Enershare

The Energy Data Space for Europe

European Common Energy Data Space Framework Enabling Data Sharing - Driven Across – and Beyond – Energy Services

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D2.1 Use cases' descriptions and list of minimum Data Space building blocks required for pilots

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List of Acronyms

API	Application Programming Interface
BDVA	Big Data Value Association
CEC	Citizen Energy Communities
CPO	Charging Point Operator
DSO	District System Operator
DER	Distributed Energy Resources
EC	European Commission
EV	Electric Vehicle
GDPR	General Data Protection Regulation
HEMRM	Harmonized Electricity Market Role Model
IDSA	International Data Spaces Association
IEC	International Electrotechnical Comission
IM	Identity Management
IoT	Internet of Things
KPI	Key Performance Indicator
ML	Machine Learning
NILM	Non-intrusive Load Monitoring
OEM	Original Equipment Manufacturer

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O&M	Operation & Maintenance
P2G	Power-to-Gas
PV	Photovoltaic
REC	Renewable Energy
RES	Renewable Energy Sources
RHFC	Regenerative Hydrogen Fuel Cells
RPF	Reverse Power Flows
SLA	Service Level Agreement
UC	Use Case
WME	Workflow Management Engine
WP	Work Package
XML	Extensible Markup Language

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Executive summary

The ENERSHARE project has the objective to build the grounds for a European Energy Data Space. This is to be achieved by the implementation of demonstration use cases in six different pilots across Europe.

This deliverable summarises the work performed in task 2.1 which gathered information on the use cases to present use case descriptions in a standardised manner according to IEC-62559-2. This enabled a cross-use-case analysis. Based on these descriptions, the requirements for data space building blocks have been derived. The eleven use case descriptions form the main content of this document. They are presented with short textual descriptions in section 3.2. The annex consists of the full use IEC 62559-2-case templates which will also be uploaded to the smart-grid-use-case repository. Another pilot is subject to changes and will be presented in an updated version of this document.

From the overview of the use cases it may be concluded that within the ENERSHARE project there is a balanced mix of actors both from the energy market and technology perspective and also from the digital value chain perspective. Several cross-use case collaboration opportunities have been identified. A common approach to electricity metering data based on domain data standards has the largest overlap across use cases.

The building block list deduced from these descriptions reveal that there is a strong focus on data models and formats as well as on trusted data exchange including identity management and access and usage control mechanisms and policies. Across all use cases there is a generic need for governance building blocks to sustain the overall digital ecosystem in the mid- and long run. Nine use cases need to comply with regulation issues connected to personal user data according to the general data protection regulation (GDPR). Further requirements from energy system regulations and further legal and regulatory compliance are subject to work in taks 2.4. Organisational and operational issues such as service level agreement are being planned for use cases with higher maturity level. Business building blocks do seldom occur at this point but are expected to be further analysed in task 2.3

The content of this deliverable will serve as input to the development of the reference architecture in the ongoing work in work package 2 and will be used for the further development of the pilots in work package 9.

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1 Introduction

1.1 About the project

ENERSHARE vision is to develop and demonstrate a European Common Energy Data Space, which will deploy an 'intra-energy' and 'cross-sector' interoperable and trusted Energy Data Ecosystem. Data Spaces are expected to set up a level playing field for data sharing and aim at creating a market for data to be shared efficiently and securely within EU, where private and public entities can fully control the use of the data they generate, and where both businesses and public sector have easy access to a large pool of high-quality data. Currently existing implementations of Data Space technological building blocks, in particular International Data Space Association (IDSA) building blocks, have not been validated against energy business scenarios or requirements.

ENERSHARE will provide a technological Reference Implementation for a Common European Data Space adapted to the energy sector, which leverages on, adapts, evolves, and validates Data Space architectures like IDSA and GAIA-X, as well as underlying open-source technological implementations for domain-agnostic data-oriented technology components.

1.2 About this document

This deliverable 2.1 titled "Use cases' descriptions and list of minimum Data Space building blocks required for pilots" summarises the description of all use cases planned within the ENERSHARE project and derives the required data space building blocks from it. The objective of this document is to collect all use case descriptions according to IEC standard 62559-2 [2] in one document and make them available for further technical planning in the further tasks and technical work packages.

Chapter 3 presents relevant resources which have been used to structure the content. It then presents short descriptions of the use cases in the project. Based on the descriptions, several analyses across use cases are provided in chapter 3. Use case descriptions are provided within the document in a short form in section 3.2 which includes the name, objective, short description and scenario overview. The full IEC-templates are listed in the annex with one section for each use case. These descriptions will be uploaded to the smart-grid-use-case-repository.

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The summary of the use case descriptions includes an overview on the topics within the use cases with regard to EU taxonomy [3]. It further maps the roles and organisations involved from the perspective of the harmonised electricity market role model [4] to the role model by the International Data Space Association [5] to provide a matching between the energy and the digital value chain. An analysis on common needs on data models and overlap on information items within the use cases provides further insights for further work on the pilots and on semantic interoperability.

Chapter 4 starts with a short description on the data space building blocks as they have been described in the OPEN DEI whitepaper [1] and as they are understood and used in the project. The second part presents the list of required minimum data space building blocks.

Chapter 5 sums the content and findings up and provides conclusions, some interpretation, and an outlook.

The deliverable is linked to deliverable 9.1 on the pilot's preparation, measurement, and verification plan. It will serve as a living document that will integrate future updates and additions on the use case requirements which will be provided by task 2.2 on requirements with regard to the incentive design from the perspective of social science and humanities and from task 2.3 on the overall business concept design and functional specification. With these inputs it will form the input for the deliverable 2.3 with a first approach on the reference architecture for the project.

1.3 Intended audience

This deliverable is marked as public. The use case descriptions will also be uploaded to the smart grid use case repository. The intended audience for this deliverable is:

- Internal pilot partners for further development stages of use cases.
- Internal technical partners to inform about requirements as defined across use cases, especially to provide input on the following deliverable on the description of a reference architecture.
- External developers of further Energy Data Space projects in Europe to inform about the content and to enable the identification of topics of common interest.

It is important to note, that the description process raises functional requirements, but afterwards and during the architecture design and the software development process,

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other requirements often emerge. Additional functional or non-functional requirements define expected performance (e.g. maximum response time) and drive the technical architecture and the testing process. All these further requirements should be integrated back into the use case descriptions.

1.4 Reading recommendations

This document is divided into 5 chapters and an extensive annex that include the detailed use case descriptions. Chapter 1 is this introduction. Chapter 2 provides information on the method applied for the work leading to this deliverable and is divided into a subsection on the use case description process and the deriving of the building blocks. Chapter 3 lists the short descriptions of use cases and provides summaries on topics, roles, and information items. Chapter 4 provides the building block list with further explanation on the building block categories.

It is recommended to make use of the table of content and navigate to specific parts of the use case descriptions in the annex that are of specific interest to the reader.

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2 Method

2.1 Use case description process

The use cases of ENERSHARE are jointly documented using the IEC 62559 template [2]. In order to gather the necessary input for the template, the pilot partners were involved in a multi-step process. The first step to describe Use Cases is to have an initial interview with its pilot partners to gain a first impression of the Use Case. This includes the understanding of the pilots' general objectives, the individual companies' objectives, existing IT-Architectures that might be useful for the Use Case, perceived barriers and business and system roles in the pilot.

Afterwards, Fraunhofer formalized the interviews' insights by providing a first draft of the Use Case into the IEC 62559-2 template. This action also helped identifying issues for further discussions.

In an iterative process, during more workshops and interviews, the IEC 62559-2 Use Case Template were filled out: alignments with the Technical Management (Fraunhofer), WP 9 (data flows and KPIs) and Task 2.2 (social innovation) were made and the usage of action items helped to finalize the use case description.

Based upon this deliverable, T2.5 creates the Reference Architecture for the ENERSHARE data space and after the Use Case description is approved by all participating parties, it will be uploaded into the Use Case Repository.

2.2 Deriving building blocks from use cases

In addition to the standardised use case description, the objective of this deliverable is to provide a list of building blocks that will be required to implement the use cases within the pilot. The analysis looks at the functional level. Technological design choices will be taken at a later stage as part of the architectural tasks and deliverables.

The building blocks as described in the OpenDEI whitepaper "Design principles for Data Spaces" [1] form the basis for this work. The building blocks are separated into technical, governance, business and organisational or operational components. The full list includes a total of 27 building blocks.

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Table 1: Categories of building blocks for data spaces as proposed in the Whitepaper Design Principles for Data Spaces [1]

Category	Building Block name	Category	Building Block name
Technical Building Blocks	• Data Models and Formats • Data Exchange APIs • Provenance and traceability • Identity Management • Access and Usage control / Policies • Trusted Exchange • Metadata and Discovery Protocol • Data Usage Accounting • Publication and Marketplace Services • System Adaptation • Data Processing • Data Routing and Preprocessing • Data Analytics Engine • Data Visualisation • Workflow Management Engine	Business Building Blocks	• Service Level Agreement • Accounting Scheme • Billing / Charging Scheme • Smart Contract
		Governance Building Blocks	• Data Space Boards • Overarching cooperation agreement • Continuity Model • Regulations
		Organisational / Operational Building Blocks	• Unique Identifiers • Authorisation Registry • Trusted parties • Domain Data Standard

The use case descriptions were analysed with regard to the specific scenarios, steps, information items and requirements to derive the building blocks list. For each use case scenario these description elements were investigated for their implication on the requirement of building blocks. The outcome of this analysis is a table with references to process steps, information items and requirements. The results are summarised and described in section 4.2.

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3 Use case descriptions

3.1 Main resources for the description of use cases

During the process of use case description, different standards were used in order to provide a comparability of the different use cases. The guiding template for the documentation is the IEC 62559-2 Use Case description template. As the IEC 62559 is already widely used between different European projects like BRIDGE, ENERSHARE uses it as well to benefit on the standardized way to document the requirements of different projects in the European energy sector. To increase the reusability of the work done in this work package, all use cases will be uploaded as well to the Smart Grid Use Case repository [6].

To ensure a common understanding of the involved roles of the electricity market the Harmonized Electricity Market Role Model (HEMRM) is used. The role model presents common names of the electricity market, which are involved in an information exchange [4].

Additional to the electrical market view, a view on the data value chain is included as well, as ENERSHARE focusses mainly on the benefits of sharing data between multiple participants. For this view on the data value chain, the current reference architectures of the International Data Space Association is used [5].

3.1.1 Data Value Chain

With the increasing importance of digitalization in general, the efficient and automated handling and processing of data becomes essential to benefit from the economic potential of value creation from digital services.

Building on existing models on supply chain and value chain models from other industrial sectors, there are also models for value creation from data resources through digital processes. For this project we use the big data value chain as depicted in Figure 1 by the big data value association (BDVA).

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Figure 1: Big data value chain (BDVA) [7]

This model starts with the generation and acquisition of data which is then processed in data analysis that generates value adding information. Data Storage and the curation of data resources is another part in the chain. The output is generated by providing the processed data or generated insights to the customer by means of visualisation of results or digital services in machine-to-machine communication.

Key stakeholders for the digital value chain are the vendors of the information and communication technology and the broad range of private and public users across different industrial sectors. Data entrepreneurs and R&D institutions will be actors that drive innovations which build on data demand and supply. [7]

3.1.2 IEC 62559-2 Use case description template

The IEC 62559-2 Use Case description template is designed by the International Electrotechnical Commission (IEC) [2], an international organization working with standardization. It relies on the IEC's use case methodology, which provides a common understanding of functionalities, actors and processes among different technical committees or organizations. It is created as a software engineering tool and the methodology can help with the development of standards since it simplifies the analysis of requirements considering new or existing standards. Furthermore, the use case methodology is divided into three parts: the first being IEC 62559-1, which comprises the concept and processes in standardization as the basis for a common use case repository. In addition, this repository serves the purpose of gathering use cases within the IEC on a collaborative platform in order to organize a harmonization of use cases. Therefore, generic use cases are provided to form the basis for further standardization work. Moreover, IEC 62559-1 offers the processes and basics for the use case methodology like terms or use case types.

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The second part, IEC 62559-2, covers the definition of the templates for use cases, an actor, and a requirement list. This information also includes the structure of a use case template:

1. Description of the Use Case
    1. Name of the use case
    2. Version management
    3. Scope and objective of use case
    4. Narrative of use case
    5. Key performance indicators (KPI)
    6. Use case conditions
    7. Further information to the use case for classification / mapping
2. Diagrams of use case
3. Technical Details
    1. Actors
    2. References
4. Step by step analysis of the use case
    1. Overview of Scenarios
    2. Steps - Scenarios
5. Information exchanged
6. Requirements
7. Common terms and definitions

IEC 62559-3, which forms the third part, is based on IEC 62559-2, and contains the required core concepts of a use case template, an actor list and a list for requirements transformed into an XML format. The purpose of this transformation is to be able to convert the content of the template to other engineering systems.

The initial intention for the IEC to create the use case methodology is to facilitate the management of system level requirements in more complex systems like Smart Grids or Smart Cities, but as it is written in a general manner, it can also be used in other domains. Furthermore, the system level requirements need to be provided with many domains of expertise as well as be broken down to facilitate the sharing of ideas and requirements of use cases and business cases among the Technical Committees which often have various backgrounds. The intention is to receive specifying standards that support system level functions. Domain experts, for example, provide general ideas and functional requirements, while system experts rather modify the use cases to be able to specify interfaces, dedicated functionality, data, and service model exchange. Moreover, the use

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case methodology and its common methods and terms support further engineering activities.

Another intention for the use case methodology to be created is to set up a frame of consistency within the IEC so that the provision of use cases is made possible in a consistent manner and that the standards can serve as a basis for the use case repository for the gathering, administration, maintenance, and evaluation of use cases.

In general, the use case methodology is a process starting with the definition of business ideas, goals and requirements and putting those to detail in the use case description. Furthermore, it serves as a basis for the identification or link to a reference architecture, as it offers the description of which types of components need to be used and in a broader perspective to help with further standardization work. [2]

3.1.3 Harmonised Electricity Market Role Model (HEMRM)

The energy system has evolved in the past simultaneously in different countries. Therefore, different names for similar roles have evolved. In order to enable a better cross-country communication between different participants of the energy sector, the HEMRM was developed. It intends to give designated common names to the parties involved in information exchange in the energy sector. A single party or legal entity can take over multiple roles, but it would also be possible that each role is represented by a different party [4].

As an example, the following table shows two definitions of roles which are frequently used during the ENERSHARE Use Case description.

Table 2: Exemplary description of roles from the harmonised electricity market role model [4]

Role Name	Description
Market Information Aggregator	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use. Note: The Market Information Aggregator may receive information from any market participant that is relevant for publication or distribution

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System Operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity

3.1.4 International Data Space reference architecture

Additionally, to the energy system view displayed in the HEMRM model, the view on data is depicted in the Reference Architectures of the International Data Space Association.

The International Data Space Reference Architecture (IDS-RAM) consists of five layers to represent the different viewpoints of involved stakeholders. Additional to those five layers, three perspectives, Security, Certification and Governance, are incorporated. The perspectives need to be implemented within all of the layers and are therefore listed separately [5].

An overview of the layers and perspectives can be found in the graphic below:

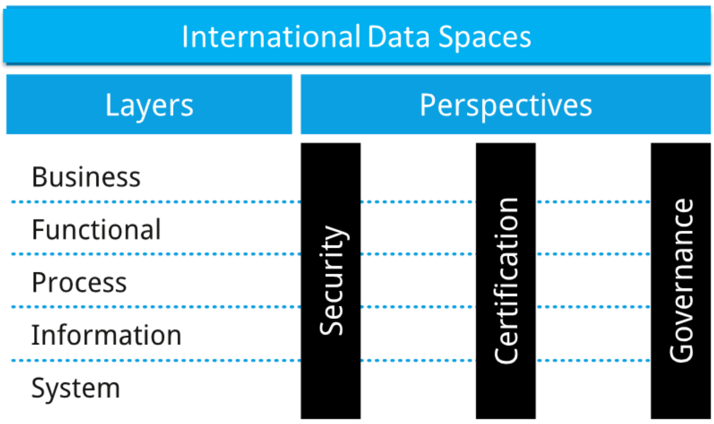

Figure 2: International Data Space Reference Architecture [5]

For our purpose of the use case description, we will mainly focus on the business layer as this layer contains the necessary roles to describe the cases.

Similar to the HEMRM, the IDS RAM defines roles to generalize the activities of participants in an information exchange. Whereas the HEMRM focusses on the view of the energy

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market, the IDS Ram puts a spotlight on the information exchange itself. The described roles are depicting the data value chain in a context of a data space. The IDSA distinguishes between basic rules, which shall help in the discussion of technical tasks in the IDS and business roles, which are suitable for a generic discussion of the data sharing in an early stage. Therefore, we focus on the business roles, but basic roles can be considered during complex use case scenarios. The business roles are clustered into four categories, which are Core Participant, Intermediary, Software Developer and Governance Body [5].

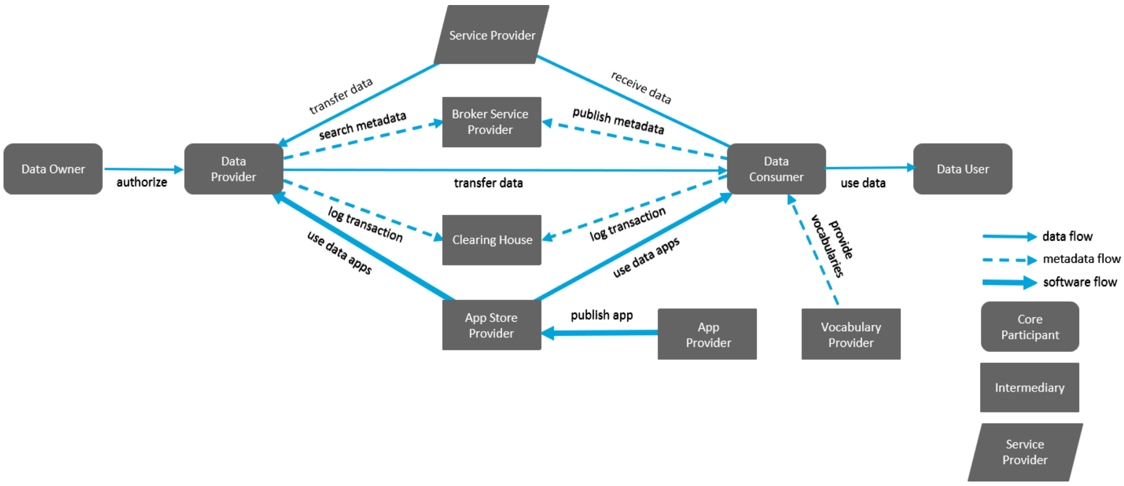

Figure 3: Roles and interactions in the International Data [5], chapter 3.1.2]

Core Participants

Roles from the category Core Participants are required for each data exchange conducted in a data space.

The business role Data Supplier is aggregating the three basic roles Data Creator, Data Owner, and Data Provider. This means that the role is able to create data, has the means to define usage policies and payment models and provides access to the data via the data space. [5]

The Data Customer receives the data from the Data Supplier. Basic roles subsumed under this business role are Data Consumer (data is sent directly), Service Consumer (data is processed by Service Provider upon reception) and Data User (legal entity that uses the data in accordance with usage policies) [5].

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Intermediary

Intermediaries act as platforms for several Data Suppliers and Data Customers. They are trusted entities, which could provide a variety of services resulting in six business roles: Data Intermediary, Service Intermediary, App Store, Vocabulary Intermediary, Clearing House, and Identity Authority.

A Data Intermediary can either act on behalf of the basic role of a Data Provider or Data User. In this role he provides technical access to the Data Space to exchange data for his customer. Moreover, the Data Intermediary can be a Data Broker, providing metadata about different data offers to provide a service that increases the findability of offered data resources.

Similar to the Data Intermediary the Service Intermediary can either provide metadata about services or the service itself. A service processes data to increase the value or the quality of the data. Multiple services can be chained together to provide a complex and powerful process to interact with the data. If the Service Intermediary has not developed the offered service by himself but consumes it from a third-party app, he assumes the basic role of an App Consumer.

The App Store offers a variety of third-party algorithms, which can be downloaded to the connector of the app consumer and used in this location. In contrast to the activities of the Service Intermediary, the App Store cannot execute any apps on its platform.

In order to enable a common language and a common understanding between the participants of the Data Space vocabularies are used. The Vocabulary Intermediary provides and publishes vocabularies but does not own or govern those. This role will be taken over by a Standardization Organization.

To build a business model within a Data Space there needs to be clarity if a data transfer was completed successfully and could be billed accordingly. The task of logging all activities performed in the Data Space is done by the Clearing House.

To avoid unauthorized access to data the Identity Authority is an important role in the Data Space to secure that the participants interacting with each other, are who they claim to be [5].

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Software Developer

Different domains have different requirements towards a Data Space. Therefore, enough flexibility should be given to adapt to domain specific situations. In order to fill this flexibility with useful functionality, IT companies provide software to Data Space users. There are two business roles in this category: the App Developer and the Connector Developer.

The App Developer develops apps that can be offered via the App Store and installed on the connector of the customer. The App will provide functionality to alter and process data.

In contrast to the App Developer the software developed by the Connector Developer will not be distributed by a Data Space entity but by the usual distribution channels. The connector represents the basic and most important element to participate in the dataspace as a Data Supplier or Data Customer [5].

Governance Body

The responsibility of a Governance Body is to provide rules and guidelines in order to achieve a standardization in the data exchange. The category contains the Certification Body and Evaluation Facilities as well as the Standardization Organisation.

The Certification Body provides with the help of the Evaluation Facilities certifications of participants on the one side and on the other side a technical certification for developed Apps, Connectors and Services.

The business role Standardization Organization fulfils the basic roles of Vocabulary Creator and Vocabulary Owner as most standards are typically described as a vocabulary or an ontology. The IDSA presents a special role as a Standardization Organization as it governs over the IDS-RAM but is not taking part in the actions of the different Data Spaces [5].

3.1.5 EU taxonomy compass

The EU Commission has introduced a taxonomy to classify economic activities according to their degree of environmental sustainability with the Delegated Act on the climate objectives [3]. As a tool for visual support, the EU Taxonomy Compass facilitates to access to the terms and structure of the taxonomy [8]. To further structure and compare the content of the use cases the activities from the taxonomy filtered for the Mitigation measures from the Energy sector have been used.

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3.2 Use case short descriptions

The following chapter gives a short overview of the use cases of ENERSHARE. The detailed use case description according to the IEC 62559 template can be found in the Annex.

The following table gives an overview of the use cases in scope.

Table 3: Overview of pilots and use cases in ENERSHARE

Pilot	Use Case	Title
P1-ES		Wind farm integrated predictive maintenance and supply chain optimization
P2-PT	A	Leveraging on consumer-level load data to improve TSO's operational and planning procedures.
P2-PT	B	Instantiation of energy communities and digital simulation of business models
P2-PT	C	Detect irregularities in energy consumption in households with seniors living alone
P2-PT	D	Suggest maintenance of appliances based on NILM data
P3-SI		Optimal multi-energy vector planning - electricity vs heat
P4-GR		Digital Twin for optimal data-driven Power-to-Gas planning
P5-IT	A	Cross-sector Flexibility Services for aggregators and DSO
P5-IT	B	Services for e-mobility CPOs, EVs drivers and DSO
P5-IT	C	Flexibility provision for electricity grid with water pumps and predictive maintenance of the pumps
P6-		*- Pilot is currently subject to change -*
P7-LV		Cross-value chain services for energy-data driven green financing

For each use case a short description of the planned activities together with the planned objectives will be provided. Pilot 6 is currently subject to change. The use case description will be added after a final decision has been taken on its new scope in an updated version of this document.

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3.2.1 P1-ES: Wind farm integrated predictive maintenance and supply chain optimization

Scope

This pilot aims to foster data driven innovation in the onshore and offshore wind energy industry, along its value chain, to maintain its competitive advantage and contribute to the decarbonisation of the economy.

Objectives

(1) Design and development of an offshore wind digital platform (IDSA reference architecture and components included) as one of the core technologies, for enabling the federated data sharing and machine learning (ML) based services between data owners and data users.

(2) Enrichment of the IDSA architecture's components with innovative solutions (IDSA connectors in the edge, edge computing, data-driven and Digital Twin based operation and maintenance (O&M) algorithms, synthetic failures data generation).

(3) Creation of the most adequate business model for data monetisation.

Short Description

Windfarm owners and wind turbine Original Equipment Manufacturer (OEMs) have access to the data collected from the wind energy turbines in operation and they are the only players that are presently extracting value out of data at the top of the value chain. However, European components suppliers, ICT companies and ML service providers have difficulties to fully automatically access the data produced by the different systems in wind turbines in real-life operation. This fact causes certain limitations to extract full value out of data and to improve their competitiveness through digitalisation of products and services.

This pilot aims to foster data driven innovation in the onshore and offshore wind energy industry, along its value chain, to maintain its competitive advantage and contribute to the decarbonisation of the economy.

Scenario Overview

The use case consists of the following scenarios:

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1) Anomaly detection using hybrid model (physics-based model + data-driven)

3.2.2 P2-PT-A: Leveraging on consumer-level load data to improve TSO's operational and planning procedures.

Scope

Using behind-the-meter data to improve operational and planning procedures of the Portuguese transmission system operator, using smart services from the Energy Data Space.

Objectives

The objective of this use-case (UC) is to assess the value of behind-the-meter (consumer-level) load data to the Transmission System Operators (TSOs) in improving operational and planning procedures, by taking advantage of the Energy Data Space ecosystem's advanced capabilities for data sharing. The ultimate goal of this UC is to quantify the improvement of well-established procedures for network planning and operation that TSOs are responsible to execute and translate it into the value – monetary and/or social – of the available behind-the-meter data.

The proposed analysis may be breakdown into four main topics to be addressed:

- Evaluate impact of using aggregated and individual consumer-level data, exploring federated learning, to improve net-load forecasting at the substation level.
- Evaluate the evolution of net-demand at the substation-level by using data on the typology/amount of load and generation (RES) at the end-consumer side. Assess whether this data unveils the need to refine TSOs' grid planning procedures, including the definition of additional scenarios to assure system stability and security.
- Track and quantify the aggregated demand-side flexibility potential of end-users (assuming an energy community configuration) and evaluate the potential for participation in the balancing markets for ancillary services provision (service managed by the TSO).
- Identification of opportunities for cross-sector synergies between electrical and gas demand at the consumer-level.

