenergy.org/projects/sogno/
[14] https://www.opendei.eu
[15] https://www.opendei.eu/wp-content/uploads/2022/09/OPEN-DEI-Energy-Data-Spaces-EHM-v1.0.pdf
[16] https://mobility-dataspace.eu
[17] https://mobility-dataspace.eu/use-cases
[18] https://mobility-dataspace.eu/data-catalogue
[19] https://www.eebus.org
[20] https://github.com/spine-tools/Spine-Toolbox
[21] https://www.eebus.org/release-eebus-use-case-specification-e-mobility
[22] https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Data-Connector-Report-90-No-10-November-2023-6.pdf
[23] https://joinup.ec.europa.eu/collection/egovernment/solution/cef-context-broker/about
[24] https://fiware-orion.readthedocs.io/en/master/

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Annex 1 – FLOW Components Business and Technical Requirements - Template

WP and Task reference	<specify in which WP and specific task the component is connected and developed>
Responsible	<specify responsible partner and main contact person>
Deadline	
Business Requirements	
Objective	<what is the problem that this service/component address and solve, and why is it necessary to address it>
Actors:	<who are the organisations/operators involved in providing the service, and what is their role >
Platform involved in delivering the functionality:	<Equigy, Sogno, CBP, Enel X proprietary platform>
Opportunities	<who is paying for this service, or what are the benefits/opportunities related to this service>
User/Consumer:	<who is the user or consumer of the feature, is he paying, what is the added value>
Data specification:	<who is the owner of the data and are the data sensitive (involve personal or protected data)>
Threats:	<are there any concerns related to the implementation of this feature>
Implementation Challenges:	<why this service it has not been already implemented, and what are the challenges to moving forward>
Technical Requirements	
Name of Component/Service:	<please write here the name of the architectural element e.g. Market Platform (Component) or State Estimation Tool (Service)>
Type	<*Component* or *Service*>
Functionality	<please write here in free text a short description of the operation of this module/component. A list of functions and operations will be a plus>
Input Connections & Interfaces	<please write the components from which it receives input (input dependencies) and mention if possible the available connection interfaces e.g. API etc.>

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Output Connections & Interfaces	<please write the components to which it sends the results (output dependencies) and mention also the available interfaces e.g. API etc.>
Software Requirements/Development Language	<specify any software requirements related to the architectural element, explain the Programming Language that is used during the development of the component>
Hardware Requirements	<specify what hardware requirements are of the module, give specifications about the hardware requirements which are necessary for the best functionality of the component>
Status of the development of the component	<specify if the component is “already developed” or “partially developed” or “to be developed from scratch”. Starting TRL would be a must>

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