Short Description

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This UC takes advantage of the Energy Data Space extended functionalities for safe data sharing to perform an evaluation of the value of the behind-the-meter data to the TSO in some of its operational and planning procedures. The UC will focus in using the consumption/generation data from energy communities' users to i) improve load forecasting at the substation level, ii) evaluate the evolution of load typology and respective impacts in the grid dimensioning, that may be fed-forward for refinements in the TSO's planning strategies; iii) track and quantify the aggregated flexibility potential at the energy communities level, that can be scaled-up to the system level e.g. through balancing services; iv) identification of potential for cross-sector synergies (electricity and gas) at the communities level.

Scenario Overview

The use case consists of the following scenarios:

1) Net-load forecast at substation-level
2) Analysis of the consumption evolution to improve grid planning
3) Flexibility estimation
4) Cross-sector opportunities

3.2.3 P2-PT-B Instantiation of energy communities and digital simulation of business models

Scope

Planning and business model assessment of renewable energy communities (REC) – Article 2 (16) Recast Renewable Energy Directive – and Citizen Energy Communities (CEC) – Article 2(11) Recast Internal Electricity Market Directive.

Objectives

The main goal is to explore the combinatorial value of data owned by different Data Owners (i.e., its cross-silo value) for optimal design of REC and/or CEC considering their economic feasibility, simulation of different assets ownership business models and integration of vulnerable citizens.

The following specific objectives are associated to primary use cases:

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1) Sizing and economic evaluation of REC and/or CEC business models considering consumption and generation profiles available in the Data Space, as well as other data sources such as open market data (prices) and weather data, and the possibility of assets sharing models.
2) Given a specific REC/CEC structure (members and assets), simulate its operation to estimate the dispatch of the flexible resources and the resulting energy price for the internal transactions within the community, according to the business model selected, also considering the inclusion of vulnerable citizens in the community (e.g., alternative electricity tariff scheme, financial schemes for community sharing).
3) Extract approximated flexibility models for smart appliances (e.g., using non-intrusive load monitoring data), enabling an overall quantification of flexibility and estimation of energy savings from intelligent load control.

Short Description

The main actor of this use case is the Service Provider that receives data (consumption, generation, open weather measurements / forecasts, etc.) available in the Data Space (via Data Provider) to study and simulate different configurations and business models for REC and/or CEC. This includes the following functions: i) sizing of the distributed energy resources (DER) within the community, including the joint ownership of assets; ii) construction of flexibility models, with field data, for thermal loads; iii) simulation of pricing mechanisms within the community, considering the retailers' tariffs and flexibility from DER. This will enable economic feasibility analysis of energy communities, and to potentially engage vulnerable citizens, which can be identified by combining data collected from the residencies with external data (e.g., weather, average income, etc.), in energy trading / sharing activities under different business models. The benefit is to de-risk investment in shared energy resources and maximize the benefits of new local energy communities.

Scenario Overview

The use case consists of the following scenarios:

1) DER sizing and economic evaluation of the REC / CEC business model
2) Estimation of flexibility potential and energy savings from thermal domestic loads
3) Simulation of energy price within the REC / CEC

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3.2.4 P2-PT-C Detect irregularities in energy consumption in households with seniors living alone

Scope

Improve quality of living and energy consumption in the households of seniors living alone and provide alarm services to notify relatives or health care agents in case of a trigger event.

Objectives

Detect irregularities in energy consumption in households with seniors living alone

Short Description

Establish insurance and healthcare services for the community (and for the providers) by learning energy utilization patterns to recognize potential problems and trigger alarms. This aims mainly at senior citizens with reduced mobility or disability problems and do not have close assistance or conditions to call for help in case of need. The use case will also monitor changes in domestic environment (temperature, humidity, etc.), enabling an assessment of the impact on the current health status of the citizen.

Scenario Overview

The use case consists of the following scenarios:

1) Detection of irregularities in seniors' energy consumption

3.2.5 P2-PT-D Suggest maintenance of appliances based on NILM data

Scope

Improve quality of living and energy consumption in households by detecting higher energy consumptions of appliances early on and increase energy efficiency by suggesting maintenance or renewal of appliances.

Objectives

Use non-intrusive load monitoring (NILM) data to suggest maintenance of appliances or renewal (e.g. fridge)

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Short Description

Use NILM data to detect appliance retrofit opportunities in private rental sector and social housing, taking into account the types of properties and socio-economic data. This information will be shared with consumers and housing providers.

Scenario Overview

The use case consists of the following scenarios:

1) NILM analysis for opportunities of maintenance or renewal of appliances

3.2.6 P3-SI Optimal multi-energy vector planning - electricity vs heat

Scope

The Energy-Climate Atlas platform constitutes a unique set of innovative methodological approaches and tools that enable cities, local communities, and energy system operators to take an important step forward in energy planning, reliable and secure supply and ensuring a high quality of life.

Objectives

1) Data aggregation, pre-processing, and visualisation in Energy-Climate Atlas
2) Data analytics for populating feature stores with measurement, contextual and behavioural data to profile, segment and cluster users according to corresponding services / engagement programmes
3) Flexibility potential assessment of the electric power system
4) Development of heat flexibility valorisation strategies across different actors while maintaining digital sovereignty
5) Planning of coordinated measures between district heating and electric power systems operators to secure demand and achieve climate goals

Short Description

The use case focuses on sector coupling between heat and electric power systems, which can be done through cogeneration or power-to-heat generation and storage. In the context of district heating and the use of technologies such as heat pumps and seasonal thermal storage, great potential can be seen for providing flexibility to the electric system.

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However, to realise the full potential of thermal flexibility, close cooperation between all actors in a given geographic area of district heating and the logical clusters of users involved is required. In terms of infrastructure planning and assessment of flexibility potential, electricity and heat distribution network capacities must be geographically mapped along with photovoltaic, biomass, hydropower, and geothermal sources, while operation requires additional fine-grained profiling and segmentation of users, as well as technical means for managing distributed systems.

Scenario Overview

The use case consists of the following scenarios:

(1) Flexibility assessment
(2) Planning of measures

3.2.7 P4-GR Digital Twin for optimal data-driven Power-to-Gas planning

Scope

The aim of this pilot is to create a Digital Twin for optimal data-driven Power-to-Gas (P2G) planning. The P2G Digital Twin will model multiple scenarios for hydrogen production and storage from RES under different energy demand profiles. A first system will perform useful profiling, comparisons, and forecasts of the customers' demand and provide an understanding of the factors that influence the decision-making process for the use of natural gas and green hydrogen in the energy mix. A second system will create long-, mid- and short-term scenarios of the required green hydrogen production and renewable energy.

Objectives

The objective of the case study is to form a combined optimization platform, named TwinP2G, coupling the electricity transmission system with natural gas demands, leveraging a Digital Twin architecture that will enable multi-resolution simulations involving P2G technologies and (regenerative) hydrogen fuel cells. TwinP2G will enable data- and simulation-driven P2G and RHFC optimal planning leveraging RES surplus for green hydrogen production via electrolysis.

Short Description

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Producing hydrogen from low-carbon energy is costly at the moment, and the development of hydrogen infrastructure is slow and holding back widespread adoption. Virtual environments are required to analyse different scenarios for a quicker and safer integration of hydrogen in the energy system. From renewable sources (such as wind and photovoltaic) to electrolyser capacity, to buffers (such as energy and hydrogen storage), multiple variables and data sources must be considered to meet the increased energy demand. In this respect, the technology of Data Spaces offers great potential for hydrogen promotion to accelerate the energy transition. In this direction, this pilot aims to develop a Digital Twin application for enabling the design of thorough P2G use cases in Greece in order to assess and optimize the several quantities related to P2G investments (e.g. electrolyser, buffer and fuel cells optimal capacity and locations).

Scenario Overview

The use case consists of the following scenarios:

1) Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (short-term horizon)
2) Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (long-term horizon)
3) Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (short-term horizon)
4) Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (long-term horizon)

3.2.8 P5-IT-A Cross-sector Flexibility Services for aggregators and DSO

Scope

Reduction of reverse power flows into the distribution grid through optimization of self-consumption

Objectives

- Load forecast for household and primary substation and PV feed-in estimation
- Flexibility estimation for each household
- Reduce reverse power flow / Optimization of the grid and maximization of self-consumption

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- Security Services deployed by DSOs to Consumers
- App development
- User engagement incl. updating infrastructure based on the use case needs

Short Description

This UC aims to take advantage of the sources of flexibility offered by cross-sector to reduce Reverse Power Flows (RPF) into the power distribution grid and reduce the impact on distribution grid. Optimised grid management, which leads to increased self-consumption and self-sufficiency, reduced losses and detailed observability of parameters in real time, drastically reduces the number of faults that can occur on the grid. For end consumers, this leads to various advantages, such as greater continuity of supply, less environmental impact from their own consumption, greater awareness of their impact on the energy system and a drive towards active and more sustainable behaviour.

Scenario Overview

The use case consists of the following scenarios:

1) Variable demand response

3.2.9 P5-IT-B Services for e-mobility CPOs, EVs drivers and DSO

Scope

Value creation from flexibility provision of electric vehicles to the grid

Objectives

- Use the vehicles to provide flexibility to the grid and reduce grid congestion levels
- App development/adaption
- Increase CPO ability to attract EV users to their charging stations
- Increase CPO revenue
- Reduce charging session costs for EV users

Short Description

Prioritization of charging and/or parking slot availability in peak hours (e.g., in the night) for consumers sharing EV recharging profiles; dynamic parking pricing aligned to the grid congestion level for consumers who share their mobility patterns with the DSO.

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Scenario Overview

The use case consists of the following scenarios:

1) Grid monitoring
2) Charging schedule notification
3) EV users involvement
4) Grid congestion problem avoided

3.2.10 P5-IT-C Flexibility provision for electricity grid with water pumps and predictive maintenance of the pumps

Scope

Exploiting new services for sustainable management of water distribution systems which are also beneficial for optimizing grid operations.

Objectives

- Increase the efficiency of the grid by using flexibility of the water network and water pumps
- Forecasting water demand variations using the real time data and historical data available

Short Description

In the morning when everyone gets ready for the day, the water consumption is high, in the night the water consumption decreases by 80 percent. That means at night pressure at the source can be reduced while still allowing customers to have sufficient tap pressure. Our water distribution network manages their operation on the instant water demand of the network, meaning that the use of the equipment is conditioned by the immediate water necessity. Water demand forecasting is crucial for the sustainable management of water distribution systems. It is directly related to a supply service with reduced operating costs, such as the electric energy required for pumping and plays an important role in the optimal performance of pumps. Water demand prediction is crucial to have optimal water demand balance, minimise overpressure and, consequently achieve water and energy savings.

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Scenario Overview

The use case consists of the following scenarios:

1) Flexibility
2) Predictive Maintenance

3.2.11 P7-LV Cross-value chain services for energy-data driven green financing

Scope

Green financing for energy efficiency services for strengthening debt and equity financing of energy efficiency investments, providing investors and project developers the opportunity to easily evaluate key performance indicators of future projects. The scope of this use case stems from the need of providing innovative services which will be based on Data Spaces, counting on cross-value chain stakeholder data-driven services, at the interplay among smart meters data and financing.

Objectives

- Make the data from two financing schemes for renewable energy and energy efficiency calls available to the dataspace:
- Ministry of Environmental protection[1], Latvian environmental investment fund: EKII-6 (Call) Reducing greenhouse gas emissions from households - support for the use of renewable energy sources
- Ministry of Economics*, Department of Energy Financial Instruments, programs (2) for the renovation of one-apartment residential houses and two-apartment residential houses and for increasing energy efficiency and solar PV installation
- Automatically anonymize data in order to use it compliantly
- Calculate cost efficiency KPIs to allow consumers to calculate their return on invest and energy savings
- Forecast energy production if the RES technology is installed
- Integrate analysis results into the homepage of the Ministry of Energy and climate in the form of an app with the aim to raise awareness of the households of the

[1] Departments from the Ministry of Environmental protection and Ministry of Economics are planned to be merged creating the Ministry of Energy and climate.

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energy efficiency actions and RES technology instalment possibilities as well as do the initial assessment if the households want to apply for support programs.

Short Description

The aim of this pilot is to create a solid framework through cross-sectoral integration of data on financial performance of energy efficiency projects. The scope is to strengthen debt and equity financing of energy efficiency investments, providing investors and project developers the opportunity to easily evaluate key performance indicators of future projects. Besides traditional AI-based green financing analytics services, in the context of this pilot the evaluation of energy data sharing to other sectors and the exploitation of how this pilot concept should evolve to become a more generic data sharing solution will be further investigated.

Scenario Overview

The use case consists of the following scenarios:

1) Anonymization
2) PV forecast
3) Cost and energy efficiency calculation

3.3 Summary of use cases

Within this section we provide an overview across all use case descriptions. Based on the scope of use cases, we show which topics are being addressed in the project. Then the actors and roles from the energy market perspective and from the data space role model are mapped to each other. Finally, the information items that are being planned within the use cases have been analysed in order to identify focus areas and overlaps.

3.3.1 Topics covered

The use cases described in the ENERSHARE project range over different sectors, focusing on different aspects of the energy system. The EU taxonomy compass [8] underlying the Delegated Act on the climate objectives [3] has been used to map the topics in the EU use cases to the relevant activities planned.

Activities on electricity transmission and distribution will be addressed in seven use cases, often in combination with flexibility services provided to the grid system operators. PV generation will be relevant to three use cases. As pilots 3 and 4 address the system

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planning level across several energy sectors including heat and / or gas they span a broad range of activities.

The following table gives an overview:

Activity number	Activity name	P1-ES	P2-PT-A	P2-PT-B	P2-PT-C	P2-PT-D	P3-SI	P4-GR	P5-IT-A	P5-IT-B	P5-IT-C	P7-LV	Total
4.1	Solar photovoltaics			1					1			1	3
4.3	Wind power	1											1
4.9	Transmission and distribution		1				1	1	1	1	1		6
4.10	Storage of electricity		1	1			1	1					4
4.11	Storage of thermal energy						1					1	2
4.12	Storage of hydrogen							1					1
4.14	Transmission and distribution networks for gases							1					1
4.15	District heating/cooling						1						1
4.16	Electric heat pumps			1			1						2
4.17-4.20	Cogeneration of heat/cool and power						1						1
4.21	Solar thermal heating											1	1
4.22	Geothermal energy						1					1	2
4.23	Heat/cool from renewable non-fossil gaseous and liquid fuels							1				1	2
4.29	Electricity generation from fossil gaseous fuels							1					1

3.3.2 Roles and organisations

With respect to the electricity system the use cases in ENERSHARE include actors that represent a broad variety of roles in the HEMRM model. From the data space perspective, the main business roles of data suppliers, service intermediaries and data customers are covered.

Table 4 provides an overview on the market roles of the organisations in each use case. Energy Service Companies are occurring most often across the use cases as they provide digital services and act as data consumers. Aggregators for market information, resources

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and metered data are providing data for these services. The system operators act both as data provider and consumers, e.g., in communicating their need for flexibility and consuming the data on available flexibility potential as a service. The list of market roles also includes the consumer who also acts as data provider and consumer of data and services.

Table 4: Overview on number of organisations with HEMRM market roles in ENERSHARE use cases. (Organisations may be included in several use cases and count only for one in the total.)

Market Role (HEMRM 2022)	P1-ES	P2-PT-A	P2-PT-B	P2-PT-C	P2-PT-D	P3-SI	P4-GR	P5-IT-A	P5-IT-B	P5-IT-C	P7-LV	Total
Energy Service Company	3		1			1	1			1	1	7
System Operator		1				2	1	1	1	1		5
Market Information Aggregator		1		1	1						1	2
Producer	1					1						2
Consumer			1					1	1		1	1
Resource Provider									1			1
Ressource Aggregator								1				1
Balancing Service Party												
Metered Data Aggregator								1				1
Total	3	2	2	1	1	4	2	2	3	1	3	17

In Table 5 a quantitative analysis of HEMRM-Data Space role combinations is provided. The figures are based on the number of organisations within the ENERSHARE consortium and their respective combination of roles.

Table 5: Overview on combination of roles according to the harmonised electricity market role model and the IDSA reference architecture. Figures represent the number of organisations with HEMRM- Data Space role combination across use cases

		Data Supplier		Service Intermediary	Data Customer		
Market Role (HEMRM 2022)	Connector User	Data Owner	Data Provider	Service Provider	Data Consumer	Service Consumer	Unique Entities
Energy Service Company	7			7	4		7

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System Operator	4	1	3	2	1		6
Market Information Aggregator	2		2	1			3
Producer	1		2		1		2
Consumer			1		1	1	1
Resource Provider	1		1	1	1		1
Ressource Aggregator	1		1		1		1
Metered Data Aggregator	1		1				1
No. of Unique Entities	15	1	9	10	8	1	16

3.3.3 Information items

Based on the use case description template for the pilots the information items required for all use cases in ENERSHARE have been analysed to identify focus areas and overlaps in requirements.

Table 6 shows categories for data that were clustered from the individual entries and the number of items that have been mentioned across all pilots. Data being listed for a use case means that information from this category will be required for a use case. It does not mean that this data will be publicly available.

Data on electricity consumption is the most prevalent category across the use cases. Data on consumers is also frequently mentioned but varies widely in its specifics. The same is true for economic data which often includes price or cost information and assumptions for calculation. Furthermore, it includes outcomes and recommendations from predictive maintenance services.

Further data that will be required for several use cases include weather and environmental data and data on flexibilities. E-Mobility and building data have strong and detailed needs in the pilots P5 and P7.

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Table 6: Overview on overlapping data categories across use cases in ENERSHARE

Information Category	P1-ES	P2-PT-A	P2-PT-B	P2-PT-C	P2-PT-D	P3-SI	P4-GR	P5-IT-A	P5-IT-B	P5-IT-C	P7-LV	Total
Electricity Consumption		3	1	4	2	1	3	3	7	1	2	27
Consumer Data		2	12	5				1	2		4	26
E Mobility									16			16
Building Data			3								14	17
Economic Data	2		9		3				1	1	1	17
Flexibility		3	3			3				2		11
Generation asset data	4		1			1		1			2	9
other data			1			1	5					7
Environment			1	2		1					2	6
Grid Data						1	1	3				5
Natural Gas		1					2					3

Table 7 lists identical information needs from different use cases. Access to meter data will be necessary for 6 use cases. Flexibility potential will be determined and exchanged in four use cases in pilots 2, 3 and 5. Data from load forecasts will be required in four cases. Predictive maintenance services are planned in three pilots yet on different assets.

Table 7: Overview on specific overlapping information requirements across use cases in ENERSHARE

Information Category	P1-ES	P2-PT-A	P2-PT-B	P2-PT-C	P2-PT-D	P3-SI	P4-GR	P5-IT-A	P5-IT-B	P5-IT-C	P7-LV	Total
Meter Data		1	1			1		2	1		1	7
Predictive maintenance	2				3					1		6
Flexibility potential		1	1			2				2		6
Load Forecast		1					1	1	1			4
Grid Topology						1	1	1				3
Temperature				1							1	2
Production Forecast										1	1	2

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4 Data Space Building Blocks

4.1 Categories for data space building blocks

Data spaces are being built by combining technical and organisational building blocks which enable the technical, business, operational and organizational capabilities. Not only are they an essential part of the data space's soft infrastructure but also a service building a data space within and across domains. Furthermore, some parts of the building blocks are essential to data spaces in general and can be found in multiple ones; others will have to be adapted individually for sector-specific data spaces [1].

The general building blocks include the technical and the governance building blocks. The former describes building blocks responsible for the technical architecture of data spaces and are further divided into interoperability, trust, and data value. The latter consider the general governance structure of the data space including overall business, operational

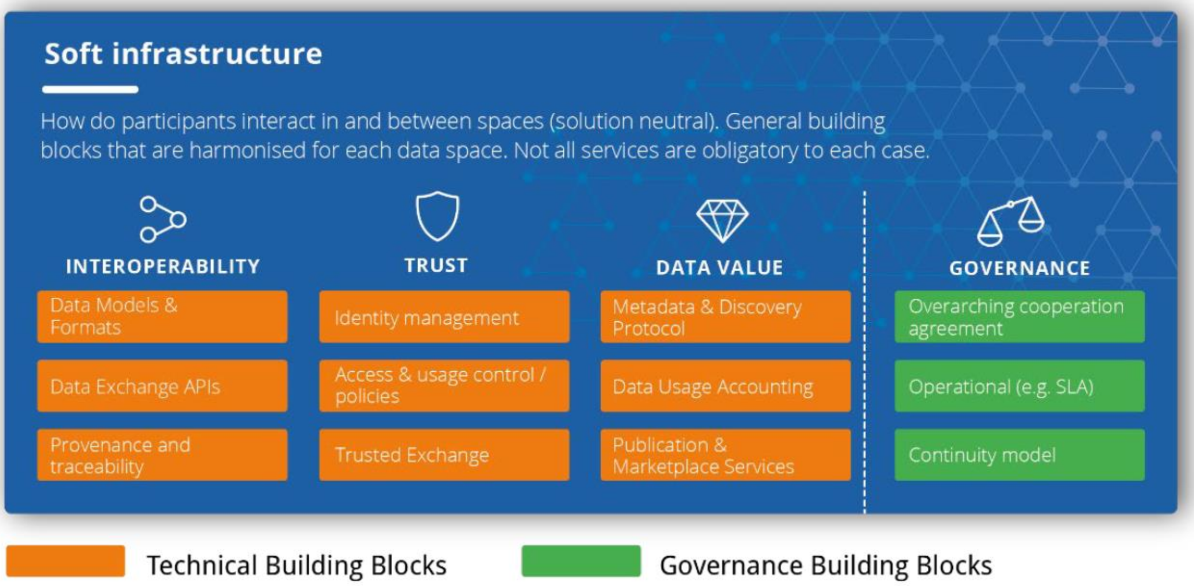

Figure 4: Data spaces building blocks [1]

and organizational agreements. Both will be described further in this chapter.

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4.1.1 Technical

4.1.1.1 Interoperability

Interoperability among participants in a data space is essential to the access and provision of data. To facilitate the implementation of interoperability into a data space, three building blocks are defined: *Data Models and Formats* provide "a common format for data model specifications and representation of data in data exchange payloads" [1].

In order to ensure full interoperability between the data space's participants, the *Data Exchange APIs* building block needs to be implemented as well as it facilitates sharing and exchange of data between systems of data space participants. A common example for APIs is the FIWARE Context Broker.

The third building block facilitating interoperability is described as *Data Provenance and Traceability*, which includes the implementation of mechanisms that provide the tracking of data during the process of their provision and usage. Additionally, more important functions on the origins of data to audit-proof logging of transactions [1] as well as application level tracking of data are part of this building block.

4.1.1.2 Trust

To encourage actors to participate in a data space, it must provide mechanisms that ensure data sovereignty and trust. Data sovereignty is defined as "the capability of a natural person or corporate entity for exclusive self-determination with regard to its economic data goods", which leaves the data spaces' participants able to operate and control their data in the data space [1, p. 27].

The *Identity Management (IM)* building block helps enable data spaces to do so as it provides organisations, individuals, machines, and other actors operating in the data space with verified and authenticated identities. These include additional information that authorization mechanisms make use of to enable data access and usage control [1, p. 45].

Another building block ensuring trust among the data space and its participants is *Access and Usage Control / Policies*. Within this building block, data access and usage policies as part of the terms and conditions are guaranteed during the publication of data resources or services or negotiation between data providers and consumers. The misuse of resources and data is prevented by data access and data usage control mechanisms implemented by the data providers and consumers or combined in more complex data value chains by prosumers. This building block relies on the Identity Management building

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block as identification and authentication are the basis for access and usage control [1, p. 46].

The third building block covers the aspect of *Trusted Exchange*. This tool ensures the identity and conformity with predefined rules and policies among the participants of a data space in order to secure data exchanges and transactions. This building block can be realized through technical or organizational measures [1, p. 46].

4.1.1.3 Data Value

Data as an economic asset need to be operated properly concerning the publication of data offerings, their discovery based on metadata, and data access/usage accounting (p.40). The building block *Metadata and Discovery Protocol* covers the publishing and discovery mechanisms for offerings of data resources and services as it covers the creation of common descriptions of resources, services, and participants, which can be domain-agnostic or –specific. Semantic-web technologies enable such descriptions and include linked-data principles. In an example, data space participants need to gain corresponding usage rights in order to access the wanted data asset [1, p. 46, 51].

Data usage accounting is a building block serving as the basis for accounting access to and/or the usage of data by different users of a data space. Furthermore, it encourages the use of mechanisms for clearing, payment, and billing as well as data-sharing transactions out of a market [1, p. 46, 51].

In addition, *Publication and Marketplace Services* are needed to offer data resources and services under specific terms and conditions. These services enable dynamic access and discovery as well as the process management linked to the creation and monitoring of smart contracts [1, p. 46, 51].

4.1.1.4 Additional technical building blocks

The building blocks mentioned in this chapter can be considered as an addition to the technical building blocks as they facilitate the creation of systems plugged into a data space.

The first building block considered as an addition to the Technical Building Blocks is the *System Adaptation*. This building block is responsible for the facilitation of the transfer of data to and from the data space and the participants' systems (i.e., database systems, data-processing systems, enterprise systems, cyber physical systems, IoT-enabled systems). To do so, it interfaces with data resources exported by the systems and

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transforms the data formats in a way they can be exchanged within the data space, i.e., IoT protocols are a medium to interface with IoT resources, database protocols are needed to interface with databases, etc.

Data usage restrictions can be enforced with the help of the *Data processing* building block as shared data coming from systems that are connected to the data space through system adapters can be processed. Furthermore, technical solutions can accompany or substitute organizations' rules or legal contracts, but in return they increase the complexity of data usage control by data space providers or operators.

Another additional technical building block called *Data Routing and Preprocessing* refers to a dynamic form of data routing to the data-processing node. This building block is mostly a data middleware platform or a combination of several platforms working with different technical requirements according to the routed and collected data. Hence, stream-processing middleware platforms are helpful with the routing and pre-processing of streaming data. Not only technical aspects but also aspects for the compliance with data usage policies are included in this building block [1, pp. 47-48].

As a data space consists of different platforms that generate multiple data flows, the *Data Analytics Engine (DAE)* building block is required to support the synthesis and analysis of these data flows by applying methods like statistical analysis, machine learning and other techniques. This building block needs to be adapted to data characteristics involved [1, 48,52].

The *Data Visualization* building block is a tool that helps a data space offer presentation and visualisation features of its shared and exchanged data. This can take place in different forms that range from dashboards to augmented analytics. A data space in the finance sector, for example, might need to visualize credit scores and other parameters or participants; diagrams and figures can be presented using a dashboards created with the support of this building block [1, p. 48, 52].

When taking a look at data-processing use cases including the interaction of multiple data sources, data consumers, and data services, the *Workflow Management Engine (WME)* building block helps to ensure a proper organization and structure of those workflows (containing data extraction, transformation, and analysis, as well as data presentation and visualisation) [1, p. 48].

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4.1.2 Governance

All business transactions are based on frameworks that include agreements among all actors in a data space.

The *Data Space Boards* building block comprises the governance for a data space considering decision-making, guidance steering and conflict resolution. In addition, *Overarching Cooperation Agreements* need to be made among all data space actors considering functional, technical and legal aspects. Furthermore, some agreements can be reusable in a generic or sector-specific way, while others are use-case specific.

In the *Continuity Model* building block, processes for the management of changes, versions, and releases for standards and agreements as well as a governance body for decision-making and conflict resolution are documented.

In addition, the *Regulations* building block also needs to be considered in the administration of a data space. It includes laws or administrative rules made by an organization for the guidance or prescription of conduct of its members or in a specific country [1].

4.1.3 Organisational and Operational

In order to ensure data sovereignty, operational and organisational agreements need to be made, as they support and enable usage policies. Furthermore, these agreements also bring trust into the data space because of the connection they build between the physical and digital world. The data space's interoperability is based on those agreements and has to be maintained and synchronized continuously between all parties.

Building blocks related to interoperability

To be more precise, a building block related to interoperability is defined, for which the maintenance of specific general agreements, domain specific models or other documents is needed. Measures for change, release and version management are provided by the continuity model. The *Domain Data Standard* building block comprises the language (syntax and semantics) for data sharing in a specific sector or domain. A combination of multiple standards is needed to accomplish specific goals.

Building blocks related to trust

The building blocks related to trust are an addition to the technical building blocks as operational and organisational measures bring trust into the data space. Thus, the

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provision of a digital identity to a legal or natural entity for a reliable identification and authentication builds a connection between the physical and digital world.

The first building block under this category is called *Unique Identifiers* describes a tool that enables a reliable identification of legal entities, natural persons, or things across domain specific or country specific identification schemes. Furthermore, the identification is extended with value-adding tributes (like the commercial register number or tax identification number) which are provided by trusted parties.

Authorisation Registries established according to the operational agreements in the data space are then used to identify each data space participant and verify and validate their digital identities in order to map them to real-world objects. When a participant is authenticated, a structured admission process along with a compliance assessment is needed to build up trust. In addition, neutral bodies approve and monitor these registries.

Moreover, *Trusted Parties* verify and validate the participants' capabilities based on their authenticated identities, as they first acquire or evaluate the capabilities in a structured process like through certifications or registrations. Then the verification of the claims against a digital identity takes place. Therefore, the trusted parties' main aim is to provide neutral digital evidence on specified facts, whose basis are predefined measurable criteria according to regulations or (sector-)specific agreements.

4.1.4 Business

The business building blocks contained in this chapter help regulate the terms and conditions of the sharing and exchange of data as well as the business relationships between the actors operating in the data space.

The *Operational Service Level Agreements (SLAs) define* the specification of the services offered by a Data Service Provider in a data space and standards that need to be followed and quality that has to be met in these services. [1, p. 57].

To keep track of accounting practices and reports performed in the operation of the data space according to applied business models, the *Accounting Scheme* building block has been created. Furthermore, it specifies reports and data-sharing parameters to be produced and reported for every business actor and transaction in the data space [1, p. 57].

As data providers do not necessarily provide their data for free, a data space is in need for *Billing/Charging Schemes* including the resources and specified rules for the billing of services and transactions using accounting data and reports as a basis. The common schemes used are based on the data volume, the number of requests for, or connections to, a service or the time period for the usage of the data In addition, the *Data valuation method* block provides methods used to estimate the data value of shared data in a data space [1, p. 57, 59].

The *Smart Contracts* building block connects legal and organizational to technically enforceable and measurable agreements. Thus, Smart Contracts in general are protocols of terms and conditions agreed upon by two or more parties in a data space including data usage policies, legal aspects, SLAs and other agreements [1, p. 41, 57].

4.2 List of required minimum data space building blocks

Based on the use case descriptions and the process described in section 2.2 we identified which building blocks will be required to implement the process steps within the scenarios, information handling or fulfilment of requirements in the pilot use cases. Table 8 summarises how frequently building blocks are needed across the scenarios:

Table 8: List of technical building blocks of data spaces with the number of scenarios that require these blocks

Building Block Category	Building Block name	Number of Scenarios
Technical	Data Models and Formats	22
	Data Exchange APIs	22
	Identity Management	21
	Trusted Exchange	21
	Data Processing	15
	Metadata and Discovery Protocol	16
	Access and Usage control / Policies	16
	Publication and Marketplace Services	13
	System Adaptation	9
	Provenance and traceability	7
	Data Visualisation	5
	Data Analytics Engine	4
	Workflow Management Engine	3
	Data Routing and Preprocessing	3
	Data Usage Accounting	1

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Governance	Data Space Boards	23
	Continuity Model	23
	Overarching cooperation agreement	23
	Regulations	11
Organisational	Domain Data Standard	17
	Unique Identifiers	2
	Authorisation Registry	0
	Trusted parties	0
Business	Service Level Agreement	8
	Smart Contract	1
	Accounting Scheme	1
	Billing / Charging Scheme	1

A detailed mapping of building block requirements to use case scenarios within the pilots is shown in Table 9.

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Table 9: Building Blocks requirements by Use Case Scenarios

	Building Block name	No.of Scenario	P1-ES	P2-PT-A-1	P2-PT-A-2	P2-PT-A-3	P2-PT-A-4	P2-PT-B-1	P2-PT-B-2	P2-PT-B-3	P2-PT-C	P2-PT-D	P3-SI-1	P3-SI-2	P4-GR	P5-IT-A	P5-IT-B-1	P5-IT-B-2	P5-IT-B-3	P5-IT-B-4	P5-IT-C-1	P5-IT-C-2	P7-LV-1	P7-LV-2	P7-LV-3
Technical	Data Models and Formats	22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	Data Exchange APIs	22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Identity Management	7						1	1	1	1					1			1		1				
	Trusted Exchange	21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	
	Data Processing	16			1	1	1	1	1	1	1	1				1	1	1	1	1		1	1	1	
	Metadata and Discovery Protocol	21	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	
	Access and Usage control / Policies	16		1	1		1	1	1	1		1	1			1	1	1	1	1		1	1	1	
	Publication and Marketplace Services	1										1													
	System Adaptation	13		1	1		1	1	1	1		1							1	1	1	1	1	1	
	Provenance and traceability	9	1								1	1				1	1	1	1			1	1		
	Data Visualisation	15	1	1				1	1	1	1	1	1	1			1				1	1	1	1	1
	Data Analytics Engine	3														1	1					1			

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	Workflow Management Engine	4	1	1									1		1										
	Data Routing and Preprocessing	5	1												1	1						1			1
	Data Usage Accounting	3						1	1	1															
Governance	Data Space Boards	23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Governance	Continuity Model	23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Governance	Overarching cooperation agreement	23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Governance	Regulations	11		1				1	1	1	1	1				1			1				1	1	1
Organisational	Domain Data Standard	8						1	1	1	1					1	1					1		1	
Organisational	Unique Identifiers	1																		1					
Organisational	Authorisation Registry	1																		1					
Organisational	Trusted parties	1																	1						
Business	Service Level Agreement	2															1		1						
Business	Smart Contract	0																							
Business	Accounting Scheme	0																							
Business	Billing / Charging Scheme	17	1	1	1		1	1	1	1	1		1		1	1		1			1	1	1	1	1

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4.2.1 Technical

The most frequently mentioned technical building blocks are data models and formats and data exchange APIs for the exchange of data. These are needed for all machine-to-machine interactions in the data space. There is only one scenario (P7-LV-3) which plans for a direct user interaction on a website.

Trusted exchange and with it the implementation of identity management solutions and the application of usage policies are relevant for almost all of the data exchange processes. For data assets that are to be made transparently available through the data space publication, building blocks like a broker or marketplaces are required. This implies the need for metadata descriptions and a discovery protocol.

Other technical building blocks are mentioned occasionally. System adaptation is relevant to the pilots 1, 2 and 5. Data provenance and tracking are mentioned in pilots 2 and 5. Mentions of building blocks on visualisation, data routing and processing as well as workflow management are few and the use case do rather plan these processes with established software components in a conventional IT architecture setup. For instance, Grafana may be used for visualisations in several use cases, yet it will be integrated in the local system setup of the pilot participants and not be operated as a data space service.

The data space feature of data usage accounting is exclusively mentioned in the use case P2-IT-2D when detected anomalies of appliances are provided to potential service providers.

4.2.2 Governance

The governance building blocks are assumed to be implicitly included in the objective of creating an Energy Data Space and thus obligatory to all use cases to be implemented within a Data Space environment.

Regulations are mentioned in 11 use case scenarios. Most of them refer to the GDPR and occur when user data that is linked to natural persons are used within a use case. For pilot 7 there are regulations on the methodology of calculations within the applications as this use case is supporting the workflow of the public administration. Further regulation on the European and national level apply to electrical grid data. Also compliance with anti-trust laws to avoid that fair competition is undermined by data provision between in-kind competitors need to be ensured. These regulatory requirements are further explored within ENERSHARE in Task 2.4.

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4.2.3 Organisational / Operational

Domain data standards are the most relevant operational building blocks across the use cases. This refers to the information items such as metering data as set out in section 3.3.3 which are needed in several use cases. However, with the perspective of a growing and interoperable energy data space there is also a strong need to apply data standards on key areas like e-mobility (pilot 5) and building efficiency (pilot 7).

Unique identifiers are referenced twice in pilot 5. They are to be applied as identifiers for electrical meters and electrical vehicles. It is likely that further use cases will require unique identifiers but did not yet specify it in the templates.

No mentions are found on an authorisation registry and trusted third parties. This may be seen in light of the focus on the energy applications that are to be implemented at a prototype scale within the research project where these roles are not relevant.

4.2.4 Business

A service level agreement (SLA) was mentioned in the requirements of eight use cases. Though, it will be relevant for most of the use cases to achieve the intended operational status.

Further business building blocks like accounting schemes, billing or charging schemes or smart contracts are only mentioned in the description of pilot 5. The electric mobility platform is planned to use smart contracts with EV customers and allow for micropayments as reward for the flexibility provision.

4.2.5 Summary

The use cases within ENERSHARE can demonstrate nearly the full set of building blocks discussed for data spaces. There is a strong focus on data and trusted exchange. Data used in the use cases should include data models and formats, possibly be aligned with domain data standards, and enriched with metadata and discovery mechanisms through publication services and marketplaces.

Trusted exchange makes use of the identity management within the data space and the access and usage control and policies and will be implemented across all use cases. These building blocks form the core of the requirements from the current bottom-up use case perspective.

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From the work on the use case description, different levels of maturity of use case planning have emerged. Use cases with more advanced planning have already included more detailed and focused requirements and process descriptions. This coincides in some cases with the integration of business and operational building blocks.

5 Conclusions

This deliverable concludes the use case description of the pilots planned in the project ENERSHARE. It describes 11 use cases of 6 pilots of the projects. One pilot is subject to change and the use case analysis is ongoing. This document will be updated with the findings in future versions. It further created a list of building blocks based on the use case descriptions and identified cross-use case collaboration potential.

The digital ecosystem within the ENERSHARE consortium consists of a balanced mix of data suppliers, data customers and service intermediaries. It spans the digital value chain from the generation and acquisition of data from established systems, generating insights from data analysis and processing to the provision of services to customers.

From the use case analysis there is a clear focus on the core building blocks related to data and trusted exchange. Therefore, the connector framework, the identity management and the required access and usage policies should have high priority in the first iterations of the data space implementation.

There is also potential for cross use case and cross pilot cooperation on data models and format. The most prevalent kind of data is metering data that is relevant in all but one pilots. Furthermore, data on flexibility need and potential and on load forecast are key within pilots 2 and 5 and are well suited to make use of domain data standards.

Business building blocks have only been integrated in pilot 5. As sustainable business models are to be created along the creation of the data space this may further be studied within the project as part of task 2.3.

At this early stage of the project, most use cases focus on the core functionalities of data spaces. At the same time, they deal with challenging issues on the energy system technology aspect, e.g. when services for combined system planning on inter-energy

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(electricity, heat and gas in pilots 3 and 4) or inter-sector planning and optimisation (electricity and water networks in pilot 5) are concerned. It may be expected that new requirements will emerge as further functionalities from advanced building blocks are being understood and picked up by business process owners. These will then be integrated in future versions of the use case descriptions and lead to new developments as developers get more familiar with the potential and available technical components.

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7 Appendix

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7.1 Pilot 1 - Use Case 1 – Wind farm integrated predictive maintenance and supply chain optimization

7.1.1 Description of the Use Case

7.1.1.1 Name of the use case

Use case identification		
ID	Area / Do- main(s) / Zone(s) [OPTIONAL]	Name of the use case
P1-ES		Wind farm integrated predictive maintenance and supply chain optimization

7.1.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2	20.01.2023	Volker Berkhout	Integration of input, Scenario steps, extended actor descriptions	
0.3	25.01.2023	Volker Berkhout	Added pitch system in business case and narrative	
0.4	21.02.2023	Ainhoa Pujana	Added gearbox in some missing parts	

7.1.1.3 Scope and objectives of use case

Scope and objectives of use case

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Scope	This pilot aims to foster data driven innovation in the onshore and offshore wind energy industry, along its value chain, to maintain its competitive advantage and contribute to the decarbonisation of the economy.
Objective(s)	(1) Design and development of an offshore wind digital platform (IDSA reference architecture and components included) as one of the core technologies, for enabling the federated data sharing and machine learning (ML) based services between data owners and data users; (2) Enrichment of the IDSA architecture's components with innovative solutions (IDSA connectors in the edge, edge computing, data-driven and Digital Twin based O&M algorithms, synthetic failures data generation) (3) Creation of the most adequate business model for data monetisation through the platform
Related business case(s)	The main business cases for this pilot are linked to the business cases of the actors and include: - Provision of new data analytics tools and digital twins for predictive maintenance to reduce maintenance costs and increase availability of wind turbines. - Provision of a data-driven approach for fault detection and diagnosis on the following wind turbine subsystems: generator, gearbox, pitch system and power converter. This approach is used to give early indications of performance degradation, allowing therefore maintenance to be well scheduled before reaching a severe damage stage.

7.1.1.4 Narrative of Use Case

Narrative of Use Case
Short description
Windfarm owners and wind turbine OEMs have access to the data collected from the wind energy turbines in operation and they are the only players that are presently extracting value out of data at the top of the value chain. However, European components suppliers, ICT companies and ML service providers have difficulties to fully automatically access the data produced by the different systems in wind turbines in real-life operation. This fact causes certain limitations to extract full value out of data and to improve their competitiveness through digitalisation of products and services.

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This pilot aims to foster data driven innovation in the onshore and offshore wind energy industry, along its value chain, to maintain its competitive advantage and contribute to the decarbonisation of the economy.
Complete description
This pilot aims to foster data driven innovation in the onshore and offshore wind energy industry, along its value chain. The scope in this use case is to design and develop an offshore wind digital platform, for enabling the federated data sharing and ML based services between data owners and data users. The platform will be based on IDS architecture and include the design and development of IDSA connectors in the edge in addition to cloud-based services. It will include the design and development of an integrated monitoring strategy for predictive maintenance of electrical drivetrain components, more specifically the generator (DFIG/permanent magnet technology) and the power converter, as well as the gearbox and pitch system of wind turbines. It will consist of a combination of data-driven models with physical models of the generator, gearbox, hydraulic pitch system and potentially of the power converter into an integrated digital twin strategy. Normality models and a set of potential failure conditions will be developed. Both low frequency SCADA data (10-min) and higher frequency data (kHz range) if available, as well as maintenance/failure reports will be used. The application of edge computations in the models will be analysed. The proposed case consists in providing a novel method based on ML algorithms to detect anomalies on several wind turbine subsystems (generator, gearbox, hydraulic pitch system and power converter) and identify their possible root causes. To do so, the SCADA data from onshore and offshore wind farms are used to construct fault detection and diagnostics algorithms. In this context, classic anomaly detection approaches are doomed to be ineffective to point out sensor measurements responsible for the failure. Moreover, these models are generally not straightforwardly interpretable to humans. To cope with these problems, a two-phases anomaly detection algorithm will be implemented: • The first step aims to learn an anomaly detection model based on SCADA data (10mn time-step). • In the second step, we develop an original approach to interpret anomaly results returned by the model in order to provide important insights about what deviation caused the anomaly. It is important to emphasize that, beyond the wish to use a two-step algorithm to discover the main causes of the anomaly, there is also the intent to validate the anomalies, help decision-making, and optimize the planning of maintenance measures. For wind turbine condition monitoring cloud services will be used together with edge computing.

7.1.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)

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ID	Date	Description	Reference to mentioned use case objectives
O5-4		Digital Twin (wind turbine)	
5ET-2		Nº of stakeholders/services providers with access to wind turbines data	
5-ET3		Nº of services created with wind turbine data	
LEI1-ET2		Reduction of the operation and maintenance costs of the windfarms	
LEI1-ET3		Optimisation of the designs of the components and subsystems monitored	

7.1.1.6 Use case conditions

Use case conditions
Assumptions
Digital Twin Performance • The most important electrical properties of the generator and converter are needed to construct the physic model as a base of the digital twin • Data related to the operation of the hydraulic pitch system are needed to construct the digital twin of the hydraulic pitch system • Data related to the operation of the gearbox are needed to construct the digital twin of the hydraulic pitch system • Availability of a sufficiently rich model training dataset, for healthy system behaviour • Besides, a set of labelled failures must be available
Prerequisites

The main requirements are data availability identified in the assumptions. Particularly detailed generator/converter/hydraulic pitch system parameters (design and operation) are essential. Required data includes:
• General operational data
  o Wind speed
  o Pitch angle
  o Rated active power
  o Rated torque
  o Rated voltage
  o Rated current

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- Generator data
    - Power Factor
    - Nominal speed of generator
    - Frequency
    - Stator resistances, reactances/inductances
    - Stator winding temperatures
    - Moment of inertia of rotor
    - Efficiency
    - Type and location of existing sensors
- Converter data
    - Grid-side converter nominal AC voltage
    - Grid side coupling inductor
    - Line filter capacitor
    - Nominal DC bus voltage
    - DC bus capacitor
    - Boost converter inductance
- Hydraulic pitch system data
    - Hydraulic system pressure
    - Accumulator pressure
    - Oil temperature
    - Cylinder position
    - Proportional valve commands
    - Pump charging time
    - Cylinder's piston chamber pressure
    - Cylinder's Rod chamber pressure
- Gearbox
    - Oil temperature
    - Bearing temperature
    - Wind speed
    - Rotational speed
    - Generator power output
    - Vibration/acceleration

7.1.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Level of depth

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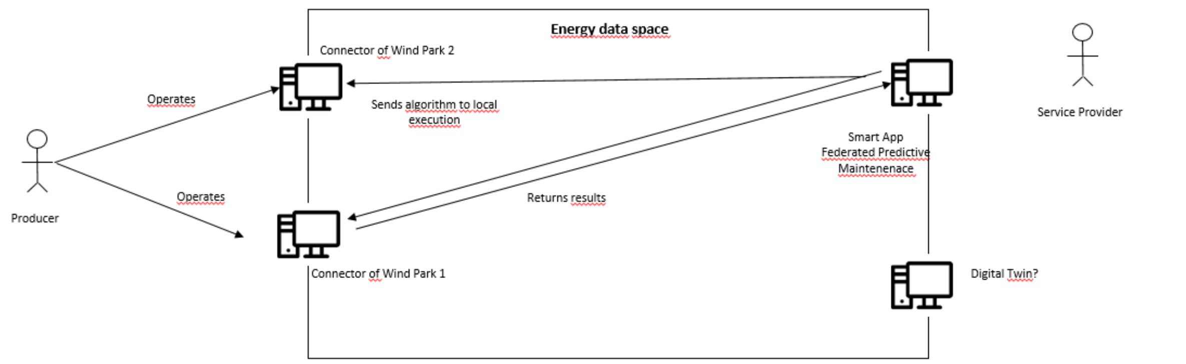
High level use case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Technical / System
Further keywords for classification
Wind energy, wind turbine, generator, converter, IGBT, hydraulic pitch system, failure, predictive maintenance, monitoring, digital twin.

7.1.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case



7.1.3 Technical details

7.1.3.1 Actors

Actors

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Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
Producer	Role	A party that produces electricity.	This is a type of Party Connected to the Grid, wind farm operator
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself.	The ESCO may provide insight services as well as energy management services

Actors			
Grouping		Group description	
People		Users involved in the modelling and interpretation of the data	
Actor name	Actor type	Actor description	Further information specific to this use case
Domain Expert	human	Predictive maintenance engineer responsible for interpretation of health indicators	This person will be responsible for the interpretation of the outcomes of the methods developed in the pilot

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Data Scientist	human	Data analyst responsible for the modelling of the generator and converter	This person will be responsible for the development and training of models used for the predictive maintenance context

Actors			
Grouping		Group description	
Third Parties		Representation of companies participating in the process	
Actor name	Actor type	Actor description	Further information specific to this use case
Maintenance service provider	Business	A party that provides maintenance services.	
Turbine original equipment manufacturer (OEM)	Business	Produce appliances in consumer's household.	Will be simulated during the project
Turbine component supplier	Business	A company that supplies components.	

Actors			
Grouping		Group description	
Information Systems		Information management platforms	
Actor name	Actor type	Actor description	Further information specific to this use case
SCADA-System	System	Supervisory control and data acquisition system of assets	

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Condition-Based Monitoring System	System	Monitoring of asset condition	
Data Space Connector	System	Connects the specified data to the data space	
Digital twin of turbine	System	System that stores historical data, integrates physical and data-driven models of the wind turbine	
Digital twin of generator and converter	System	System that stores historical data, integrates physical and data-driven models of the generator and converter	
Digital twin of hydraulic pitch system	System	System that stores historical data, integrates physical and data-driven models of the hydraulic pitch system	
Digital twin of gearbox	System	System that stores historical data, integrates data-driven models of the hydraulic pitch system	
Federated Predictive Maintenance App	System	Application that runs on the edge device	
Anomaly interpretation engine	System	System that evaluates anomalies detected by apps.	

Actors

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Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Provider	Role IDS	Services are offered by a Service Provider and consumed by a Service Consumer.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	
App Provider	Role IDS	The app provider develops and provides applications for digital services by a service provider.	
App Consumer	Role IDS	The app consumer runs the app in the own connector.	

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7.1.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.1.4 Step by step analysis of use case

7.1.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Anomaly detection using hybrid model (physics based model + data-driven) and/or data-driven model	Diagnostics for detection of anomalous behaviour of the different drivetrain components (PM generator, gearbox, power converter, hydraulic pitch system)	Data scientist responsible for the respective data	• Unsupervised and/or supervised algorithm of wind turbine asset • Warnings from SCADA or CMS	• Sensor data • WT controller data • Component details are available	Health indicators are shown in dashboard

7.1.4.2 Steps-Scenarios

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Scenario								
Scenario name:	Anomaly detection using hybrid model (physics based model + data-driven) and/or data driven model							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1			Provide sensor data for creation of digital twin		Producer	Energy Service Company	I-1, I-2, I-3, I-4. I-5	R-DA-1, R-DA-2, R-IF-1, R-IF-2
2			Create ML model for federated learning app		Energy Service Company			R-HS-1
3			Run federated learning app on edge device		Producer			R-IF-4
4			Interpret anomaly if detected		Producer	Energy Service Company	I-5	R-IF-3
5			Visualise result		ESCO	Producer	I-6	

7.1.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs

I-1	Raw sensor data of the wind turbine generator sampled at high frequency (KHz)	Measurements	R-DA-1
I-2	Raw sensor data of the wind turbine converter sampled at high frequency (KHz)	Measurements	R-DA-1
I-3	Raw sensor data of the hydraulic pitch sampled at high frequency (KHz)	Measurements	R-DA-1
I-4	Raw sensor data of the gearbox sampled at high frequency (KHz)	Measurements	R-DA-1
I-5	SCADA data of the wind turbine sampled at low frequency (10min)	Measurements	R-DA-2
I-6	Data on detected anomalies	Error estimate	R-HS-1
I-7	Interpretation recommendation	Decision support	

7.1.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-DA	Data availability requirement	Requirement linked to the necessary data to be available for the use case.
R-HS	Health state ground truth info	Requirement linked to the availability of information about the health state of the machine
R-IF	Algorithm interfacing APIs	Requirement linked to the availability of software component interfacing APIs

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Requirement RID	Requirement name	Requirement description
R-DA-1	High frequency data available	The required high frequency data for the generator, converter, gearbox and hydraulic pitch system are available
R-DA-2	SCADA and log data available	The required status log data and SCADA data are available
R-HS-1	Health information for case	The health state of the generator, converter, gearbox and hydraulic pitch system ground truth data is available for the sensor data of R-DA-1 and R-DA-2
R-IF-1	Raw data interfacing API	Interface for extracting raw sensor data from data source
R-IF-2	Preprocessed data interfacing API	Interface for storing/extracting preprocessed data
R-IF-3	Model API ENGIE models	Interface for communicating with ENGIE models
R-IF-4	Model API Tecnalia models	Interface for communicating with Tecnalia models

7.1.7 Common terms and definitions

Common terms and definitions	
Term	Definition
Wind turbine	Wind turbine generator. The entire wind turbine including tower, blades and nacelle.
Generator	Subcomponent of the wind turbine that allows to convert rotation of the blades into electricity
(Power) converter	Subcomponent of the wind turbine that allows to convert AC power to DC power and back to AC power at another frequency. It is used to allow control of the variation of the wind turbine speed.
Hydraulic pitch system	Subcomponent of the wind turbine that allows to turn the rotor blades as optimally as possible into the wind
Gearbox	Subcomponent of the wind turbine to increase rotational speed from a low-speed rotor to a higher speed electrical generator
Anomaly	An anomaly is detected when there is sufficient difference between the measured value of a physical quantity and its corresponding value as predicted by a model.

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Health score	The translation of anomalies into a metric representing the condition of an asset.

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7.2 Pilot 2 – Use Case 2a – Leveraging on consumer-level load data to improve TSO's operational and planning procedures.

7.2.1 Description of the Use Case

7.2.1.1 Name of the use case

Use case identification		
ID	Area / Domain(s) / Zone(s) [OPTIONAL]	Name of the use case
UC_A_Pilot2		Leveraging on consumer-level load data to improve TSO's operational and planning procedures.

7.2.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2	31.01.2023	Nuno Fulgêncio, Alexandre Gouveia, Gonçalo Glória	First draft	

7.2.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Using behind-the-meter data to improve operational and planning procedures of the Portuguese transmission system operator, using smart services from the Energy Data Space.
Objective(s)	The objective of this use-case (UC) is to assess the value of behind-the-meter (consumer-level) load data to the Transmission System Operators (TSOs) in improving operational and planning procedures, by taking advantage of the Energy Data Space ecosystem's advanced capabilities for data sharing. The ultimate goal of this UC is to quantify the improvement of well-established procedures for network planning and operation that TSOs are responsible to execute, and translate it into the value – monetary and/or social – of the available behind-the-meter data.

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	The proposed analysis may be breakdown into four main topics to be addressed: - Evaluate impact of using aggregated and individual consumer-level data, exploring federated learning, to improve net-load forecasting at the substation level. - Evaluate the evolution of net-demand at the substation-level by using data on the typology/amount of load and generation (RES) at the end-consumer side. Assess whether this data unveils the need to refine TSOs' grid planning procedures, including the definition of additional scenarios to assure system stability and security. - Track and quantify the aggregated demand-side flexibility potential of end-users (assuming an energy community configuration) and evaluate the potential for participation in the balancing markets for ancillary services provision (service managed by the TSO). - Identification of opportunities for cross-sector synergies between electrical and gas demand at the consumer-level.
Related business case(s)	TSO can potentially reduce forecast errors, reducing the need for activation of corrective measures and thus improving grid resilience. Improving the TSO operational planning procedures by accounting with a more accurate definition of the evolution of the load. Increase the size of the reserve markets' participants' pools which, in principle, tend to promote the reduction of the price of the services. Enhance local energy usage with cross-sector (electricity & gas) alternatives to relief the upstream electric network stress.

7.2.1.4 Narrative of Use Case

Narrative of Use Case
Short description
This UC takes advantage of the Energy Data Space extended functionalities for safe data sharing to perform an evaluation of the value of the behind-the-meter data to the transmission system operator (TSO) in some of its operational and planning procedures. The UC will focus in using the consumption/generation data from energy communities' users to i) improve load forecasting at the substation level, ii) evaluate the evolution of load typology and respective impacts in the grid dimensioning, that may be fed-forward for refinements in the TSO's planning strategies; iii) track and quantify the aggregated flexibility potential at the energy communities level, that can be scaled-up to the system level e.g. through balancing services; iv) identification of potential for cross-sector synergies (electricity and gas) at the communities level.
Complete description
Relying on the capabilities of the Energy Data Space, the UC will be focused on the data exchange between consumers and the Portuguese transmission system operator (TSO). Besides providing an opportunity to test safe and secure data exchange between an open data market and a regulated company, this UC aims to withdraw the value of scaling-up behind-the-meter load and generation data

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to the TSO – accessing and using the Energy Data Space as a data consumer – in the perspective of improving part of its operation and planning activities. This UC will be materialized into the Portuguese Pilot (Pilot 2, under WP9), and the main agents that take part in the interaction, through the Energy Data Space, are the following: RD NESTER will be acting as the TSO and data consumer; Smart Energy Lab (SEL) will act as energy community manager and data owner/provider; INESC TEC will act as a forecasting (federated) service provider. The UC will explore four main actions, including i) substation-level net-load forecasting, ii) network planning scenarios refinement, iii) flexibility potential for balancing services and iv) electricity to gas cross-sector opportunities. These sections are following explained:

i) Forecast: In order to assess the value that behind-the-meter load profiles data from the energy communities might have for system operation and planning, in this first action of the UC, the data will be scaled-up to the TSO for the refinement of the up-to day-ahead load forecasting algorithms at the substation level. The impact of the use of the aggregated load consumption at these lower voltage levels of the grid will be evaluated by benchmarking the following solutions:
    a. The TSO's (RD NESTER) "AI.Forecast" algorithms, which rely uniquely on historical load data at the substation (confidential data, from the Portuguese TSO REN). The AI.Forecast is an Artificial Intelligence (AI) -based architecture for electricity forecasting developed by RD NESTER. It uses an ensemble of machine learning (ML) methods for the automatic learning of load forecasting models, merged using Support Vector Machines (SVM) with a linear kernel for improved robustness and ability to generalize. The individual methods composing the ensemble are: 1) SMV relying on model fitting with support vectors regression using Radial Basis Function kernels; 2) Random forests randomly sampling the training set to provide inputs to tree-like models and combining them in the final result; 3) and Deep-learning (DL) using long short-term memory networks (LSTM) with two layers that learn long-term dependencies between time steps of sequence data. Hence, and contrary to model-driven forecasting, AI.Forecast provides site-driven solutions by extracting implicit site specific information from the site's electricity demand and generation data.
    b. The federated-learning load forecasting algorithm developed by INESC TEC, based on additive vector autoregressive models with a data privacy protocol, which embeds the load consumption data from distributed consumers from SEL, to provide an estimation of the aggregated load at the same power substations, up to day ahead scenarios.

   The accuracy of both methods will be measured, using well-established metrics, and compared. The possible accuracy improvement of the load forecasting resultant from the use of individual consumers' data will be translated into the monetary value of the data for the forecasting task, by including an analysis of the impact of the forecasting error in the operation procedures. It is expected that the study provides insights of the future growing interest of the TSO (and TSOs in general) to access the Energy Data Space to acquire similar data, for similar processes.

ii) Grid planning scenarios: The second action of the UC will address the value for TSO of data on the evolution of the net-demand in the end-consumers/prosumers of SEL's Living Lab, namely in the perspective of refining grid planning scenarios and eventually identify specific technical needs. As in the first action, SEL will provide the data over the Energy Data Space to the TSO, represented by RD NESTER. This action will rely on three main steps: 1) SEL will characterize consumers in terms of their assets' typology and power consumption, including the quantification of the presence of energy generation, storage systems, electric heating, electric vehicles and other. The consumer profiling will account with the inter/extrapolation of the already identified consumer profiles under the SEL universe, and aim for a level of representativeness capable of capturing the net-demand characteristics for a given area of the country, including the evolution trends over time (constrained by the time horizon of the available data). This analysis will rely not only on numerical manipulation,

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but also on social information (age range, housing types, energy mix and EVs usage) of the consumers/prosumers, and will be developed by SEL and RD NESTER; 2) RD NESTER will consume the analysis in 1) to evaluate the impact of the evolution of net-demand in the grid, exploring scenarios with the aforementioned characteristics; 3) and also cross-relate the characteristics that are withdrawn from point 1) with the already in-force planning scenarios applied by the TSO, for a gap analysis. As in the previous, this action intends to derive the value for TSO in consuming data from the Energy Data Space, capable of providing an improved visibility over the evolution of net-demand, and materialize this analysis in a refinement of planning procedures.

iii) Flexibility potential: In the third action of the UC, the TSO (RD NESTER) will consume data provided by SEL on the aggregated power/energy flexibility available on the energy communities' customers side to evaluate the potential for participation in the support of the system, namely through balancing services. The analysis intends to evaluate the capability of energy communities to meet qualification requirements (communication to the market infrastructures and technical capabilities of the assets), in particular for European-level reserve markets access (TERRE, MARI, PICASSO). The TSO (RD NESTER) will consume data of the flexibility potential, and evaluate the value of this information in light of the Portuguese systems' flexibility needs for reserve (based on historical data on balancing markets' needs and activation).

iv) Cross-Sector: The fourth action of the UC intends to shed some light on the opportunities for cross-sector synergies, namely ascertain the potential of transitioning parts of energy consumption from electricity to gas, at the level of the energy communities led by SEL, and evaluate the impact of the electrical consumption deferral to the TSO level. This way it is possible to determine the value of cross-sector flexibility, where the energy vector of consumption changes according to the system's needs, analysis for which the data present on a potential Energy Data Space is crucial. Also in a perspective of system planning, the TSO (RD NESTER) will consume data related with the cross-sector potential which is provided by SEL. The analysis will be translated into a set of recommendations of withdrawn conclusions of the impact of taking advantage of such cross-sector synergies at this level.

7.2.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**
UC2A-KPI-1	M34	Relative improvement of accuracy of forecast algorithm from TSO (RD NESTER) with relation to forecasting from the Service Provider (INESC TEC).	Improve TSO operational planning procedures by using aggregated consumer level data to optimize net-load and RES generation forecast up to day ahead.
UC2A- KPI-2	M34	Amount of flexibility ready for market	Aggregate demand side flexibility potential of energy community to make the potential available to balancing markets
UC2A- KPI-3	M34	Number of new proposed scenarios to be considered in the network planning procedures.	Use consumption data to identify which consumers' evolution of load in terms of typology and amount, exploring the impact

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			this information may have on system planning, by feeding-back to TSO's planning procedures.
UC2A- KPI-4	M34	Amount of energy (in MWh) that may be transposed across energy sectors (from electricity to gas)	Leverage on data from SEL to identify opportunities for cross-sector synergies, namely transforming electrical demand into gas.

7.2.1.6 Use case conditions

Use case conditions
Assumptions
The types and geographical dispersion of the clients of the Living Lab from SEL are assumed to be possible to inter/extrapolate to particular parts of the country (e.g. Lisbon), where RD NESTER is addressing the study of the four main actions of the UC.
Prerequisites
- Availability of Smart Energy Lab (SEL) data on clients' consumption (aggregated by amount and typology) and potential for flexibility and cross-sector. - Availability of load power consumption at the substation level (in this UC, it will be used confidential data from the Portuguese TSO).

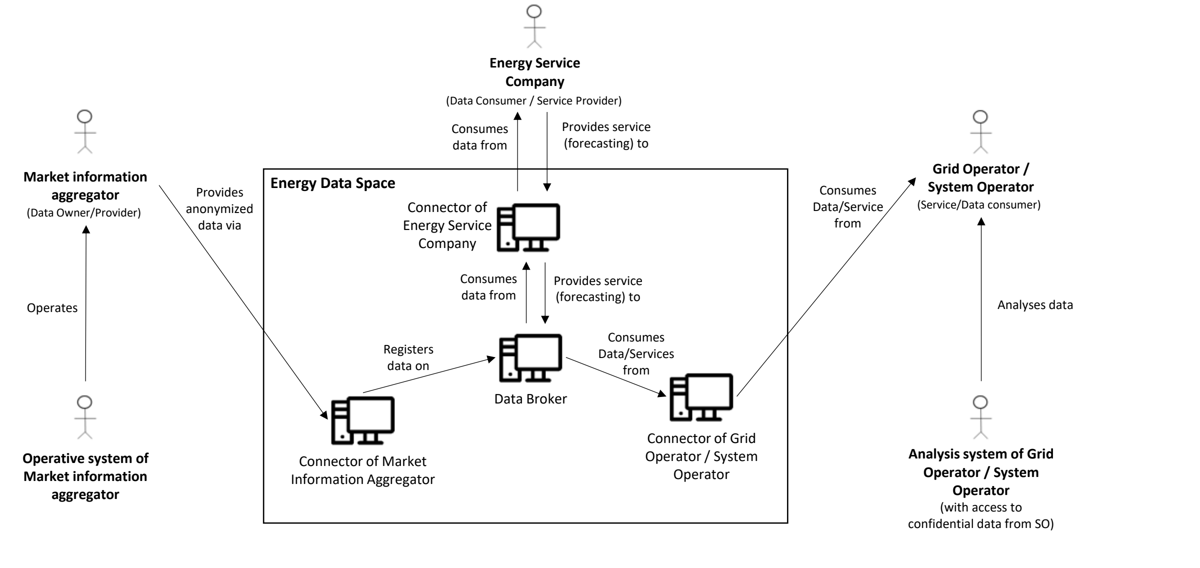
7.2.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
BRIDGE use cases (https://smart-grid-use-cases.github.io/): • Procida Local energy community (GIFT) – AI.Forecasing tool from RD NESTER is applied in this use case.
Level of depth
High-Level Use Case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
RES forecast, flexibility, balancing market, energy community

7.2.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case



7.2.3 Technical details

7.2.3.1 Actors

Actors			
Grouping		**Group description**	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
System Operator	Role	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the electrical system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system	RD NESTER will represent the role of the System Operator, by providing a link with the

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		to meet reasonable demands for the transmission of electricity.	Portuguese TSO's requirements.
Market Information Aggregator	Role	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use.	SEL, which collects, manages and provides data from the participants of the Living Lab.
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	INESC TEC will act as a Service Provider (forecasting), and Data Consumer (SEL consumers' data).

Actors			
Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	In this UC, the data ownership (which belongs to the clients of SEL) is transferred to SEL, acting as Data Owner.
Data Provider	Role. IDS / GAIA-X	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	SEL
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling perspective, the Data Consumer is the mirror entity of the Data Provider; the activities performed by the Data Consumer are therefore	INESC TEC, RD NESTER

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		similar to the activities performed by the Data Provider.	
Service Provider	Role. IDS	Service Providers offers additional data services (e.g., for data analysis, data integration, data cleansing, or semantic enrichment) to improve the quality of the data exchanged in the International Data Spaces. Can be considered a Data Provider and a Data Consumer at the same time (e.g., as a Data Consumer, it receives data from a Data Provider, then provides its specific service, and then turns into a Data Provider itself and offers the data in the International Data Spaces).	INESC TEC will consume data from SEL and provide the forecasting service to the System Operator, without having access to confidential data used by the TSO.
Broker Service Provider	Role. IDS	Intermediary that stores and manages information about the data sources available in the Data Spaces. As the role of the Broker Service Provider is central but non-exclusive, multiple Broker Service Providers may be around at the same time (e.g., for different application domains). The activities of the Broker Service Provider mainly focus on receiving and providing metadata.	This actor is not explicitly represented in the diagram since its activities are intrinsically represented by the Data Broker action.
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	RD NESTER (TSO)

Actors			
Grouping		Group description	
Information Systems			
Actor name	Actor type	Actor description	Further information specific to this use case

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Connector of System Operator	System	Connects the Grid Operator/System Operator to the data space.	
Analysis systems of System Operator	System	Analyse given data in order to provide RES generation forecast and more.	
Connector Market Information Aggregator	System	Connects the Market Information Aggregator to the data space.	
Operative system of Market Information Aggregator	System	ICT-System that supports in the day-to-day operation of the Market Information Aggregator.	

7.2.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.2.4 Step by step analysis of use case

7.2.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Net-load forecast at substation-level.	RD NESTER will consume the forecasting algorithm from INESC TEC, which uses data from SEL's consumers, and	RD NESTER, INESC TEC	RD NESTER requests the forecasting tool from INESC TEC	Forecasting tool from INESC TEC is ready. Confidential data	

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		benchmark it against the AI.Forecast tool to evaluate the impact of consumers' data in forecasting load at the substation level.		using the Data Space.	from the TSO (historic load data at the substation) is available for RD NESTER only.	
2	Analysis of the consumption evolution to improve grid planning	RD NESTER consumes SEL data on load profiles and respective typology to feed planning procedures of the TSO.	RD NESTER, SEL			
3	Flexibility estimation	RD NESTER consumes SEL data on flexibility potential for balancing services, and evaluate potential to the system.	RD NESTER, SEL			
4	Cross-sector opportunities	RD NESTER consumes SEL data on cross-sector potential and evaluate impact in the system.	RD NESTER, SEL			

7.2.4.2 Steps-Scenarios

Scenario								
Scenario name:	Net-load forecast at substation-level.							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1.1		Data collection	Collection of relevant data by Smart Energy Lab		SEL			
1.2		Data Anonymization	Anonymized Data provision of individual meters by Smart Energy Lab		SEL			
1.3		Data Provisioning	Provide anonymized data from SEL clients into the Data Space, that is consumed by INESC TEC		SEL	INESC TEC	I-1, I-3	P2A-F-05
1.4		Federated-Learning Forecasting	INESC TEC uses data from SEL to train FL forecasting models, capable also to		INESC TEC			P2A-F-02

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			integrate load historical data from substation.					
1.5		Service provision	INESC TEC provides load forecasting model to RD NESTER, capable of ingesting confidential data locally (at the TSO side), namely historical data from load at the substation-level.		INESC TEC	RD NESTER		P2A-F-05
1.6		Improved load forecasting for TSO0	End of the process, and evaluation of value of data from SEL in the forecasting of load at the substation.		RD NESTER			

Scenario								
Scenario name:	Analysis of the consumption evolution to improve grid planning.							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
2.1			Provide individual meter data to data space		SEL	RD NESTER	I-1, I-3	P2A-F-05
2.2			Analysis of SEL's clients consumption and generation profiling analysis.		SEL			P2A-F-03
2.3			Data provision analysis from step 2.2		SEL	RD NESTER	I-4	P2A-F-05
2.4			Analysis of future grid planning		RD NESTER			P2A-F-04

Scenario

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Scenario name:	Flexibility potential estimation							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
3.1			Data provision of consumption analysis		SEL	RD NESTER	I-4	P2A-F-05
3.2			Aggregated demand side flexibility potential of energy community		SEL	RD NESTER	I-5	P2A-F-01
Scenario								
Scenario name:	Cross-sector opportunities							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
4.1			Data provision of consumption		SEL	RD NESTER	I-1, I-3, I-6	P2A-F-05
4.2			Analysis of opportunities of cross-sector synergies (electricity and gas)		SEL	RD NESTER	I-6	P2A-F-01, P2A-F-05
4.3			Recommendations for cross-sector		RD NESTER		I-8	P2A-F-06

7.2.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information	Name of	Description of information	Requirement, R-IDs

exchanged, ID	information	ex- changed	
I-1	Distribution of electrical devices	The information contains the different categories of electrical devices and their distribution over the households	
I-2	Net-Load forecast	The information contains up-to day-ahead forecasts for the net-load at the substation-level	P2A-F-04
I-3	Meter data	Individual meter data showing energy consumption	
I-4	Client profiling (consumption and generation)	Profiles of consumption and generation from locally metered data, and respective social characterization (age range, housing type).	
I-5	SEL users' flexibility potential	Aggregated flexibility potential from SEL's end users, for a given time horizon.	
I-6	SEL users gas consumption	Data from SEL users on their gas consumption describing technology, amount and time stamp	
I-7	SEL users' potential for cross-sector	Data from SEL users on potential for cross-sector synergies, namely transferring electrical consumption to gas	
I-8	TSO's recommendations for cross-sector	List of recommendations from TSO with regards to the need for cross-sector, to be applied at the end-user side.	

7.2.6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
F	Functional	Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2A-F-01	Calculate demand side flexibility potential	TSO shall be able to calculate the aggregated flexibility potential of consumers from SEL, to evaluate the potential of participating in balancing markets.

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P2A-F-02	Federated-learning load forecast	INESC TEC produces a model for load forecasting at the substation level, using load data from SEL clients.
P2A-F-03	SEL clients profiling and representativeness.	SEL will estimate and define the profiles of its clients considering their electrical consumption (technology and amount) and generation (distributed generation mix), and social characteristics (age range, housing type). This analysis will also assess the representativeness of these profiles in a given geographical area.
P2A-F-04	Grid planning analysis	TSO will evaluate the impact of the evolution of end-user consumption/generation in the grid planning strategies, by taking advantage of data available in the Energy Data Space.
P2A-F-05	Access Rights	Limit access rights of data resources in the data space to only authorized users
P2A-F-06	Cross-sector opportunities	TSO will leverage on electrical and gas consumption from SEL users, and SEL analysis for cross-sector opportunities, to provide recommendations back to the Data Space.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2A-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P2A-NF-02	Data Accessibility	Grant access to data in accordance with usage policies and access rights

7.2.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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7.3 Pilot 2 – Use Case 2b – Instantiation of energy communities and digital simulation of business models

7.3.1 Description of the Use Case

7.3.1.1 Name of the use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of the use case**
UCB_Pilot2	Energy Communities	Instantiation of energy communities and digital simulation of business models

7.3.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2	14.11.2022	Ricardo Bessa	Start of the use case drafting	
0.3	16.12.2022	Ricardo Bessa, José Villar, Armando Moreno, José Paulos	First draft of the use case	

7.3.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Planning and business model assessment of renewable energy communities (REC) – Article 2(16) Recast Renewable Energy Directive – and Citizen Energy Communities (CEC) – Article 2(11) Recast Internal Electricity Market Directive.

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Objective(s)	The main goal is to explore the combinatorial value of data owned by different Data Owners (i.e., its cross-silo value) for optimal design of REC and/or CEC considering their economic feasibility, simulation of different assets ownership business models and integration of vulnerable citizens. The following specific objectives are associated to primary use cases: 1) Sizing and economic evaluation of REC and/or CEC business models considering consumption and generation profiles available in the Data Space, as well as other data sources such as open market data (prices) and weather data, and the possibility of assets sharing models. 2) Given a specific REC/CEC structure (members and assets), simulate its operation to estimate the dispatch of the flexible resources and the resulting energy price for the internal transactions within the community, according to the business model selected, considering also the inclusion of vulnerable citizens in the community (e.g., alternative electricity tariff scheme, financial schemes for community sharing). 3) Extract approximated flexibility models for smart appliances (e.g., using non-intrusive load monitoring data), enabling an overall quantification of flexibility and estimation of energy savings from intelligent load control.
Related business case(s)	REC and CEC emphasise participation and effective control by citizens, local authorities & smaller businesses whose primary economic activity is not the energy sector. Moreover, their main purpose is to generate social and environmental benefits rather than focusing on financial profits.

7.3.1.4 Narrative of Use Case

Narrative of Use Case
Short description
The main actor of this use case is the Service Provider that receives data (consumption, generation, open weather measurements / forecasts, etc.) available in the Data Space (via Data Provider) to study and simulate different configurations and business models for REC and/or CEC. This includes the following functions: i) sizing of the distributed energy resources (DER) within the community, including the joint ownership of assets; ii) construction of flexibility models, with field data, for thermal loads; iii) simulation of pricing mechanisms within the community, considering the retailers' tariffs and flexibility from DER. This will enable economic feasibility analysis of energy communities, and to potentially engage vulnerable citizens, which can be identified by combining data collected from the residencies with external data (e.g., weather, average income, etc.), in energy trading / sharing activities under different business models. The benefit is to de-risk investment in shared energy resources and maximize the benefits of new local energy communities.
Complete description
This use case includes two optimization problems, the first one aims at determining the optimal installed capacities in the REC /CEC, considering typical consumption profiles, availability of renewable energy sources, and costs of technologies (both capital and operational cost). The second optimization problem considers the operation of the community constrained by the installed capacity from the first optimization problem, in particular its electrical energy sharing / trading, where the optimized dispatch of controllable energy resources (e.g., storage, thermal loads, electric vehicles) is obtained considering the opportunity costs of the community members (retailing tariff for the electricity consumed from the grid, and selling price for the electricity sold back to the grid), together with an internal electricity price to settle the internal energy transactions among members, which can be computed with different approaches or algorithms, to be used to study different financial schemes for communities. It includes 3 Primary Use Cases (PUC), divided in the following steps:

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1. DER sizing and economic evaluation of the REC / CEC business model

Determining the optimal installed capacities in the REC /CEC by combining data available in the Data Space and considering assets sharing between members of the community.

1.1 Request DER sizing and economic evaluation service from Data Space App store

The Service Consumer subscribes (via the Broker Service Provider) the service and provides mandatory parameters for service provision, namely: minimum size of the community, maximum distance between member of the communities, percentages of asset sharing, generation technologies and DER assets and capacity constraints, reference costs for technologies (in alternative, this data can be made available in the Data Space by another Data Provider), consumers ID to consider (optional), type of community (REC /CEC), business model to be considered, that depends on the financing and energy sharing mechanisms selected [1] and determines the objective function to optimize (e.g., total energy costs minimization, profit of specific members maximization, self-consumption maximization), the pricing mechanism for the internal transactions (part of the business model and can be, for example the mid-market rate or an intermediate market rate, a price computation based on the supply-demand ratio , or a price based on a post-delivery pool simulation, as described latter in Section 7), and can also constraint the problem to be solved (e.g., minimum revenues based on a transaction fee, etc.). The Service Consumer can be an energy consumer (or prosumer), or a flexibility services provider or energy services company or an energy supplier. Moreover, it can be a non-energy player such as financing services supplier or a poverty mitigation organization.

1.2 Request data from the Data Space

Required data (typical consumption profiles or past consumption values of the consumers considered, investments costs of technologies, opportunity costs of the consumers (usually their full electricity tariffs, i.e. including the energy cost and access tariffs and any other charge, of buying energy from their retailers when they are consuming, or selling energy back to their retailers when they are generating), and weather conditions or typical generation profiles of renewable generators) from the Data Space is requested by the Data Consumer (which also takes the Service Provider role) to the Data Provider.

1.3 Obtains consent for data sharing

The Data Provider obtains consent from the Data Owner for sharing its data in the context of service (1.1) provision. The Data Owner can be an energy consumer or sub-meter data hub operator. In fact, energy consumers can act as Data Owners and Service Consumer at the same time.

1.4 Data transaction

Transaction of data occurs between the Data Provider and the Data Consumer, with the Data Space Clearing House as intermediary (it keeps logs of this transaction).

1.5 Runs optimization problem

Using the transferred data, the optimization problem is solved to find the optimal installed capacity in the REC / CEC considering an optimal operation with perfect information. The outputs are: i) size of the assets to be installed, ii) schedules of the flexible assets, iii) energies transacted and transaction prices, iv) individual and collective investments, operation, and total costs.

1.6 Output data transferred to the Service Consumer

The Service Consumer receives the output data, and the service provision/transaction is completed.

2. Estimation of flexibility potential and energy cost savings from thermal domestic loads

2.1 Request service from Data Space App Store

The Service Consumer subscribes (via the Broker Service Provider) the service. The Service Consumer can be an energy consumer, a flexibility services' provider, an energy services company, or an energy supplier willing to get an estimation of flexibility from specific consumers (thermal loads) or estimation of flexibility potential (per consumer or in each area).

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2.2 Request data from the Data Space

Required data from the Data Space is requested by the Data Consumer (which is the Service Provider) to the Data Provider in text or similar format:

- Mandatory:
  - EWH specification sheet including:
    - storage capacity - volume (l or m^3) or mass (kg)
    - minimum and maximum delivery temperature (°C or K)
    - stored water temperature limit (°C or K)
    - functioning wattage (W)
  - Sensor-based stored water temperature (°C or K), at least to measure the outlet water temperature (historical dataset)
  - Minimum (for the end-user comfort) outlet water temperature (°C or K)
- Optional, but recommended:
  - total hot water usage (flow rate – if not provided, inferred from historical dataset)
  - network inlet water temperature (if not provided, estimated from water companies' data)
  - Average shower duration (min), where historical data form other users or reference/typical values can be used
  - Average showers start period (hour of the day), where historical data form other users or reference/typical values can be used
  - Number of showers per day (numerical), where historical data form other users or reference/typical values can be used

2.3 Obtains consent for data sharing

The Data Provider obtains consent from the Data Owner for sharing its data in the context of service (2.1) provision. The Data Owner can be an energy consumer or sub-meter data hub operator. Energy consumers can act as Data Owners and Service Consumer at the same time.

2.4 Data transaction

Transaction of data occurs between the Data Provider and the Data Consumer, with the Data Space Clearing House as intermediary (it keeps logs of this transaction).

2.5 Runs optimization problem

Using the transferred data, an optimization problem is solved to enhance the operation of the EWH, by shifting loads based on a set of usage and operating restrictions (user and device defined, respectively), ensuring that the user's usage schedule is not changed.

2.6 Output metadata transferred to the Service Consumer

The Service Consumer receives the output data and/or thermal appliance model, and the service provision/transaction is completed. The service consumer can integrate this information in the PUC 3. The output is:

- EWH functioning calendar (binary variable for EWH operation status – on/off heating trigger)
- Estimated energy cost savings
- Estimated flexibility offered by the EWH at the time interval, calculated as the difference between the previously scheduled baseline consumption and the effectively and modified scheduled consumption.

3. Simulation of the operation of the REC / CEC and computation of the internal transactions price

3.1 Request internal pricing and REC / CEC operation service from Data Space App store

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The Service Consumer subscribes (via the Broker Service Provider) the service and provides mandatory metadata for service provision, namely: community structure and percentages of asset ownerships and other business model descriptors to be defined for each model, such as the energy sharing and the selected internal pricing mechanism [1]. (1)

3.2 Request data from the Data Space

Required data (typical consumption profiles or past consumption values of the consumers considered, assets capacities, integral electricity tariffs of buying and selling energy between consumers and retailers, and weather conditions or typical generation profiles of renewable generators) from the Data Space is requested by the Data Consumer (which is the Service Provider) to the Data Provider.

3.3 Obtains consent for data sharing

The Data Provider obtains consent from the Data Owner for sharing its data in the context of service (3.1) provision. The Data Owner can be an energy consumer or sub-meter data hub operator. In fact, energy consumers can act as Data Owners and Service Consumer at the same time.

3.4 Data transaction

Transaction of data occurs between the Data Provider and the Data Consumer, with the Data Space Clearing House as intermediary (it keeps logs of this transaction).

3.5 Runs selected pricing mechanism and settlement

The algorithm to compute the pricing mechanism selected (i.e., mid-market rate intermediate-market rate, supply-demand ratio or based on a post-delivery pool, see section 7) is executed to determine the price for the internal transactions for each settlement period. To do so, for each community member a consumption or generation bid is assumed depending on if its energy balance is a net consumption or a net generation. Then, for each of these bids, the price is the opportunity cost of selling, in case of net generation, or of buying, in case of net consumption. Then, depending on the pricing mechanism selected, the mid-market rate or an intermediate-market rate can be computed from the maximum selling price and minimum buying price as a simple or weighted average respectively, the price based on the supply-demand ratio based on [2], or the post-delivery pool-based price by simulating a post-delivery [3] pool (possibly with an iterative procedure if there are flexible resources). In addition, based on the energy sharing mechanism selected and the consuming or generating behavior of the community members, the internal transactions among them are determined and settled using the computed price and the ownership of the community assets, providing the individual and collective energy bills.

3.6 Output metadata transferred to the Service Consumer

The Service Consumer receives the output data (energy transacted among prosumers and transaction prices, schedules of the flexible assets, internal settlement and collective and individual operation costs or energy bills), and the service provision/transaction is completed.

7.3.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**
1-SO2		% of cost reduction in the energy bill for individuals / consumers	Related to specific objectives (1)-(3)
5-ET7		Nº of viable sharing economy business models by the end of the project	Objective (1) – community sizing considering joint ownership of assets; Objective (2) – pricing simulation considering energy sharing

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07-2		Nº of non-energy sectors that benefit from Data Space	Objective (1) – financing sector for assets renting; Objective (2) – Poverty reduction associations studying financial schemes to reduce energy poverty of vulnerable citizens

7.3.1.6 Use case conditions

Use case conditions
Assumptions
In terms of geographical scope, we will consider two possibilities: CEC do not bind to immediate vicinity (according to Recast Internal Electricity Market Directive); REC must be in the vicinity of renewable energy projects owned/developed by that community (according to Recast Renewable Energy Directive).
Prerequisites
• Availability of smart meters or sub-metering in consumers premises • Data owner consent for data sharing • Operational Data Space where consumers share time series data about active power consumption (at least from the household meter, but sub-metering is also relevant) and static data about installed assets (PV, EV, etc.) and socio-economic data.

7.3.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
GAIA-X use cases (https://gaia-x.eu/use-cases/): • Smart, privacy-preserving coordination of energy supply and demand • Local communities – Local communities of energy setting up and decentralization • Local communities – Stadtwerke/local open data for business models3 Comments: Mainly focused in "static" data about assets and without exploring the value/benefits of cross-silo data sharing, i.e., the combinatorial value of data. **BRIDGE use cases** (https://smart-grid-use-cases.github.io/): • Optimal sizing of a Local Energy System (E-LAND) • Optimization of operation of Local Energy System (E-LAND) • Procida Local energy community (GIFT) Comments: Concerns mainly assets sizing and does not consider consumer pairing to create a local energy community. Mainly focused on the optimal operation of the microgrid / local energy community.
Level of depth
High level use case (HLUC)
Prioritization
High level of priority
Generic, regional or national relation
Generic
Nature of the use case

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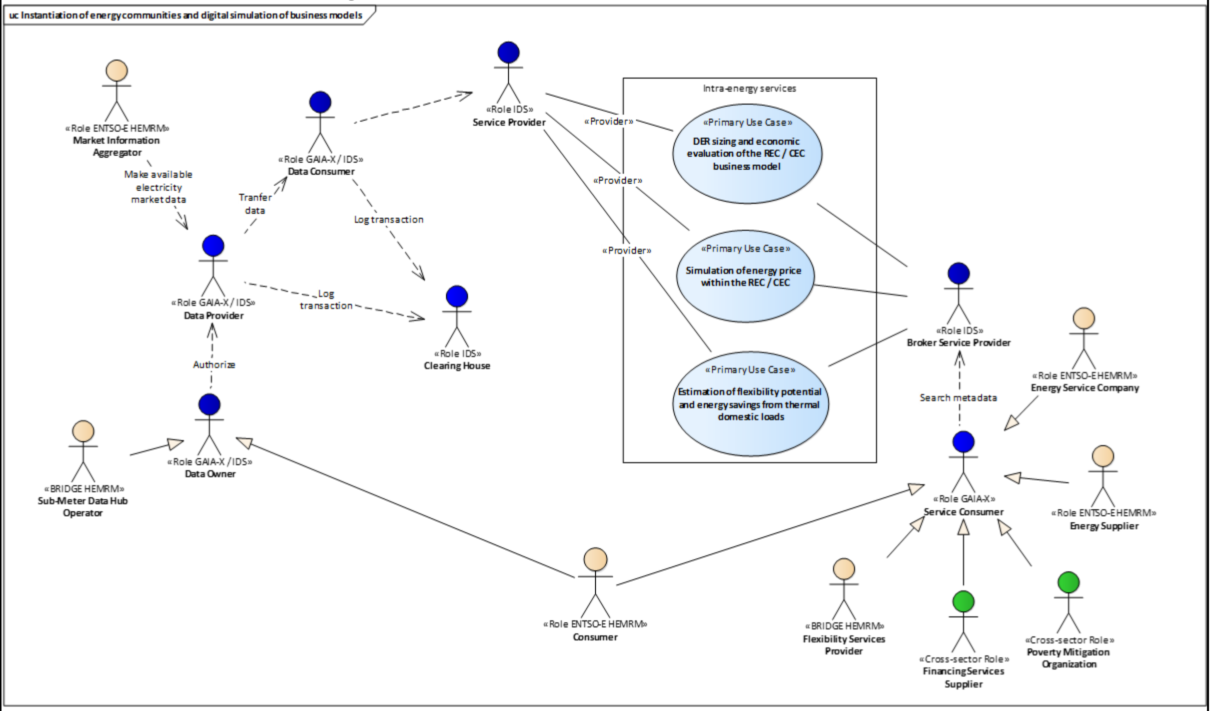
Business use case
Further keywords for classification
Energy communities, distributed energy resources, business models, sizing, optimisation

7.3.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Role model and use case diagram:



7.3.3 Technical details

7.3.3.1 Actors

Actors	
Grouping	**Group description**
Harmonized electricity market role	The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.

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Actor name	Actor type	Actor description	Further information specific to this use case
Consumer	Role	A party that consumes energy.	
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	
Energy Supplier	Role	An Energy Supplier supplies electricity to or takes electricity from a Party Connected to the Grid at an Accounting Point.	
Energy Trader	Role	A party that is selling or buying energy.	
Market Information Aggregator	Role	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use.	
Resource Aggregator	Role	A party that aggregates resources for usage by a service provider for energy market services.	

Actors			
Grouping		Group description	
BRIDGE		A Differential Analysis with Respect to the ENTSO-E – ebIX – EFET Model"	
Actor name	Actor type	Actor description	Further information specific to this use case
Flexibility Services Provider	Role	A party providing flexibility services to energy stakeholders via bilateral agreements or flexibility markets.	
Sub-Meter Data Hub Operator	Role. BRIDGE	Sub-meter Data Hub Operator in the sphere of an Energy Service Provider operating on not validated data.	

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Actors			
Grouping		Group description	
Data Space Role Model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS / GAIA-X	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Provider	Role. IDS	A Service Provider receives data from a Data Provider (or another Service Provider) and either returns the calculation result to the same or directs it to an indicated Data Consumer (which then is a Service Consumer at the same time). A service offers e.g. data analysis, data integration, data cleansing, or semantic enrichment to improve the quality of the data exchanged.	
Broker Service Provider	Role. IDS	Intermediary that stores and manages information about the data sources available in the Data Spaces. As the role of the Broker Service Provider is central but non-exclusive, multiple Broker Service Providers may be around at the same time (e.g., for different application domains). The activities of the Broker Service Provider mainly focus on receiving and providing metadata.	
Clearing House	Role. IDS	Intermediary that provides clearing and settlement services for all financial and data exchange transactions. It might be possible that the two roles "Clearing House" and "Broker Service Provider" are assumed by the same	

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		organization, as both roles require acting as a trusted intermediary between the Data Provider and the Data Consumer.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

7.3.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link
1	Scientific paper	A. Moreno, J. Villar, C. S. Gouveia, J. Mello, and R. Rocha, "Investments and Governance Models for Renewable Energy Communities," in EEM 2022, Sep. 2022.	Published	Financing and energy sharing mechanisms	IEEE	https://doi.org/10.1109/EEM54602.2022.9921004
2	Scientific paper	B. Zhang, Y. Du, E. G. Lim, L. Jiang, K. Yan, "Design and Simulation of Peer-to-Peer Energy Trading Framework with Dynamic Electricity Price," in AUPEC 2019, Nov. 2019.	Published		IEEE	https://doi.org/10.1109/AUPEC48547.2019.211948

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3	Scientific paper	J. Mello, J. Villar, R. J. Bessa, M. Lopes, J. Martins, and M. Pinto, "Power-to-Peer: a blockchain P2P post-delivery bilateral local energy market," in EEM 2020, Sep. 2020.	Published		IEEE	https://doi.org/10.1109/EEM49802.2020.9221901
4	Technical report	Reference arthictecture model. Version 3.0	Public	Role model	IDSA	https://internationaldataspaces.org/wp-content/uploads/IDS-Reference-Architecture-Model-3.0-2019.pdf
5	Technical report	GAIA-X: Technical Architecture	Public	Role model	GAIA-X	https://www.bmwk.de/Redaktion/EN/Publikationen/gaia-x-technical-architecture.pdf?__blob=publicationFile&v=7

7.3.4 Step by step analysis of use case

7.3.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	DER sizing and economic evaluation of the REC / CEC business model		Service Provider	Service consumer requests service	Consumption and generation profiles / time series available in the Data Space & tariff data	Information available about REC / CEC optimal sizing
2	Estimation of flexibility potential and energy savings from thermal domestic loads		Service Provider	Service consumer requests service	Technical information from the EWH available; typical profiles or historical info about	Data available about estimated energy cost savings and flexibility

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					shower duration and start; sensor for outlet water	
3	Simulation of energy price within the REC / CEC		Service Provider	Service consumer requests service	Consumption and generation profiles / time series available in the Data Space & tariff data	Collective and individual operation costs or energy bills

7.3.4.2 Steps-Scenarios

Scenario								
Scenario name:	DER sizing and economic evaluation of the REC / CEC business model							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1.1	Triggering event	Request service	Request DER sizing and economic evaluation service from Data Space App store	CREATE	Service Consumer	Broker Service Provider	I-1, I-2, I-3, I-4, I-6, I-7, I-9, I-10	QoS-3, QoS-6, CONF-1
1.2	1	Send meta-data	Send meta-data for service provision	CREATE	Broker Service Provider	Service Provider	I-1, I-2, I-3, I-4, I-6, I-7, I-9, I-10	QoS-1, QoS-2, QoS-3, DM-6
1.3	1	Request data	Request data from the Data Space	CREATE	Data Consumer / Service Provider	Data Provider	I-6	QoS-1, QoS-2, QoS-3
1.4	3	Obtain consent	Obtain consent for data sharing	CREATE	Data Provider	Data owner	I-11	SEC-5
1.5	3	Transfer data	Transaction of data occurs	GET	Data Provider	Clearing House	I-5, I-8, I-12, I-13, I-14	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-

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								6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
1.6	3	Transfer data	Transaction of data occurs	GET	Clearing House	Data Consumer / Service Provider	I-5, I-8, I-12, I-13, I-14	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
1.7	5	Run optimization	Optimization problem solved to find the optimal installed capacity in the REC / CEC	EXECUTE	Service Provider	Service Provider		
1.8	5	Transfer results	Output metadata transferred to the Service Consumer	CREATE	Service Provider	Service Consumer	O-1, O-2, O-3, O-4	SEC-1, SEC-7, SEC-8

Scenario								
Scenario name:	Estimation of flexibility potential and energy cost savings from thermal domestic loads							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
2.1	Triggering event	Request service	Request Estimation of flexibility potential and energy savings service from Data Space App store	CREATE	Service Consumer	Broker Service Provider		QoS-3, QoS-6, CONF-1
2.2	1	Request data	Request data from the Data Space	CREATE	Data Consumer / S Provider	Data Provider	I-6	QoS-1, QoS-2, QoS-3
2.3	2	Obtain consent	Obtain consent for data sharing	CREATE	Data Provider	Data owner	I-11	SEC-5

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2.4	2	Transfer data	Transaction of data occurs	GET	Data Provider	Clearing House	I-8, I-15, I-16, I-17, I-18, I-19, I-20, I-21, I-22	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
2.5	2	Transfer data	Transaction of data occurs	GET	Clearing House	Data Consumer / App Provider	I-8, I-15, I-16, I-17, I-18, I-19, I-20, I-21, I-22	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
2.6	4	Run optimization	Optimization problem solved to enhance the operation of the EWH	EXECUTE	Service Provider	Service Provider		
2.7	4	Transfer results	Output metadata transferred to the Service Consumer	CREATE	Service Provider	Service Consumer	O-6, O-7, O-8	SEC-1, SEC-7, SEC-8

Scenario								
Scenario name:	Simulation of the operation of the REC / CEC and computation of the internal transactions price							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
3.1	Triggering event	Request service	Request internal pricing and REC / CEC operation service from Data Space App store	CREATE	Service Consumer	Broker Service Provider	I-3, I-4, I-6, I-7, I-9, I-10	QoS-3, QoS-6, CONF-1

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3.2	1	Send meta-data	Send meta-data for service provision	CREATE	Broker Service Provider	Service Provider	I-3, I-4, I-6, I-7, I-9, I-10, O-1, O-4	QoS-1, QoS-2, QoS-3, DM-6
3.3	1	Request data	Request data from the Data Space	CREATE	Data Consumer / Service Provider	Data Provider	I-6	QoS-1, QoS-2, QoS-3
3.4	3	Obtain consent	Obtain consent for data sharing	CREATE	Data Provider	Data owner	I-11	SEC-5
3.5	3	Transfer data	Transaction of data occurs	GET	Data Provider	Clearing House	I-5, I-8, I-12, I-13, I-14, O-1, O-4	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
3.6	3	Transfer data	Transaction of data occurs	GET	Clearing House	Data Consumer / Service Provider	I-5, I-8, I-12, I-13, I-14, O-1, O-4	QoS-1, QoS-2, QoS-3, QoS-4, QoS-5, QoS-6, CONF-1, CONF-2, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-5, OTHER-1
3.7	5	Run optimization	The algorithm to compute the selected pricing mechanism is executed to determine the price for the internal transactions for each settlement period	EXECUTE	Service Provider	Service Provider		
3.8	5	Transfer results	Output metadata transferred to the Service Consumer	CREATE	Service Provider	Service Consumer	O-2, O-3, O-5	SEC-1, SEC-7, SEC-8

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7.3.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information exchanged	Requirement, R-IDs
I-1	Community size	Minimum size of the community	SEC-8, DM-6
I-2	Max distance	Maximum distance between member of the communities	SEC-8, DM-6
I-3	% asset sharing	Percentages of asset sharing	SEC-8, DM-6
I-4	DER technologies	Generation technologies and DER assets and capacity constraints	SEC-8, DM-6
I-5	DER OPEX	Reference costs for technologies	SEC-8, DM-6
I-6	Consumer ID	Consumers ID to consider	SEC-1, SEC-2, SEC-4, SEC-7, OTHER-1
I-7	Community type	Type of community (REC /CEC)	SEC-8, DM-6
I-8	Opportunity cost	Opportunity costs of the consumers (usually their full electricity tariffs)	SEC-1, SEC-2, SEC-4, SEC-7, OTHER-1
I-9	Business model	Business model that determines the objective function to optimize (e.g., total energy costs minimization, profit of specific members maximization, self-consumption maximization)	SEC-8, DM-6
I-10	Pricing mechanism	Pricing mechanism for the internal transactions and can be: 1) mid-market rate, 2) intermediate market rate, 3) based on the supply-demand ratio, 4) based on a post-delivery pool	SEC-8, DM-6
I-11	Consent	Explicit consent for data use	SEC-8, DM-6
I-12	Electrical energy consumption	Electrical energy consumption: past measurements or typical profile	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-13	Weather-based generation	Weather conditions or typical generation profiles of renewable generators	SEC-1, SEC-2, SEC-4, SEC-7, OTHER-1
I-14	DER CAPEX	Investments costs of DER technologies	SEC-8, DM-6
O-1	DER size	Size of the DER assets to be installed	SEC-8, DM-6
O-2	Schedules	Schedules of the flexible assets	SEC-8, DM-6
O-3	Transactions	Energies transacted and transaction prices	SEC-8, DM-6
O-4	Investements	Individual and collective investments, operation, and total costs	SEC-8, DM-6
O-5	Internal settlement	Internal settlement and collective and individual operation costs or energy bills	SEC-8, DM-6

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I-15	Min outlet water temp	Minimum (for the end-user comfort) outlet water temperature (°C or K)	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-16	Average shower duration	Average shower duration (min), where historical data form other users or reference/typical values can be used	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-17	Average shower start	Average shower start period (hour of the day), where historical data form other users or reference/typical values can be used	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-18	Number of showers per day	Number of showers per day, where historical data form other users or reference/typical values can be used	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-19	EWH specification sheet	storage capacity - volume (l or m3) or mass (kg); minimum and maximum delivery temperature (°C or K); stored water temperature limit (°C or K); functioning wattage (W)	SEC-8, DM-6
I-20	Stored water temperature	Sensor-based stored water temperature (°C or K), at least to measure the outlet water temperature	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-21	Total hot water usage	Total hot water usage (flow rate – if not provided, inferred from historical dataset) – optional	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
I-22	Inlet water temperature	Network inlet water temperature	SEC-1, SEC-2, SEC-3, SEC-4, SEC-5, SEC-6, SEC-7, SEC-8, DM-1, DM-2, DM-3, DM-4, DM-6, OTHER-1
O-6	Energy cost savings	Energy savings resulting from the optimal operation	SEC-8, DM-6
O-7	Estimated flexibility	Estimated flexibility offered by the EWH at each time interval	SEC-8, DM-6
O-8	EWH functioning calendar	EWH functioning calendar (binary variable for EWH operation status – on/off heating trigger)	SEC-8, DM-6

7.3.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
QoS	Quality-of-service	Availability of the system, such as acceptable downtime, recovery, backup, rollback, etc. Quality of Services issues also

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		address accuracy and precision of data, the frequency of data exchanges, and the necessary flexibility for future changes.
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communications types, network bandwidth, existing protocols, etc., but only from the user's point of view.
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable.
DM	Data management	Covers both the management of the data exchanges in each Use Case step and the management of data at either end if that management is impacted by data exchanges. It should not address database design, but should concentrate on the user requirements for the interfaces to databases and other data handling applications.
OTHER	Others	Political, legal, financial, or just very specific to a particular step.
Requirement R-ID	Requirement name	Requirement description
QoS-1	Elapsed time response requirements for exchanging data	Less than 1 minute
QoS-2	Contractual timelines for exchanging data is required	Less than 1 minute
QoS-3	Availability of information flows	99.9% + availability - Allowed outage: 9 hours per year
QoS-4	Accuracy of data requirements	Requires quality flag indicating at least normal and not normal; Age of data needs to be knowable; Time skew of data must be known; Adequate accuracy can be assumed
QoS-5	Frequency of data exchanges	Upon request (for service provision); Periodicity greater than a few seconds (for data acquisition)
QoS-6	Commonly used techniques for meeting quality of service requirements of this data exchange	Failure detection; Automatic restart; Automatic failover to second source of data or function; Automatic failover of communication channels to secondary channel; Backup of data Transaction rollback; QoS monitoring; Alarming on QoS failure
CONF-1	Communication access services requirements	Request-response; Data discovery; Use of data sets
CONF-2	Data exchange methods	Client-server; publish-subscribe
SEC-1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Crucial
SEC-2	Information integrity violation: Ensuring that	Crucial

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	data is not changed or destroyed is:	
SEC-3	Authentication: Masquerade and/or spoofing: Ensuring that data comes from the stated source or goes to authenticated receiver is:	Crucial
SEC-4	Information theft: Ensuring that data cannot be stolen or deleted by an unauthorized entity is:	Crucial
SEC-5	Denial of Service: Ensuring unimpeded access to data is:	Crucial
SEC-6	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Logging of all information exchanged during this interaction is required
SEC-7	Authentication and Access Control mechanisms commonly used with this data exchange	Private (secret) key encryption
SEC-8	Procedural security measures commonly used with this data exchange	Audits
DM-1	Management of large volumes of data that are being exchanged	Some part of step involves handling large volumes of data
DM-2	Data consistency and synchronization management across systems	Day-by-day synchronization
DM-3	Management of timely access to data by multiple different users	Contractual/required time windows for multiple access are within minutes
DM-4	Validation of data exchanges	Data must include quality codes to indicate its validity; Data from different sources must be validated against each other; Data mapping of data item names is required for data from different sources
DM-5	Management of accessing different types of data to be exchanged	Each data exchange could entail different types of data

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DM-6	Data format requirements	Standardized data objects
OTHER-1	GDPR compliance	Full

7.3.7 Common terms and definitions

Common terms and definitions	
Term	Definition
Renewable Energy Community (REC)	A legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the **proximity of the renewable energy projects** that are owned and developed by that legal entity. (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities. (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.
Citizen Energy Community (CEC)	A legal entity that: (a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises. (b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits. (c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders.
Mid market rate	Pricing mechanism based on computing the average between the price of buying price from the retailer and and the price of selling energy back to the retailer, as defined in [2]. When different community members have different retailers and tariffs, we propose to use the maximum selling price and minimum buying price. It is necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Intermediate market rate	Based on the mid market rate, but instead of a simple average, we propose a weighted average to allow giving more weight to the buying or to the selling prices. It is again necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Supply-demand ration based price	This procedure provids a price proably closer to a real market outcome [2], since it takes into account the amount of supply availabe compared to the existing demand, providing a better economic signal. It is again necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying and contributing to the aggregated demand, or generating, therefore selling energy and contributing to the aggregated supply.
Post-delivery pool based price	This price is the result of simulating a post-delivery pool, post-delivery local markets being described in [3 . In the simplest case, the simulation consists in crossing the aggregated supply and demand curves. To do so, for each consumer, its net balance is computed, to know if it is consuming, therefore

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	buying energy and producing a buying bid at its opportunity cost (usually the integral tariff of buying energy from its retailer), or generating, therefore selling energy and producing a selling bid at its opportunity cost (usually the integral tariff of selling energy to its retailer). With these bids, the the aggregated supply and demand curves of the pool can be computed. If there are no flexible resources, the price is computed by crossing these curves. In case there are flexible resources whose dispatch depends on the transactions price, an iterative procedure can be used to estimate the schedule, determining again the consuming or generating behavior of the consumers, reestimating the pool price, until prices and schedules convergence. Alternatively, it may be possible to maximize the welfare so as to determine, in one step optimization problem, the price and the flexible resources schedules.

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7.4 Pilot 2 – Use Case 2c - Detect irregularities in energy consumption in households with seniors living alone

7.4.1 Description of the Use Case

7.4.1.1 Name of the use case

Use case identification		
ID	Area / Do- main(s)/ Zone(s) [OPTIONAL]	Name of the use case
P2-PT-C		Detect irregularities in energy consumption in households with seniors living alone

7.4.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	

7.4.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Improve quality of living and energy consumption in the households of seniors living alone and provide alarm services to notify relatives or health care agents in case of a trigger event.
Objective(s)	○ Detect irregularities in energy consumption in households with seniors living alone
Related business case(s)	Assisted living digital service offering

7.4.1.4 Narrative of Use Case

Narrative of Use Case
Short description
Establish insurance and healthcare services for the community (and for the providers) by learning energy utilization patterns to recognize potential problems and trigger alarms. This aims mainly at senior citizens with reduced mobility or disability problems and do not have close assistance or conditions to call for help in case of

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need. The use case will also monitor changes in domestic environment (temperature, humidity, etc.), enabling an assessment of the impact on the current health status of the citizen.
Complete description
People worldwide are living longer. According to the WHO, the number of people aged 60 years and older was 1 billion, but this number is expected to rise to 1.4 billion by 2030 and 2.1 billion by 2050 [1]. This increase is occurring at an unprecedented pace and will accelerate in coming decades, particularly in developing countries. The number of elderly people (aged 65 years or more) living in the EU is projected to reach 129.8 million inhabitants in 2050, with their relative share of the total population of 29.4% as compared to approximately 1/5 at the start of 2019 [2]. At the same time, a growing number of these are living alone in the EU, notably women. In 2018, the share of older women living in households composed of a single person was 40.2% across the EU-27, while the share for older men was 21.8 % [2]. Elderly people are more likely to suffer from issues like falls, trips, and accidents [3]. In case of medical emergency, the risk of serious injury and death as an outcome is higher if they live alone since there might be no assistance around and they may not be capable of calling for help. This use case intends to explore the concept of an assisted living digital service offer where the health status of a senior living alone is disclosed by any change in the household's energy consumption. It is assumed that aging adults have daily routines, and it is possible to determine a typical consumption profile that reflects their habits and considers seasonality from historical data. By comparing this profile with real-time data communicated via EMS, the Energy Service Provider algorithm detects if there is an event that deviates from the normal, triggering a notification that initiates a two-step process. The former is to call the senior citizen automatically or activate an alarm that he/she needs to either answer or deactivate. If this happens, the process stops; otherwise, it continues to the latter step which is to inform the family/caregivers. This service would bring several benefits to the different parties; namely, it would support the end-user's independence and improve his/her quality of life, by promoting timely assistance in the event of a medical emergency, while also reassuring the family and/or caregivers on the senior safety.

7.4.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**

7.4.1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Recruitment of participants needed, especially elderly citizens that live alone • Availability of Energy Management System

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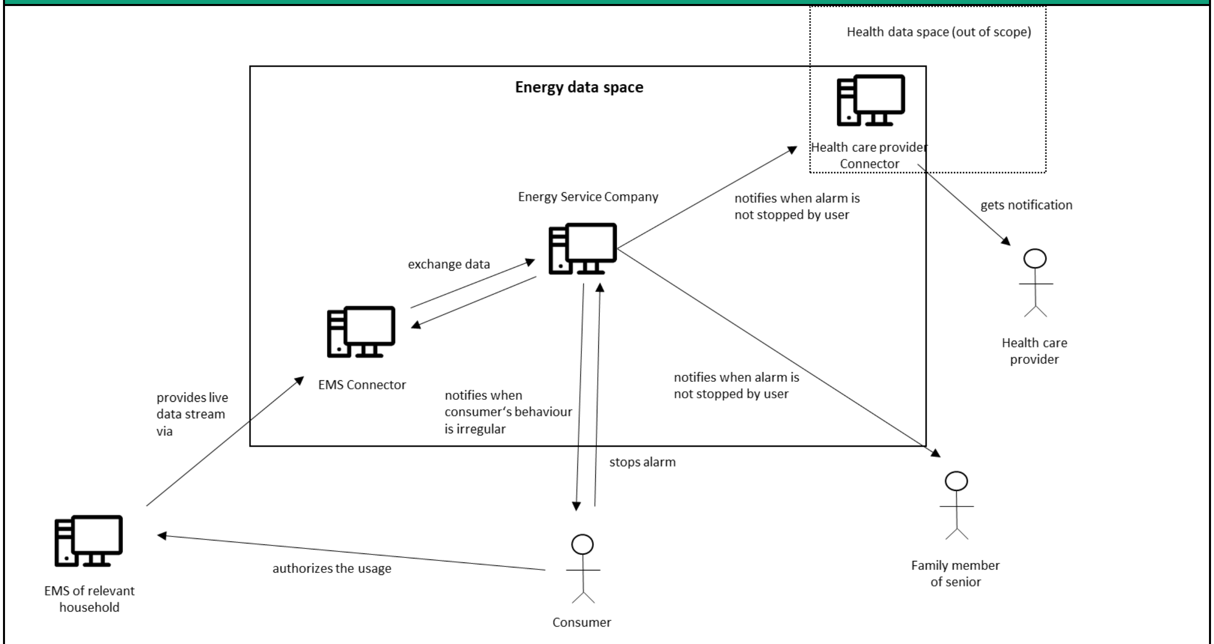
7.4.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Level of depth
High-level Use Case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Assisted living, monitoring service, health services

7.4.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case



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7.4.3 Technical details

7.4.3.1 Actors

Actors			
Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
Consumer	Role	A party that consumes electricity	This is a Type of Party Connected to the Grid. Data space roles: Data owner, Data provider, Service Consumer
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	SEL

Actors			
Grouping		Group description	
People		Representation of individuals participating in the process	
Actor name	Actor type	Actor description	Further information specific to this use case

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Family member of senior	Human		A person related to the senior living in the relevant household. (Simulated during project)
Health care provider	Human		A person or medical institution caring for the senior's health. (simulated during project)

Actors			
Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS / GAIA-X	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Clearing House	Role. IDS	Intermediary that provides clearing and settlement services for all financial and data exchange transactions. It might be possible that the two roles "Clearing House" and "Broker Service Provider" are assumed by the same organization, as both roles require acting as a trusted intermediary between the Data Provider and the Data Consumer.	Communication of notifications and alarms may be logged by a Clearing House.

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Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

Actors			
Grouping		Group description	
Information Systems		Technology systems that send, edit, save or delete data	
Actor name	Actor type	Actor description	Further information specific to this use case
EMS of relevant household	System	The Energy Management System manages and monitors the household's energy usage.	
EMS Connector	System	Connects the Energy Management System to the data space.	
Health care provider connector	System	Connects the health care provider to the data space.	

7.4.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link
[1]	Internet				WHO	https://www.who.int/health-topics/ageing#tab=tab_1
[2]	Internet				EU	https://ec.europa.eu/eurostat/documents/3217494/11478057/KS-02-20-655-EN-N.pdf/9b09606c-d4e8-4c33-63d2-3b20d5c19c91?t=1604055531000
[3]	Internet				WHO	https://www.who.int/news-room/fact-sheets/detail/falls

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7.4.4 Step by step analysis of use case

7.4.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
	Detection of irregularities in seniors' energy consumption					

7.4.4.2 Steps-Scenarios

Scenario								
Scenario name:	Detection of irregularities in energy consumption of seniors citizen							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1.1		Initial setup EMS	Provide live data stream of energy consumption		EMS System	Energy Service Company	I-1 I-2 I-3 I-4 I-5	P2A-NF-04 P2A-NF-05, P2A-NF-06, P2A-NF-07
1.2		Initial setup Health Care	Connect to Health data space		Health care provider Connector		I-7 I-8	
1.3		Algorithm development	Real time analysis service		Energy Service Company		I-1 I-2 I-3 I-4 I-5	P2C-F-01
1.4		Notification irregularity	Notify senior about irregularity		Energy Service Company	Consumer	I-9	P2C-F-02 P2C-F-03 P2C-F-07
1.5		Notification alarm	Trigger alarm via health data space		Energy Service Company	Consumer	I-10	P2C-F-02 P2C-F-04
1.6		Notification health care	Service Providers notifies		Energy Service Company	Health care provider	I-10 I-11	P2C-F-05

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			health care providers					
1.7		Notification family	Service Providers notifies family members		Energy Service Company	Family member of senior	I-10 I-11	P2C-F-06

7.4.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	Temperature	Ambient temperature	
I-2	Humidity	Ambient humidity	
I-3	current	Electrical current	
I-4	voltage	Electrical voltage	
I-5	power	Electrical active power	
I-6	Total/energy	Cumulative energy	
I-7	ID Health Care	Identification to connect to the relevant health care provider	
I-8	ID senior	Identification to determine an elderly person	
I-9	Notification signal irregularity	Data to signal an irregularity	
1-10	Notification signal alarm	Data to signal an alarm	
I-11	Alarm Cause	Explanation of the event that caused the alarm.	

7.4.6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
F	Functional	Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2C-F-01	Learn on historical data	Learn and test an analytics approach on historical data

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P2C-F-02	Detect irregularity	Analyse real time data of households
P2C-F-03	Trigger irregularity alarm with senior	Trigger an alarm if an irregularity occurs and criteria are met
P2C-F-04	Trigger full alarm with senior	Trigger an alarm if criteria and conditions are met
P2C-F-05	Trigger full alarm with health care provider	Trigger an alarm if criteria and conditions are met
P2C-F-06	Trigger full alarm with senior family members	Trigger an alarm if criteria and conditions are met
P2C-F-07	Validate alarm	Validate if the alarm could be a false alarm by e.g. calling the senior automatically
P2C-F-08	Initiate subsequent process	Initiate a subsequent process by notifying family members or an health care provider

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2A-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P2A-NF-02	Data Accessibility	Store data in a safe and tamperproof manner
P2A-NF-03	Data Protection	Handle personal data according to GDPR guidelines
P2A-NF-04	Frequency of data exchanges	Periodicity greater than a few seconds (for data acquisition)
P2A-NF-05	Commonly used techniques for meeting quality of service requirements of this data exchange	Failure detection; Automatic restart; Automatic failover to second source of data or function; Automatic failover of communication channels to secondary channel; Backup of data Transaction rollback; QoS monitoring; Alarming on QoS failure
P2A-NF-06	Authentication and Access Control mechanisms commonly used with this data exchange	Private (secret) key encryption
P2A-NF-07	Validation of data quality	Data must include quality codes to indicate its validity

7.4.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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7.5 Pilot 2 – Use Case 2d – Suggest maintenance of appliances based on NILM data

7.5.1 Description of the Use Case

7.5.1.1 Name of the use case

Use case identification		
ID	Area / Do- main(s)/ Zone(s) [OPTIONAL]	Name of the use case
P2-PT-D		Suggest maintenance of appliances based on NILM data

7.5.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2	20.01.2023	Linda Rülicke, Volker Berkhout	For Final Review	

7.5.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Improve quality of living and energy consumption in households by detecting higher energy consumptions of appliances early on and increase energy efficiency by suggesting maintenance or renewal of appliances.
Objective(s)	○ Use NILM data to suggest maintenance of appliances or renewal (e.g. fridge)
Related business case(s)	Digital service offering for preventive maintenance for home appliances with value creation pathways for different actors

7.5.1.4 Narrative of Use Case

Narrative of Use Case
Short description
Use NILM data to detect appliance retrofit opportunities in private rental sector and social housing, taking into account the types of properties and socio-economic data. This information will be shared with consumers and housing providers.

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Complete description

7.5.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**

7.5.1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Availability of Energy Management System

7.5.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Pilot 2C
Level of depth
High level use case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Business
Further keywords for classification
Predictive Maintenance, remote monitoring

7.5.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

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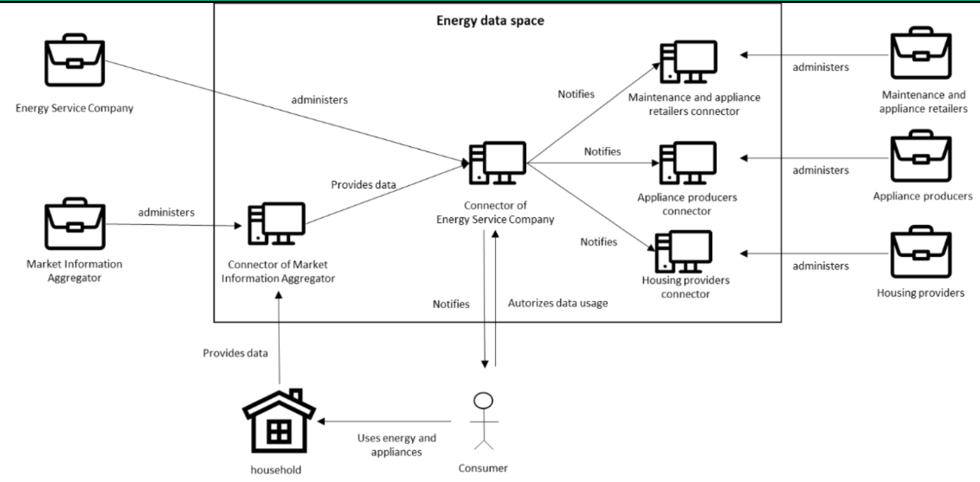
Diagram(s) of use case



7.5.3 Technical details

7.5.3.1 Actors

Actors			
Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
Consumer	Role	A party that consumes electricity	This is a Type of Party Connected to the Grid. Data space roles: Data owner, Data Provider, Service consumer
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical	SEL Data space roles: Data Consumer, Service Provider

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		infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	

Actors			
Grouping		Group description	
Third Parties		Representation of companies participating in the process	
Actor name	Actor type	Actor description	Further information specific to this use case
Housing Provider	Business	A party that owns the participant's apartment/house.	Data space roles: Data provider, Service consumer
Maintenance and appliance retailers	Business	A party that sells appliances/ provides their maintenance.	Will be simulated during the project Data space roles: Service consumer
Appliance producers	Business	Produce appliances in consumer's household.	Will be simulated during the project Data space roles: Service consumer

Actors			
Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	

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Data Provider	Role. IDS	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

Actors			
Grouping		Group description	
Information Systems		Technology systems that send, edit, save or delete data	
Actor name	Actor type	Actor description	Further information specific to this use case
EMS of relevant household	System	The Energy Management System manages and monitors the household's energy usage.	
EMS Connector	System	Connects the Energy Management System to the data space.	
Maintenance and appliance retailers connector	System	Connects the maintenance and appliance retailers to the data space.	
Appliance producer connector	System	Connects the appliance producer to the data space	

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Housing provider connector	System	Connects the housing provider to the data space.	

7.5.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.5.4 Step by step analysis of use case

7.5.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
	NILM analysis for opportunities of maintenance or renewal of appliances					

7.5.4.2 Steps-Scenarios

Scenario								
Scenario name:	NILM analysis for opportunities of maintenance or renewal of appliances							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs

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1			Provide 1day aggregate of NILM-analysis and sensor data to data space		Market Information Aggregator	Energy Service Company	I-1	P2D-F-01
2			Detect appliance health status		Energy Service Company			
3			Notify consumer		Energy Service Company	Consumer	I-2	P2D-F-04
4			Notify appliance retailers and maintenance providers via data space		Energy Service Company	Maintenance and appliance retailers	I-3	P2D-F-02
5			Provide aggregated analysis to appliance producers via dataspace		Energy Service Company	Appliance producers	I-4	P2D-F-03
6			Notify housing providers via data space		Energy Service Company	Housing Providers	I-5	P2D-F-05

7.5.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	NILM data	Data collected from NILM devices in households	P2D-F-01
I-2	Analytical results consumer	Analytical result of NILM analysis which is provided to the consumer living in the household	P2D-F-04
I-3	Analytical results retailer	Analytical result of NILM analysis which is provided to the appliances retailer in order to provide maintenance services	P2D-F-02
I-4	Analytical results producer	Analytical result of NILM analysis which is provided to the appliance producer in order to improve product design	P2D-F-03

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I-5	Analytical result housing providers	Analytical result of NILM analysis which is provided to the housing providers	P2D-F-05

7.5.6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
F	Functional	Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2D-F-01	Collect NILM data from households	
P2D-F-02	Communication to appliance retailer via data space	
P2D-F-03	Communication to appliance producer via data space	
P2D-F-04	Communication to consumer	
P2D-F-05	Communication to housing provider via data space	

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P2D-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P2D-NF-02	Data Accessibility	Store data in a safe and tamperproof manner
P2D-NF-03	Data Protection	Handle personal data according to GDPR guidelines

7.5.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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7.6 Pilot 3 – Use Case 3 – Optimal multi-energy vector planning - electricity vs heat

7.6.1 Description of the Use Case

7.6.1.1 Name of the use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of the use case**
P3-SI	Distribution, Transmission and generation / Station, Operations and Enterprise	Optimal multi-energy vector planning - electricity vs heat

7.6.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2	9.02.2023	Andrej Čampa	First draft	
0.3	15.02.2023	Andrej Čampa	Improved according to feedback	

7.6.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	The Energy-Climate Atlas platform constitutes a unique set of innovative methodological approaches and tools that enable cities, local communities, and energy system operators to take an important step forward in energy planning, reliable and secure supply and ensuring a high quality of life.
Objective(s)	(1) Data aggregation, pre-processing, and visualisation in Energy-Climate Atlas (2) Data analytics for populating feature stores with measurement, contextual and behavioural data to profile, segment and cluster users according to corresponding services / engagement programmes (3) Flexibility potential assessment of the electric power system (4) Development of heat flexibility valorisation strategies across different actors while maintaining digital sovereignty (5) Planning of coordinated measures between district heating and electric power systems operators to secure demand and achieve climate goals

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Related business case(s)	- Improving energy supply in the power grid - Cross-sector planning and operation of infrastructure and assets - Planning of infrastructure coupling (heat and electricity distribution) by utilizing flexibility potential

7.6.1.4 Narrative of Use Case

Narrative of Use Case
Short description
The use case focuses on sector coupling between heat and electric power systems, which can be done through cogeneration or power-to-heat generation and storage. In the context of district heating and the use of technologies such as heat pumps and seasonal thermal storage, great potential can be seen for providing flexibility to the electric system. However, to realise the full potential of thermal flexibility, close cooperation between all actors in a given geographic area of district heating and the logical clusters of users involved is required. In terms of infrastructure planning and assessment of flexibility potential, electricity and heat distribution network capacities must be geographically mapped along with photovoltaic, biomass, hydropower, and geothermal sources, while operation requires additional fine-grained profiling and segmentation of users, as well as technical means for managing distributed systems.
Complete description
In the context of aggressive climate targets set by global economies, the heating sector faces the greatest challenge in CO2 emissions. To meet energy efficiency and emissions reduction targets, district heating networks, the use of heat pumps and seasonal heat storage have been identified as measures with the greatest potential to increase energy flexibility. This opens up the possibility of increasing the share of renewable energy by coupling the heat and power sectors through balancing the cross-energy systems. The goal of the use case is to provide decision support at the individual user, heat/electricity utility, or community level through data aggregation, pre-processing, visualization, and analytic services. To achieve this, the use case will apply: • Data aggregation, pre-processing and visualization to evaluate applicability and plan adoption of measures to meet the forecasted energy demand and their impact. • Data analytics to populate the future store with contextual and behavioural data. • Assess the flexibility potential of the electric system through the data analytics of system-level electricity data related to heating and cooling demands, distributed heating operational and forecast data, and data on renewable energy potential and climate targets. The goal is to plan actions to valorize heat flexibility across different actors while maintaining digital sovereignty. • The platform will focus on expanding the unique set of innovative methodological approaches and tools for coordinated planning of cross-sector interactions in order to secure demand and achieve climate targets. The introduced innovative methodological approaches and tools presented will enable cities, local communities, and energy system operators to take an important step forward in energy planning, ensure reliable and secure supply, and ensure a high quality of life. Furthermore, this will support the transition to the fourth generation of district heating systems characterized by: i) digitalization, ii) decentralization and iii) improved energy efficiency through the use of energy flexibility across sectors.

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7.6.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
2-ET1		% increase of data assets accessible and reusable through the Data Space	
LEI1-ET1	Energy flexibility	Flexibility from district heating and water systems integrated in the power system operation	(3), (4)
LEI3-ET1	Flexibility demonstration	End-to-end fully interoperable demonstration with energy flexibility (heat and EV flexibility demonstrated in Slovenia and Italy)	(3), (4), (5)

7.6.1.6 Use case conditions

Use case conditions
Assumptions
• Informed consent of user is required (calorimeters). • Labelled data for model creation and/or calibration • Availability of historical data from all assets with the overlapping time period • Historical weather data is available for locations of interest
Prerequisites
• The user consent has to be contractually specified • Topology of the area of interest • Energy prices for cross-domain comparison • Costs of potential investments

7.6.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Level of depth
High level use case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Regional
Nature of the use case
Technical / System
Further keywords for classification

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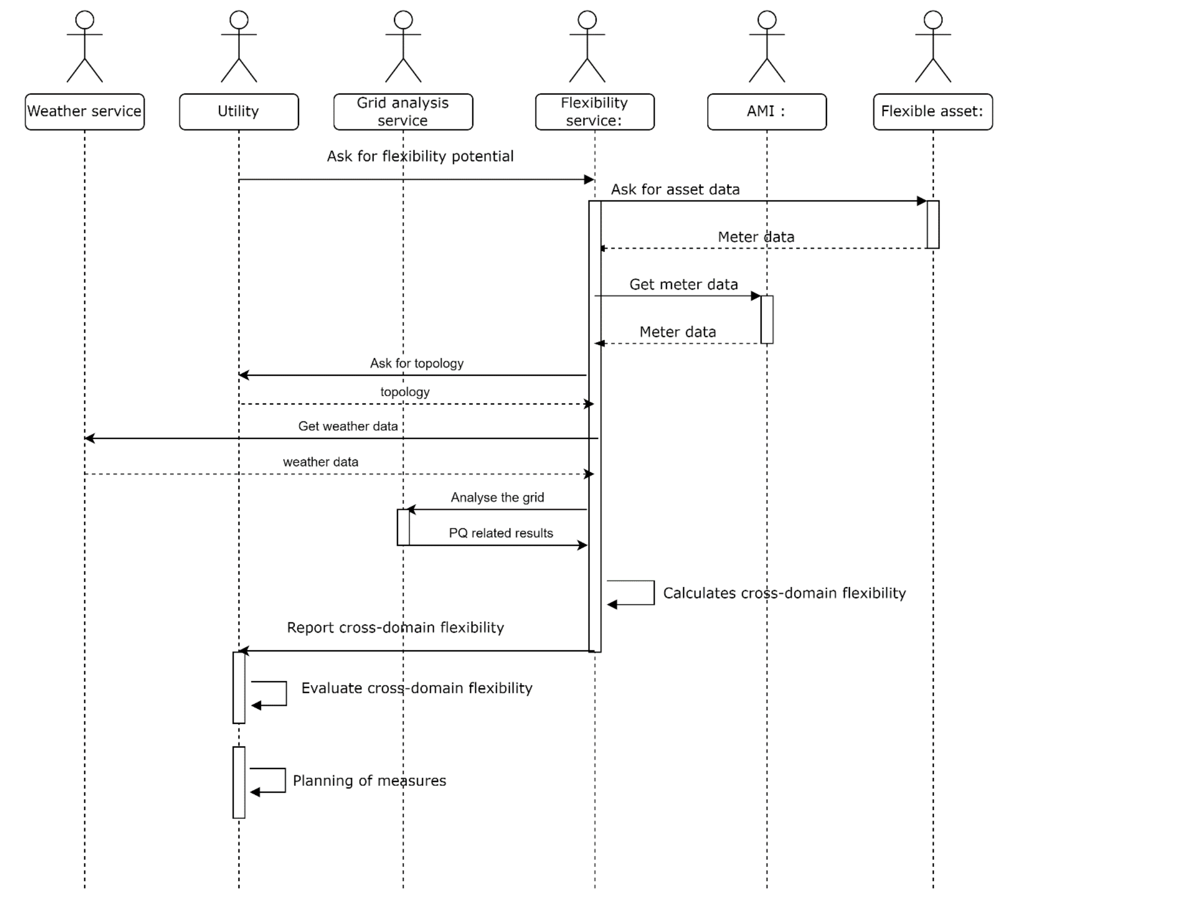
DSO, DR, DER, TSO

7.6.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case


7.6.3 Technical details

7.6.3.1 Actors

Actors	
Grouping	**Group description**
Smart grid domain	Actors involved in the smart grid domain

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Actor name	Actor type	Actor description	Further information specific to this use case
Utility	Role	A party that operates heat or electric distribution system and provides metering infrastructure.	Act as data provider and data user. It also owns the data and responsible for investment planning.
AMI	System	Advanced metering infrastructure	Metering instruments such as smart meters, calorimeters and other energy meters
Flexible asset	System	All the asset that can be potentially controlled	Heat pumps, heat storage and district heating

Actors			
Grouping		Group description	
Information Systems		Information management platforms	
Actor name	Actor type	Actor description	Further information specific to this use case
Weather service	System	Weather service provider	Forecasting and historical weather for a specific location
Grid analysis service	System	Service that analyses the Electric grid	Service analysis the MV grid for possible congestion and power quality issues for different realistic and hypothetical future scenarios
Flexibility service	System	Analytic service	Service that evaluates the flexibility potential over the cross-energy domain.

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Data Space Connector	System	Connects the specified data to the data space	

Actors			
Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In this sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS	Provides data for exchange between a Data Owner and a Data Consumer. The Data Provider is in most cases the same as the Data Owner, but not necessarily.	
Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Provider	Role IDS	Services are offered by a Service Provider and consumed by a Service Consumer.	
Service Consumer	Role. IDS	Services are offered by a Service Provider and consumed by a Service Consumer.	

7.6.3.2 References

References

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No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.6.4 Step by step analysis of use case

7.6.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Flexibility assessment	According to the cross-energy domain asses the flexibility potential for the area of interest	Flexibility service	Utility needs to assess the flexibility potential. On-demand.	• AMI data • topology • know flexible asset in the area of interest	Energy flexibility provided
2	Planning of measures	According to available flexibility, create a plan of the most promising measures.	Utility	Due to possible congestion in the feature, the evaluation of the feasibility and effectiveness of different measures is needed. On-demand.	Calculated flexibility	Planned measures

7.6.4.2 Steps-Scenarios

Scenario								
Scenario name:	Flexibility assessment							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1	Get data	data	Get data from metering devices	GET	AMI	Flexibility service	I-1	R-DA-1, RDA-2, R-DA-3
2	Get Asset	data	Create ML model for	GET	Flexible asset	Flexibility service	I-2	R-DA-1

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	data		federated learning app					
3	Get topology	data	Get topology of the grid	GET	Utility	Flexibility service	I-3	R-DA-2
4	Get weather	data	Get weather data	GET	Weather service	Flexibility service	I-4	R-DA-1
5	Analyse grid	processing	Analyse power grid capabilities	EXECUTE	Grid analysis service	Flexibility service	I-5	
6	Calculate flexibility	Processing	Analyse grid and estimates the flexibility potential	EXECUTE	Flexibility service	Flexibility service	I-6	
7	Provides results	Provides results	Provide results about flexibility potential	REPORT	Flexibility service	Utility	I-7	

Scenario								
Scenario name:	Planning of measures							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1	Get flexibility potential	Get report	Gets calculated flexibility potential	GET	Flexibility service	Utility	I-7	
2	Evaluate cross-domain flexibility	Processing	Evaluate the calculated flexibility for the are of interest and available asset	EXECUTE	Utility	Utility		
3	Planning of measures	Processing	Calculates	EXECUTE	Utility	Utility	I-8	R-I-1

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7.6.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	Metering data	Measurements	R-DA-1, R-DA-2, R-DA-3
I-2	Flexible asset characteristics	Nominal power, operating type, operation settings, type	R-DA-1
I-3	Topology	Grid topology	R-DA-1
I-4	Weather data	Measurements	R-DA-1
I-5	Analysis	Results produced by simulations of the grid	R-DA-3
I-6	Optimization	Results produced by multidomain optimization	R-DA-3
I-7	Report	Decision support	
I-8	Report	Results for investment planning	R-I-1

7.6.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-DA-1	Data availability requirement	Requirement linked to the necessary data to be available for the use case.
R-DA-2	Harmonized data	Cross-sector domain data is harmonized according to time
R-DA-3	Granularity of data	Hourly or 15min granularity of data is required
R-I-1	Initial state of the planning already available	Investment planning scenario already exists and serves as ground truth.

7.6.7 Common terms and definitions

Common terms and definitions	
Term	Definition
Heat pump	Heat pumps are available for cross-energy domain optimization
District heating	System for district heating that can be used in the cross-energy flexibility calculation.

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Flexibility	Flexible energy that is available to a zone of interest and can be used to perform various optimization scenarios, such as reducing energy consumption, improving self-consumption, reducing investment or energy costs

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7.7 Pilot 4 – Use Case 4 – Digital Twin for optimal data-driven Power-to-Gas planning

7.7.1 Description of the Use Case

7.7.1.1 Name of the use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of the use case**
	P2G simulation and optimization	Digital Twin for optimal data-driven Power-to-Gas planning

7.7.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	5.12.2022	Sotiris Pelekis	Initial creation	

7.7.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	The aim of this pilot is to create a Digital Twin for optimal data-driven Power-to-Gas (P2G) planning. The P2G Digital Twin, will model multiple scenarios for hydrogen production and storage from RES under different energy demand profiles. A first system will perform useful profiling, comparisons, and forecasts of the customers' demand general the factors providing understanding of the factors that influence the decision-making process for the use of natural gas and green hydrogen in the energy mix. A second system will create long-, mid- and short-term scenarios of the required green hydrogen production and renewable energy.
Objective(s)	The objective of the case study is to form a combined optimization platform, named TwinP2G, coupling the electricity transmission system with natural gas demands, leveraging a Digital Twin architecture that will enable multi-resolution simulations involving P2G technologies and (regenerative) hydrogen fuel cells. TwinP2G will enable data- and simulation-driven P2G and RHFC optimal planning leveraging RES surplus for green hydrogen production via electrolysis.
Related business case(s)	

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7.7.1.4 Narrative of Use Case

Narrative of Use Case
Short description
Producing hydrogen from low-carbon energy is costly at the moment and the development of hydrogen infrastructure is slow and holding back widespread adoption. Virtual environments are required to analyse different scenarios for a quicker and safer integration of hydrogen in the energy system. From renewable sources (such as wind and photovoltaic) to electrolyser capacity, to buffers (such as energy and hydrogen storage), multiple variables and data sources must be considered to meet the increased energy demand. In this respect, the technology of Data Spaces offers great potential for hydrogen promotion to accelerate the energy transition. In this direction, this pilot aims to develop a Digital Twin application for enabling the design of thorough P2G use cases in Greece in order to assess and optimize the several quantities related with P2G investments (e.g. electrolyser, buffer and fuel cells optimal capacity and locations).
Complete description
This use case will develop TwinP2G, a digital twin (DT) platform, for enabling the design and sharing of simulation based experiments based services between two main personas: data scientists (DEPA experts) and end-users (DEPA executives). Initially, a digital combined simulation and optimization platform, named TwinP2G, coupling the electricity transmission system with natural gas demands, leveraging a DT architecture that will enable multi-resolution simulations involving P2G technologies and hydrogen fuel cells. TwinP2G will enable data- and simulation-driven P2G and RHFC optimal planning leveraging RES surplus for green hydrogen production via electrolysis. The simulator will compose of 5 main components: - A data warehouse integrating external data through IDSA connectors where possible. Data will initially originate from IPTO[2] (electrical power demand, RES generation, long-term grid planning, electrical grid topologies), DESFA[3] (hourly / daily gas flows at entry and exit points, natural gas grid topologies) and other organizations (e.g. Eurostat , local and national grid topologies etc.) - A simulation and optimization platform (DT core) involving physics- and data- driven simulations accompanied by optimization capabilities. PyPSA (short-term simulation) and OSeMOSYS (long-term simulation) are examined as the main technologies of interest here. This components also leverages gas demand and electricity generation and load forecasts to empower its simulations. - A forecasting toolkit developed within the I-NERGY H2020 project and further developed within EnerShare that is developed following the MLOps principles. The forecasting component will feed the DT core with gas demand and electricity generation and load forecasts. - A front-end that serves the main user roles (personas): a data scientist (coding and modelling expert) and an energy engineer (deep understanding of energy systems but limited coding skills). The first persona will leverage a coding platform (subcomponent 1) to develop and share their experiments while the second will leverage a visualization engine (tightly related to Task 6.5 – subcomponent 2) to visualize the results of the experiments in question.

7.7.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use**

[2] https://www.admie.gr/en
[3] https://www.desfa.gr/

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			case objectives
O5-4		Digital Twin (Green Hydrogen)	Related to UC main objective
5-ET4		Nº of stakeholders using the green hydrogen digital twin	Related to main UC objective and its acceptance
LEI4-ET1		Optimise capital expenditure (CAPEX), whilst reducing risk	Related to the results of UC main objective and its operational outcome

7.7.1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Electrical Energy demand time series. • RES generation time series for the areas of interest. • Cost of potential equipment and technologies to be invested on (electrolysers, RHFC, buffers etc.). • Grid topology of the area of interest.

7.7.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Level of depth
High – Level Use Case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
Regional and maybe national
Nature of the use case
Technical
Further keywords for classification
Power-to-gas, Digital Twin, Hydrogen, Sector Coupling, Power Flow Simulation, Optimization, Flexibility, Microgrid

7.7.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

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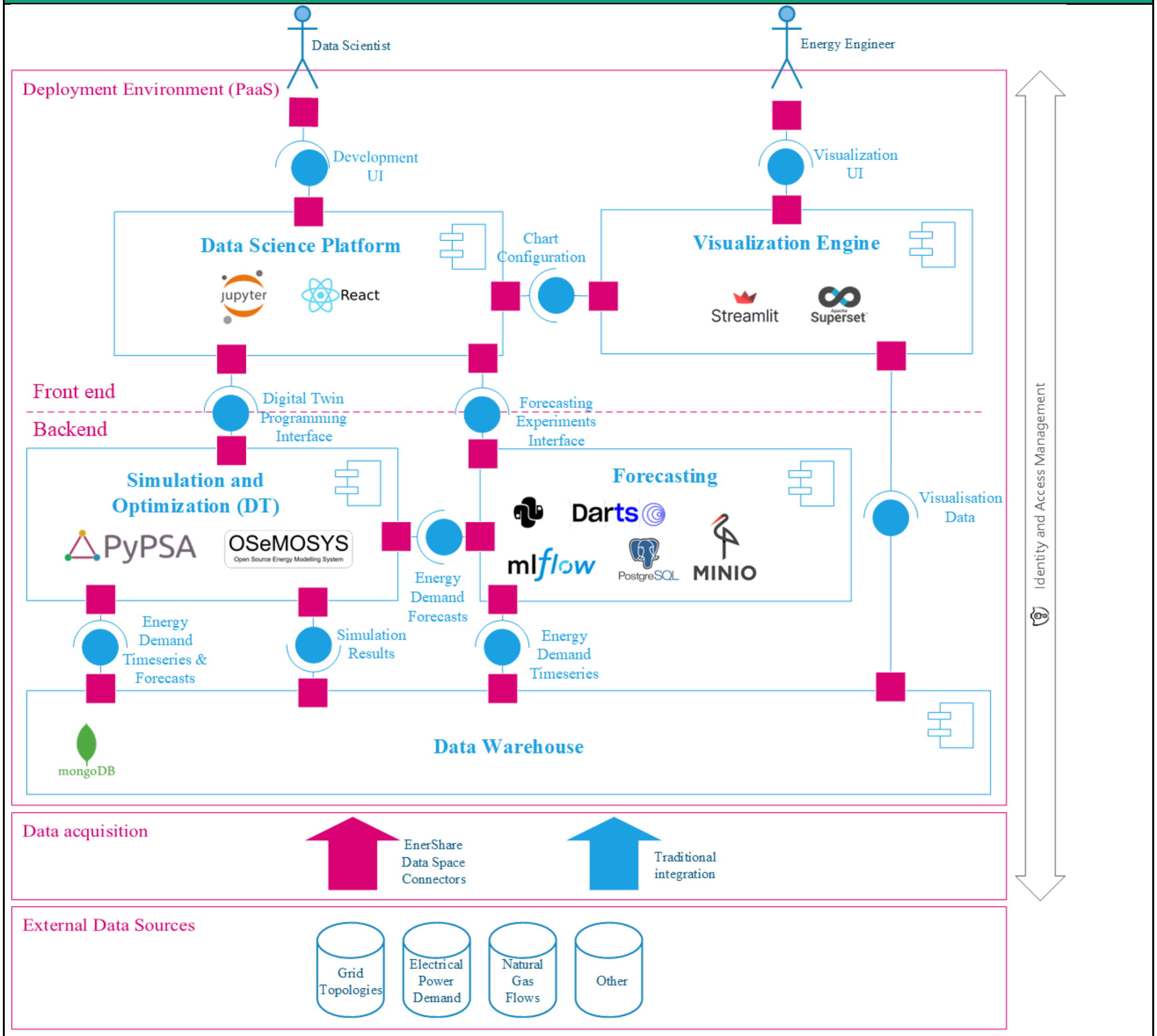
Diagram(s) of use case


Figure 1-The high-level architecture of TwinP2G

7.7.3 Technical details

7.7.3.1 Actors

Actors	
Grouping	Group description
People	Users involved in the modelling and interpretation of the data

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Actor name	Actor type	Actor description	Further information specific to this use case
Domain Expert (Energy Engineer – EE)	human	Energy engineer responsible for the interpretation of the simulation result from a financial perspective	This person will be responsible for the interpretation of the outcomes of the methods developed in the pilot
Data Scientist (DS)	human	Data analyst responsible for the modelling of the digital twin in question using TwinP2G	This person will be responsible for the development of simulations and training of forecasting models used for P2G investments assessment.

Actors			
Grouping		Group description	
Information Systems		Information management platforms	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Providers	Web Page, APIs	Data sources: IPTO, DESFA, Eurostat APIs and excel files.	
Data Warehouse	Database	Database for storing the raw time series data of measurement data	
Data Space Connector	System	Connects the specified data to the data space	
Other Data Ingestion Mechanisms	System	Connects dataset to the warehouse / dataspace	
Simulation and Optimization Platfom	System	Allows for modelling Digital Twins and running optimization tasks	

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Coding Platform	System	Permits the data scientist to interact with the DT and the forecasting toolkit either via UI or code.	
Visualization Engine	System	Used by the EE to monitor simulation and forecast results and metrics leveraging them for decision support regarding future P2G investments	
Forecasting Toolkit	System	The forecasting component will feed the DT core with gas demand and electricity generation and load forecasts. It will be triggered by the DS.	

7.7.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link
1	Whitepaper	Brown, T., Hörsch, J., & Schlachtberger, D. (2017). PyPSA: Python for Power System Analysis. *Journal of Open Research Software*, *6*(1). https://doi.org/10.5334/jors.188	Published	Digital twin core technology	PyPSA	https://pypsa.org/
2	Journal Paper	P. Fu, D. Pudjianto, X. Zhang, and G. Strbac, "Integration of Hydrogen into Multi-Energy Systems Optimisation," *Energies 2020, Vol. 13, Page 1606*, vol. 13, no. 7, p. 1606, Apr. 2020, doi: 10.3390/EN13071606	Published	Bibliography on DT's		
3	Journal Paper	Q. Zeng, J. Fang, J. Li, and Z. Chen, "Steady-state analysis of the integrated natural gas and electric power system with bi-	Published	Bibliography on DT's		

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		directional energy conversion," *Appl Energy*, vol. 184, pp. 1483–1492, Dec. 2016, doi: 10.1016/J.APENERGY.2016.05.060.				
4	Position paper	ENTSO-G and ENTSO-E, "Power to gas | ENTSOG," 2018. Accessed: Oct. 31, 2022. [Online]. Available: https://www.entsog.eu/power-gas	Published	Policy-making concepts on P2G with sector coupling	ENTSOe-ENTSOg	https://www.entsog.eu/power-gas
5	Journal Paper	QuQuarton and S. Samsatli, "Power-to-gas for injection into the gas grid: What can we learn from real-life projects, economic assessments and systems modelling?", *Renewable and Sustainable Energy Reviews*, vol. 98, pp. 302–316, Dec. 2018, doi: 10.1016/J.RSER.2018.09.007.	Published	Review of P2G considering real-life projects, economic assessments and systems modelling studies (simulation and optimization), and to compare them based on scope, assumptions and outcomes. Focuses on ingection into the gas pipeline		
6	PhD Thesis	M. Qadrdan, "Modelling of an Integrated Gas and Electricity Network with Significant Wind Capacity," 2012.		Conceptualization of a combined Gas and Electricity Network. (CGEN)		https://core.ac.uk/download/pdf/40007561.pdf
7	Journal Paper	Y. Lu, T. Pesch, and A. Benigni, "Simulation of coupled power and gas systems with hydrogen-enriched natural gas," *Energies (Basel)*, vol. 14, no. 22, Nov. 2021, doi: 10.3390/en14227680.	Published	Example of coupled NG and power simulation		https://www.mdpi.com/1996-1073/14/22/7680/htm
8	Conference Paper	Gerard, E. Carrera, O. Bernard, and D. Lun, "Smart Design of Green Hydrogen Facilities: A Digital Twin-driven approach," *E3S Web of Conferences*, vol. 334, p. 02001, 2022, doi: 10.1051/E3SCONF/202233402001.	Published	Monte Carlo driven DT		
9	Conference Paper	C. Diaz-Londono, G. Fambri, A. Mazza, M. Badami, and E. Bompard, "A Real-Time Based Platform for Integrating Power-to-Gas in Electrical Distribution Grids," in *UPEC 2020 - 2020 55th International Universities Power*	Published	Description of the Digital Twin architectured used within the PLANET H2020 project for P2G simulations		

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		Engineering Conference, Proceedings, Sep. 2020. doi: 10.1109/UPEC49904.2020.9209803.				
10	Deliverable	Marco Badami, "Deliverable D2.5 Power-to-Gas process/system models," 2019.	Published	Main source of inspiration on driving a coupled simulation. Many useful tools proposed	PLANET H2020 project	https://www.h2020-planet.eu/deliverables
11	Journal Paper	G. Fambri, C. Diaz-Londono, A. Mazza, M. Badami, T. Sihvonen, and R. Weiss, "Techno-economic analysis of Power-to-Gas plants in a gas and electricity distribution network system with high renewable energy penetration," *Appl Energy*, vol. 312, p. 118743, Apr. 2022, doi: 10.1016/J.APENERGY.2022.118743.	Published	Technoeconomic analysis of P2G plant	PLANET H2020 project	https://www.sciencedirect.com/science/article/pii/S0306261922001994?via%3Dihub
12	PhD Thesis	Διατριβή, Σ. Ανδρουλάκη, and Ε. Καθηγητής, "Ολοκληρωμένο Μεθοδολογικό Πλαίσιο για την Υποστήριξη Αποφάσεων Προβλημάτων της Ελληνικής Αγοράς Φυσικού Αερίου," Jul. 2020, Accessed: Oct. 07, 2022. [Online]. Available: http://artemis.cslab.ece.ntua.gr:8080/jspui/handle/123456789/17917	Published	National optimal trajectories for NG imports (long-term). National optimal strategies for selecting NG importers (Short-term, mid-term planning).		http://artemis.cslab.ece.ntua.gr:8080/jspui/handle/123456789/17917
13	Journal Paper	Karamaneas A., Koasidis K., Frilingou N., Xexakis G., Nikas A., and Doukas H., "A stakeholder-informed modelling study of Greece's energy transition amidst an energy crisis: the role of natural gas and climate ambition [Under Review]," *Renewable & Sustainable Energy Transition*, 2022.	Under review	An energy model for Greece built on OSeMOSYS (https://osemosys.readthedocs.io/en/latest/). A guide on how to leverage the tool. Examining extension possibilitis		

7.7.4 Step by step analysis of use case

7.7.4.1 Overview of scenarios

Scenario conditions

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No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (short-term horizon)		Data scientist	Energy Engineer urges the data scientist to start an experimentation with a Digital Twin to technoeconomically assess a potential RHFC investment.	Necessity for a short-term technoeconomic evaluation of an RHFC or renewables-related investment	Decision support for the Energy Engineer regarding the investment's feasibility
2	Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (long-term horizon)		Data Scientist	Energy Engineer urges the data scientist to start an experimentation with a Digital Twin to techno economically assess a potential RHFC investment.	Necessity for a short-term technoeconomic evaluation of an RHFC or renewables-related investment	Decision support for the Energy Engineer regarding the investment's feasibility
3	Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (short-term horizon)		Data scientist	Energy Engineer urges the data scientist to start an experimentation with a Digital Twin to technoeconomically assess a potential P2G investment.	Necessity for a short-term technoeconomic evaluation of a P2G investment within a sector-coupled environment.	Decision support for the Energy Engineer regarding the investment's feasibility
4	Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (long-term horizon)		Data scientist	Energy Engineer asks the data scientist to start an experimentation with a Digital Twin to technoeconomically assess a potential P2G investment.	Necessity for a short-term technoeconomic evaluation of a P2G investment within a sector-coupled environment.	Decision support for the Energy Engineer regarding the investment's feasibility

7.7.4.2 Steps-Scenarios

Scenario								
Scenario name:	Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (short-term horizon)							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
Similar to scenario 3 with obvious changes								

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Scenario								
Scenario name:	Develop and evaluate an electricity only Digital Twin considering fuel cell technologies (long-term horizon)							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
Similar to scenario 3 with obvious changes								

Scenario								
Scenario name:	Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (short-term horizon)							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1		Create Data	Periodically upload new datasets		Data Providers	-	I-2, I-3, I-4	R-F-DA-01, R-F-DA-02, R-F-DA-02, R-F-DA-03, R-NF-02, R-NF-03
2		Ingest Data	Acquire and preprocess external data for short-term analysis (resampling, aggregations).		Data Space Connector / Other Data Ingestion Mechanisms	Data Warehouse	I-2, I-3, I-4	R-NF-01, R-F-DA-01, R-F-DA-02, R-F-DA-03, R-F-DA-04, R-NF-02, R-NF-03
3		Trigger forecast	In case of non-automated forecasting process trigger the forecast		Data Scientist	Forecasting Toolkit	I-2, I-3, I-4	
4		Forecast	Forecast (short-term forecasts) natural gas and electricity demands		Forecasting Toolkit	-	-	
5		Send forecast			Forecasting Toolkit	Simulation and Optimizatio	I-6, I-7	

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						n Platform, Data Scientist		
6		Code the simulation	The data scientist develops the simulation		Data Scientist	Simulation and Optimizatio n Platform	I-9	
6		Simulate and Optimize	Run short-term simulation and optimizations including both P2G and RHFC		Simulation and Optimization Platform	-	I-1, I-2, I-3, I-4, I-6, I-7	
7		Send optimization results			Simulation and Optimization Platform, Data Scientist	Data Warehouse	I-5	
8		View optimization results			Data Scientist	-	I-5	
9		Send configuratio n data	Configure the Visualization Engine to show appropriate graphs		Data Scientist	Visualizatio n Engine	I-10	
		Send visualization data	Visualization data are delivered from the database		Data Warehouse	Visualizatio n Engine	I-7	
10		Show visualization s	Show visualizations for decision support		Visualization Engine	Energy Engineer	I-8	

Scenario								
Scenario name:	Develop and evaluate a sector coupled Digital Twin (natural gas + electricity) (long-term horizon)							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
Similar to scenario 3 with obvious changes								

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7.7.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information exchanged	Requirement, R-IDs
I-1	Grid topology	Grid topology as envisage by energy engineer	R-NF-01, R-F-DA-04, R-NF-02, R-NF-03
I-2	Electrical power demand	Power demands as acquired by IPTO or ENTSOe	R-F-DA-02, R-F-I-1, R-NF-02, R-NF-03
I-3	Natural gas flows	Natural Gas demand as acquired by DESFA	R-F-DA-01, R-F-I-1, R-NF-02, R-NF-03
I-4	Statistics	Statistics and long-term planning as acquired by IPTO and EUROSTAT	R-F-DA-03, R-F-I-1, R-NF-02, R-NF-03
I-5	Optimization results	Results produced by the simulation / optimization process	R-F-SIM-01, R-NF-01, R-NF-02, R-NF-03
I-6	Electrical power demand forecasts	Forecasted electrical power demands as from the Forecasting Toolkit	R-F-DA-02, R-F-I-1
I-7	Natural gas flow forecasts	Natural Gas electrical power demands as from the Forecasting Toolkit	R-F-DA-01, R-F-I-1
I-7	Visualization data	Back-end data used for vizualizations	R-F-SIM-01, R-NF-02, R-NF-03
I-8	Visualizations	Plots demonstrated to the energy engineer through the front-end of the application	R-F-SIM-01, R-NF-04, R-NF-06
I-9	Code	Code written by the data scientist to program the simulation	R-F-SIM-02, R-NF-05
I-10	Visualization Configuration	Configuration done to set up the appropriate plots in the Visualization Engine	R-F-VIS-01

7.7.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-F-XX-XX	Functional	Functional requirements: Required for the system to be functional and provide outputs.
R-NF-XX	Non-functional	Non-functional requirements: Required for the system to provide outputs of good quality.

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R-F-DA-XX	Data Availability	Necessary data for the use case are available
R-F-I-XX	Algorithm interfacing APIs	Functional Requirement linked to the availability of software component interfacing APIs
R-F-SIM-XX	Simulation	Functional Requirement linked to the simulation / optimization process.
R-F-SIM-XX	Forecast	Requirement linked to forecasts
R-XX-VIS-XX	Visualisation	Requirement linked to the visualizations
Requirement RID	Requirement name	Requirement description
R-NF-01	Availability of DT objective	Energy Engineer has collected specifications of the problem to be solved. (Horizon, Equipment costs, Optimization objective)
R-F-DA-01	Gas data availability	Requirement linked to the necessary csv / api data for natural gas to be available for download. (DESFA)
R-F-DA-02	Electrical Power Data Availability	Requirement linked to the necessary csv / api data for natural gas to be available for download. (IPTO)
R-F-DA-03	Long-term statistic data availability	The necessary csv / api data for long-term projections should be available (Eurostat, IPTO long-term planning, DESFA etc.)
R-F-DA-04	Availability of DT topology to be simulated	The topology to be simulated should be available
R-F-SIM-01	Convergence of simulation	The simulation should converge after a finite number of iterations.
R-F-SIM-02	Code quality	Code should be debugged and therefore functional
R-F-I-01	Availability of 2-way Data Space Connector	The Data Space Connector interface for communicating with external datasets should be available from the producer side as well.
R-F-VIS-01	Configuration validity	Configuration should be made in the right format
R-F-F-01	Forecasts validity	Forecasts should be in the right format
R-NF-02	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
R-NF-03	Data Accessibility	Store data in a safe and tamperproof manner
R-NF-04	Service Security	Service should be secure, and identity managed amongst human actors.
R-NF-05	Code quality	Code should be well documented and understandable
R-NF-06	Visualisation interpretability	Visualizations should be well understandable and interpretable.

7.7.7 Common terms and definitions

Common terms and definitions	
Term	Definition
Fuel cell	A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (hydrogen) and an oxidizing agent (oxygen) into electricity through a pair of redox reactions.
Electrolyser	Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyser. Electrolysers can range in size from small, appliance-size equipment that is well-suited for

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	small-scale distributed hydrogen production to large-scale, central production facilities that could be tied directly to renewable or other non-greenhouse-gas-emitting forms of electricity production.
Buffer	A tank storing hydrogen
Power-to-Gas (P2G)	Power-to-gas (often abbreviated P2G) is a technology that uses electric power (often produced by RES) to produce a gaseous fuel (often hydrogen).

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7.8 Pilot 5 – Use Case 5a – Cross-sector Flexibility Services for aggregators and DSO

7.8.1 Description of the Use Case

7.8.1.1 Name of the use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of the use case**
		Cross-sector Flexibility Services for aggregators and DSO

7.8.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	

7.8.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Reduction of reverse power flows into the distribution grid through optimization of self-consumption
Objective(s)	○ Load forecast for household and primary substation and PV feed-in estimation ○ Flexibility estimation for each household ○ Reduce reverse power flow / Optimization of the grid and maximization of self-consumption ○ Security Services deployed by DSOs to Consumers ○ App development ○ User engagement incl. updating infrastructure based on the use case needs
Related business case(s)	

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7.8.1.4 Narrative of Use Case

Narrative of Use Case
Short description
This UC aims to take advantage of the sources of flexibility offered by cross-sector to reduce the flow of RPF into the power distribution grid and reduce the impact on distribution grid. Optimised grid management, which leads to increased self-consumption and self-sufficiency, reduced losses and detailed observability of parameters in real time, drastically reduces the number of faults that can occur on the grid. For end consumers, this leads to various advantages, such as greater continuity of supply, less environmental impact from their own consumption, greater awareness of their impact on the energy system and a drive towards active and more sustainable behaviour.
Complete description
The consumption of electricity strongly depends on the behaviour and habits of end users, and the demand is practically completely inelastic. This electricity demand curve fits poorly with renewable generation, which is centred in the central hours of the day and is highly dependent on climate. As a consequence the electrical grid is subjected to voltage fluctuations and the reversal of power flows, which can lead to grid faults. In order to increase the share of renewable energy, it was therefore thought to smartly manage the energy demand so as to bring it closer to the renewable generation curve: this process is called Demand Side Management. The widespread use of real-time sensors, fast data transmission and the presence of a SCADA system makes it possible to build a system that can show users what their consumption is and provide advice on how to better manage electrical loads, save money and benefit the environment. The active involvement of users has the advantage of creating a culture of awareness of their impact on the environment and their spending, as well as enabling their participation in demand response programmes, so as to support the electricity grid in times of need. End users can, once aggregated, provide ancillary services to the electricity grid, such as voltage support and frequency regulation; these services are activated on demand, when the grid is in an emergency or alarm condition. It is therefore intended to assess how the use of electricity demand management, governed by a demand aggregator, can help the grid to manage peak power and reverse flows. An aggregator is an economic entity that involves users and acts as an intermediary between them and the distribution system operator. Users are incentivised to participate for environmental reasons, e.g. by visualising the reduction of electricity losses from the grid, or the increase of locally consumed renewable energy, or for economic reasons with dynamic price variation.

7.8.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**
5-ET6		% of electricity savings (reduction of power losses)	

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1-SO2		% of cost reduction in the energy bill for consumers	

7.8.1.6 Use case conditions

Use case conditions
Prerequisites
Flexibility estimation for each household
Optimization of the grid and maximization of self-consumption
Security Services deployed by DSOs to Consumers

7.8.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
UC 2b
Level of depth
Specialized
Prioritization
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
System
Further keywords for classification
Distribution grid, Demand response, flexibility

7.8.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case

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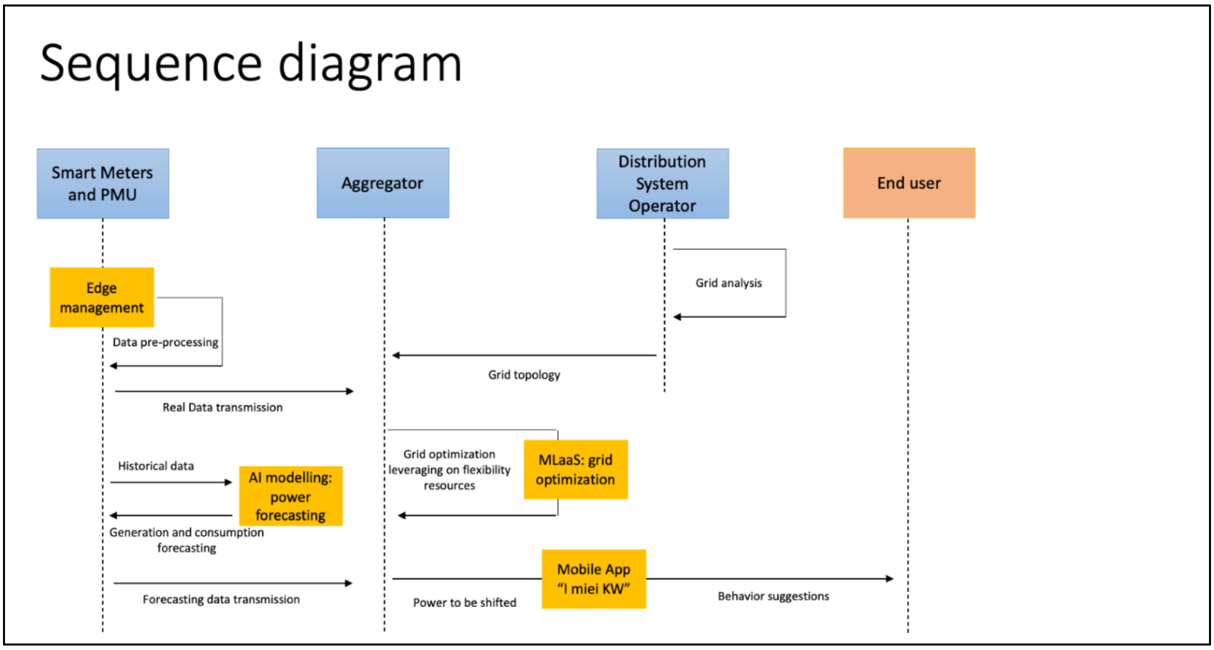

7.8.3 Technical details

7.8.3.1 Actors

Actors			
Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
Consumer	Role	A party that consumes electricity	This is a Type of Party Connected to the Grid.
Metered Data Aggregator	Role	A party responsible for the establishment and qualification of measured data from the Metered Data Responsible. This data is aggregated	

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		according to a defined set of market rules.	
Resource Aggregator	Role	A party that aggregates resources for usage by a service provider for energy market services.	
System Operator	Role	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	

Actors			
Grouping		Group description	
Data Space Role Model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	

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Data Consumer	Role. IDS / GAIA-X	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

Actors			
Grouping		Group description	
Information Systems		Technology systems that send, edit, save or delete data	
Actor name	Actor type	Actor description	Further information specific to this use case
Resource Aggregator Connector	System	Connects the Resource Aggregator to the data space.	
Metered Data Aggregator Connector	System	Connects the Metered Data Aggregator to the data space	
System Operator Connector	System	Connects the System Operator to the data space	
Edge Management	System	Data pre-processing from the Smart Meter devices	
AI modeling: Power forecasting	System	Forecasting platform to predict the generated and consumed energy	

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MLaaS Grid Optimization	System	Platform to optimize the grid operation	
Mobile App „I miei KW“	System	Mobile Application to interact with Consumer and to suggest behavioral changes	

7.8.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.8.4 Step by step analysis of use case

7.8.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Variable demand response	In this scenario, flexibilities of consumers between 5% to 15% of their consumption are considered.	Ressource Aggregator	/	/	/

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7.8.4.2 Steps-Scenarios

Scenario								
Scenario name:	Variable Demand Response							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1		Consumer Flexibility estimation	Based on historical user power curves, the available flexible energy is estimated. Different percentages of the energy are considered to be shifted in time	Flexible energy estimation	Metered Data Administrator	Ressource Aggregator	I-2 I-3 I-4	P5A-F-02
2		Distribution grid requests	Evaluate which are the needs of the distribution grid, according to the real time data	Grid optimization	System Operator	Ressource Aggregator	I-1	P5A-F-05
3		Flexible energy aggregation	Aggregation of all the available energy from consumers in order to provide ancillary services	Marketplace	Metered Data Administrator	Ressource Aggregator	I-2 I-3 I-4	P5A-F-02
4		Interaction with Mobile App	Suggest behavioral changes to consumer via Mobile App		Ressource Aggregator	Consumer	I-7	P5A-F-03 P5A-F-04 P5A -NF-06 P5A -NF-08

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7.8.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	Electrical distribution grid topology and features	Portion on the network topology, with electrical characteristics of the assets	
I-2	Smart meter data - historical	Historical electrical consumption data of consumers	
I-3	Smart meter data - live	Real data of Electrical consumption of consumers	
I-4	Phasor measurement units data	Primary substation electrical data	
I-5	Energy consumption and production forecast	Forecast of the energy produced and consumed based on historical smart meter data	
I-6	Optimized grid topology	Results of the analysis to optimize the grid based on available flexibilities	
I-7	Behavior suggestions	Behavior suggestions that are send to the consumer via a Mobile App to activate flexibilities	

7.8.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
F	Functional	Functional requirements
Requirement RID	Requirement name	Requirement description
P5A-F-01	Edge management	Pre-process smart meter data in order to increase data quality
P5A -F-02	Energy consumption and production forecast	Forecast the consumption of the households and the RES energy production of the community for a given time
P5A -F-03	Consumer registration	Consumer should be able to register in the Mobile App to participate in the project

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P5A -F-04	Mobile App interaction	The mobile App shall be able to send notifications to consumer suggesting a specific behaviour for a given time to reduce grid congestion
P5A -F-05	Optimize grid operation	Optimize the operation of the grid with the available flexibility information

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P5A-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P5A -NF-02	Data Accessibility	Store data in a safe and tamperproof manner
P5A -NF-03	Data Protection	Handle personal data according to GDPR guidelines
P5A -NF-04	Code quality	Code should be well documented and understandable
P5A -NF-05	Visualisation interpretability	Visualizations should be well understandable and interpretable
P5A -NF-06	Elapsed time response requirements for interaction of the mobile application	Less than 30 seconds
P5A -NF-07	Commonly used techniques for meeting quality of service requirements of this data exchange	Failure detection; Automatic restart; Automatic failover to second source of data or function; Automatic failover of communication channels to secondary channel; Backup of data Transaction rollback;
P5A -NF-08	Secure communication	Secure communication of sensitive data related to the infrastructure should be provided
P5A -NF-09	Data management	Data harmonization, orchestration and synchronization should be performed
P5A -NF-10	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data	
P5A -NF-11	Information integrity violation: Ensuring that data is not changed or destroyed	
P5A -NF-12	Authentication: Masquerade and/or spoofing: Ensuring that data comes from the stated source or goes to authenticated receiver	
P5A -NF-13	Information theft: Ensuring that data cannot be stolen or deleted by an unauthorized entity	

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P5A -NF-14	Denial of Service: Ensuring unimpeded access to data	
P5A -NF-15	Authentication and Access Control mechanisms commonly used with this data exchange	
P5A -NF-16	Elapsed time response requirements for exchanging data	Less than 1 minute

7.8.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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7.9 Pilot 5 – Use Case 5b – Services for e-mobility CPOs, EVs drivers and DSO

7.9.1 Description of the Use Case

7.9.1.1 Name of the use case

Use case identification		
ID	Area / Do- main(s)/ Zone(s) [OPTIONAL]	Name of the use case
P5-IT-B		Services for e-mobility CPOs, EVs drivers and DSO

7.9.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	

7.9.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Value creation from flexibility provision of electric vehicles to the grid
Objective(s)	• Use the vehicles to provide flexibility to the grid and reduce grid congestion levels • App development/adaption • Increase CPO ability to attract EV users to their charging stations • Increase CPO revenue • Reduce charging session costs for EV users
Related business case(s)	

7.9.1.4 Narrative of Use Case

Narrative of Use Case
Short description

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Prioritisation of charging and/or parking slot availability in peak hours (e.g. in the night) for consumers sharing EV recharging profiles; dynamic parking pricing aligned to the grid congestion level for consumer who share their mobility patterns with the DSO.
Complete description
Transition to electric mobility was initiated by creating new opportunities and new obstacles: by increasing the number of electric vehicles, the amount of electricity that must be supplied increases and, therefore, a necessary strengthening of the power lines follows. However, through a cooperation mechanism between DSOs (Distribution System Operators), CPOs (Charging Point Operators) and EV users, it is possible to reduce the power grid upgrade magnitude by coordinating the electric vehicles charging. DSO monitors the electricity grid and, thanks to accurate forecasting systems, is able to identify how, when and where to charge electric vehicles to avoid congestion problems. CPO will thus be able to provide a dynamic charging price based on real-time/forecasted DSO needs, to offer an advantageous charging price in charging stations located in congested areas and attract a greater number of EV users increasing its revenue. Finally, EV users will be able to share their charging profiles and acquire priority to charge at a discounted price.

7.9.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
	Charging sessions boost	Increase the number of charging sessions performed in CPO charging stations by 25%	Increase CPO ability to attract EV users to their charging stations Reduce charging session costs for EV users
	Congestion level reduction	Decrease congestion events by 50%	Help DSO to manage the grid congestion level

7.9.1.6 Use case conditions

Use case conditions
Assumptions
○ A community of EV users will be aggregated for flexibility purposes; ○ The community presents consumption patterns which can be described as from once a week to every day of the week ○ The community main goal will be to reduce energy cost, furthermore there will be an interest to increase renewable energy usage for EV charging
Prerequisites
• EV users have to be equipped with an OBD (On-Board Diagnostic) device to provide their charging data

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7.9.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Pilot 5 – Use Case A
Level of depth
High level use case
Prioritization
high
Generic, regional or national relation
Regional
Nature of the use case
Technical/Social
Further keywords for classification
Smart grid, electric vehicles, charging stations, CPO, DSO, flexibility

7.9.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case

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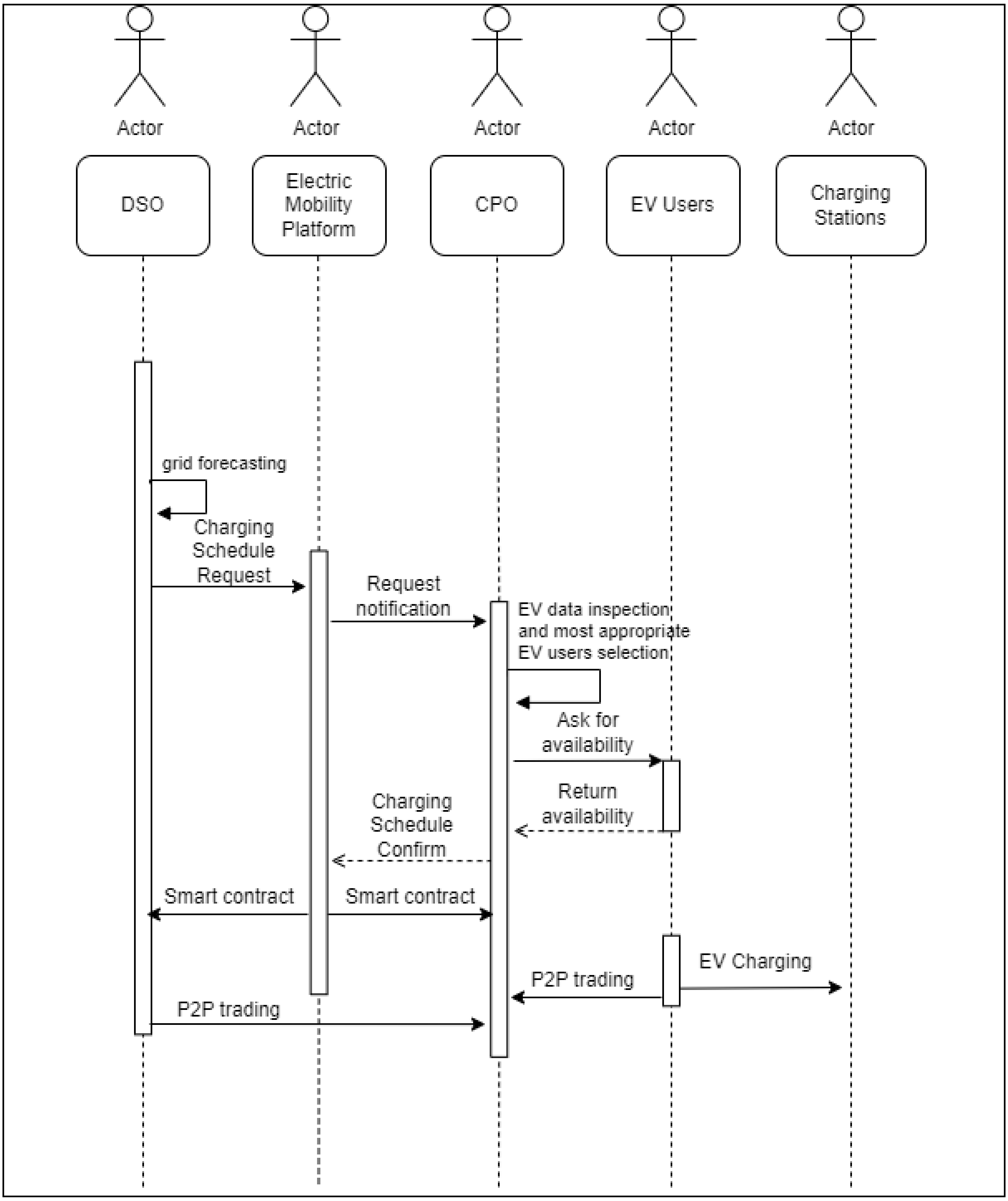

7.9.3 Technical details

7.9.3.1 Actors

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Actors			
Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
System Operator	Role	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	ASM Terni
Energy Service Company		A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	Charge Point Operator
Party Connected to the Grid		A party that contracts for the right to take out or feed in energy at an Accounting Point.	Charging station

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Consumer		A party that consumes energy.	EV users

Actors			
Grouping		Group description	
Information Systems			
Actor name	Actor type	Actor description	Further information specific to this use case
Connector of System Operator	System	Connects the Grid Operator/System Operator to the data space.	
Analysis systems of System Operator	System	Analyse given data in order to provide RES generation forecast and more.	
Charging Point System	System	Manages all actions to load the EV.	
Connector Charging Point Operator	System		
Electric Mobility Platform	System	CPO system that hosts EV users and collects electric vehicles and charging stations data. Communicate also with DSO for grid congestion management.	
Charging stations		Deployed devices suitable for EV charging	

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7.9.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.9.4 Step by step analysis of use case

7.9.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Grid monitoring	Grid/System Operator collects smart meter data and identifies congestion problem	Grid/System Operator	Forecast will be calculated every day	Smart meter data should be constantly collected	Charging schedule needed is identified
2	Charging schedule notification	Based on forecast data, Grid/System Operator sends a charging schedule to CPO	Grid/System Operator	Forecast system indicates a potential congestion problem to be mitigated	DSO system is connected with the electric mobility platform	A charging schedule request is created in the electric mobility platform
3	EV users involvement	Based on charging schedule provided by DSO, CPO asks to EV users their availability	CPO EV drivers	First EV users who provide availability are awarded the charge at a discounted price	EV users are connected with the electric mobility platform	Smart contracts between DSO and CPO is signed and charging schedule is settled

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		to comply with provided charging schedule				
4	Grid congestion problem avoided	Coordination between DSO and CPO involves solving grid congestion problem	CPO EV drivers	EV users charge their electric vehicles according with charging schedule	Charging stations are remotely controllable by CPO	Grid congestion is avoided and P2P micro payments are executed

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7.9.4.2 Steps-Scenarios

Scenario								
Scenario name :		**Grid Monitoring**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1.1	Get meter data	Get meter data	In order to keep the energy distribution service running, DSO monitors power grid, collecting meter data	GET	DSO	AMI		
1.2	Meter data	Meter data	AMI provides smart meter energy data	REPORT	AMI	DSO	I-1	P5B-F-05 P5B-F-06 P5B-NF-06 P5B-NF-07
1.3	Grid forecasting	Grid forecasting	DSO executes grid forecasting in order to identify potential congestion problems	EXECUTE	DSO	DSO	I-4	P5B-F-12 P5B-NF-06 P5B-NF-07

Scenario								
Scenario name :		**Charging schedule notification**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
2.1	Charging schedule request	Charging schedule request	DSO creates a charging schedule request on the electric mobility platform	CREATE	DSO	Electric Mobility Platform	I-5	P5B-F-13 P5B-NF-06 P5B-NF-07

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2.2	Request notification	Request notification	Electric mobility platform notify to CPO about new charging schedule request	CHANGE	Electric Mobility Platform	CPO	I-5	

Scenario								
Scenario name :	**EV users involvement**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	***Information* Exchanged (IDs)**	***Requirement, R-IDs***
3.1	EV data inspection and most appropriate EV users selection	EV data inspection and most appropriate EV users selection	CPO consults the monitoring and forecasting system and identifies suitable EV users to involve	EXECUTE	CPO	CPO	I-3 I-4	P5B-F-04 P5B-F-10 P5B-NF-06 P5B-NF-07
3.2	Ask for availability	Ask for availability	CPO contacts identified EV users to ask for their availability to charge in specific time and parking place	GET	CPO	EV users	I-5	P5B-F-13 P5B-NF-06 P5B-NF-07
3.3	Return availability	Return availability	EV users provide their availability	REPORT	EV users	CPO	I-5	
3.4	Charging Schedule Confirm	Charging Schedule Confirm	CPO confirms charging schedule in the electric mobility platform	REPORT	CPO	Electric Mobility Platform	I-5	P5B-F-13 P5B-NF-06 P5B-NF-07
3.5	Smart contract	Smart contract	Electric mobility platform notify to DSO charging schedule confirmation and	EXECUTE	Electric Mobility Platform	DSO CPO		

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			smart contract is executed between DSO and CPO					

Scenario								
Scenario name :		**Grid congestion problem avoided**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
4.1	EV charging	EV charging	EV users connect electric vehicles to charging stations and charging sessions are performed	EXECUTE	EV users	Charging stations	I-1 I-2	P5B-F-03 P5B-F-09 P5B-NF-06 P5B-NF-07
4.2	P2P trading	P2P trading	DSO remunerates CPO for service provided	EXECUTE	DSO	CPO		
4.3	P2P trading	P2P trading	EV users remunerates CPO for EV charging provided	EXECUTE	EV users	CPO		

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7.9.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I-1	Smart meter data	Smart meter ID Energy Timestamp	P5B-F-05 P5B-F-06 P5B-NF-06 P5B-NF-07
I-2	Charging station data	Charging Station ID Power Output Socket ID Socket Status Charging Session ID Start Time End Time Energy Cost	P5B-F-03 P5B-F-09 P5B-NF-06 P5B-NF-07
I-3	Electric vehicle data	Electric Vehicle ID Electric Vehicle Model Connector Type Battery Capacity Battery Power Timestamp SoC Speed Kilometers Autonomy (It is the actual kilometers that EV can do with actual SoC level) Odometer	P5B-F-04 P5B-F-10 P5B-NF-06 P5B-NF-07
I-4	Forecasting data	Energy Time	P5B-F-12 P5B-NF-06 P5B-NF-07
I-5	Charging schedule data	Energy Time	P5B-F-13 P5B-NF-06 P5B-NF-07

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7.9.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
F	Functional	Functional requirements
Requirement R-ID	Requirement name	Requirement description
P5B-F-01	Electric Mobility Platform	A platform hosting charging station managers and EV owners shall be implemented and deployed
P5B-F-02	EV user registration	Electric mobility platform shall be enabled for user registrations
P5B-F-03	Charging Station Identifier	As there will be more than one charging station involved in the trial, each individual charging station must have its own unique identifier
P5B-F-04	Electric Vehicle Identifier	As there will be more than one electric vehicle involved in the trial, each individual electric vehicle must have its own unique identifier
P5B-F-05	Electric Meter Identifier	As there will be more than one electric meter involved in the trial, each individual electric vehicle must have its own unique identifier
P5B-F-06	Smart Meter	Smart meter must be connected to internet
P5B-F-07	Smart Charging Station	Charging station must be connected to internet
P5B-F-08	Smart Electric Vehicle	Electric vehicle must be connected to internet
P5B-F-09	Charging Station Data	Charging station must provide energy data; data shall be stored for result evaluation
P5B-F-10	Electric Vehicle Data	Electric vehicle must provide energy data; data shall be stored for result evaluation
P5B-F-11	Electric Mobility Interoperability	Platform must ensure interoperability between charging station and an electric vehicle to ensure the charging session execution

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P5B-F-12	Energy Forecast	DSO shall be able to forecast electricity production/consumption and estimate flexibility need
P5B-F-13	Charging Schedule Mechanism	DSO must be able to select the charging stations to be involved for grid congestion solving and provide charging schedule request
P5B-F-14	Smart Contract	Electric mobility platform must be able to execute smart micro-contracts
P5B-F-15	Micro-Payment	Electric mobility platform must be able to process micro-payments

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P5B-NF-01	Electric Mobility Platform Reliability	Electric Mobility platform shall be capable to manage multiple users without affecting its performance
P5B-NF-02	Electric Mobility Platform OS	Electric Mobility platform shall be portable. So, moving from one OS to other OS does not create any problem
P5B-NF-03	Electric Mobility Platform Login Latency	Electric Mobility platform login shall be processed by 3 seconds
P5B-NF-04	Charging Station Latency	Charging station ping shall be under 200 ms
P5B-NF-05	Electric Vehicle Latency	Electric vehicle ping shall be under 200 ms
P5B-NF-06	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P5B-NF-07	Data Accessibility	Store data in a safe and tamperproof manner

7.9.7 Common terms and definitions

Common Terms and Definitions	
Term	**Definition**
AMI	Advanced Metering Infrastructure
DSO	Distribution Service Operator

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CPO	Charging Point Operator
EV	Electric Vehicle
P2P	Peer-to-peer

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7.10 Pilot 5 – Use Case 5c – Flexibility provision for electricity grid with water pumps and predictive maintenance of the pumps

7.10.1 Description of the Use Case

7.10.1.1 Name of the use case

Use case identification		
ID	**Area / Do- main(s)/ Zone(s) [OPTIONAL]**	**Name of the use case**
P5-IT-C		Flexibility provision for electricity grid with water pumps and predictive maintenance of the pumps

7.10.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard	Initial creation	
0.2				

7.10.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Exploiting new services for sustainable management of water distribution systems which are also beneficial for optimizing grid operations.
Objective(s)	• Increase the efficiency of the grid by using flexibility of the water network and water pumps • Forecasting water demand variations using the real time data and historical data available.
Related business case(s)	Increased efficiency in grid operation by tapping the flexibility potential of water pumps, reduce cost of water system operations through water demand forecasting and electricity consumption in lower price periods

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7.10.1.4 Narrative of Use Case

Narrative of Use Case
Short description
In the morning when everyone gets ready for the day, the water consumption is high, in the night the water consumption decreases by 80 percent. That means at night pressure at the source can be reduced while still allowing customers to have sufficient tap pressure. Our water distribution network manage their operation on the instant water demand of the network, meaning that the use of the equipment is conditioned by the immediate water necessity. Water demand forecasting is crucial for the sustainable management of water distribution systems. It is directly related to a supply service with reduced operating costs, such as the electric energy required for pumping and plays an important role in the optimal performance of pumps. Water demand prediction which is crucial to have optimal water demand balance, minimise overpressure and consequently achieve water and energy savings.
Complete description

7.10.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**
5C_1		Reduction of power peaks	
5C_2		Maintaining sufficient tap pressure throughout the day	

7.10.1.6 Use case conditions

Use case conditions
Assumptions
Technology will be provided by the technical partners
Prerequisites
Sensors for monitoring parameters for forecasting the water demand variation

7.10.1.7 Further information to the use case for classification / mapping

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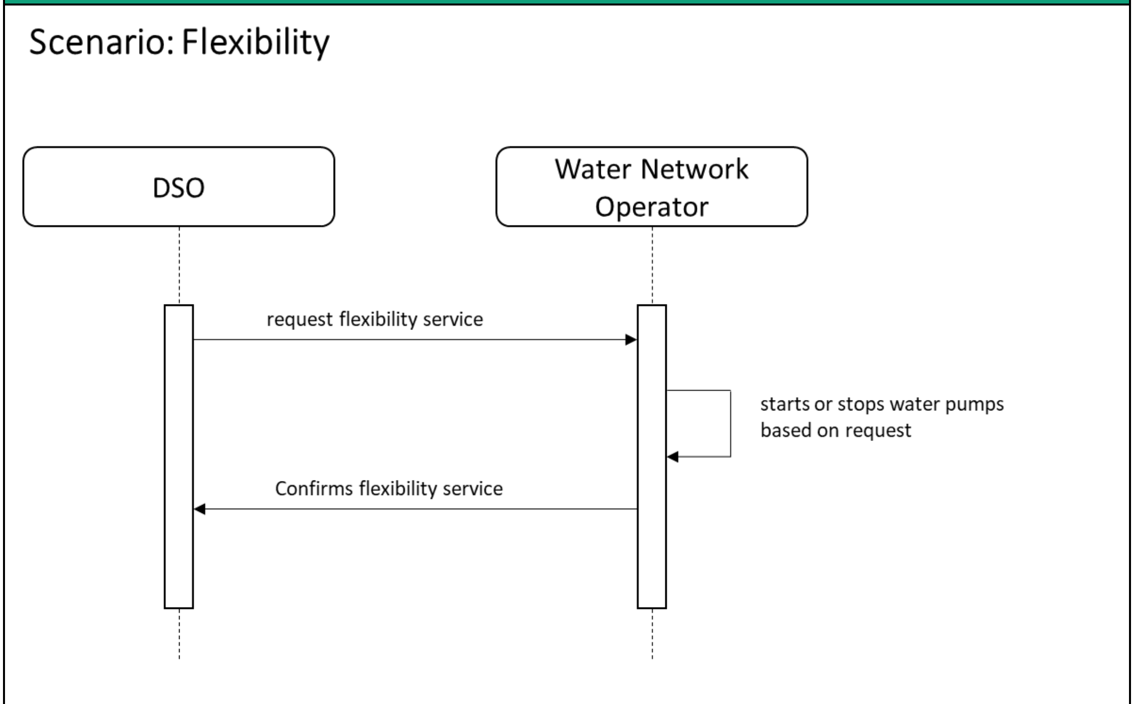
Classification information
Relation to other use cases
None
Level of depth
High-Level Use Case (HLUC)
Prioritization
Regular
Generic, regional or national relation
Generic
Nature of the use case
System
Further keywords for classification
Water pumps, flexibility,

7.10.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case


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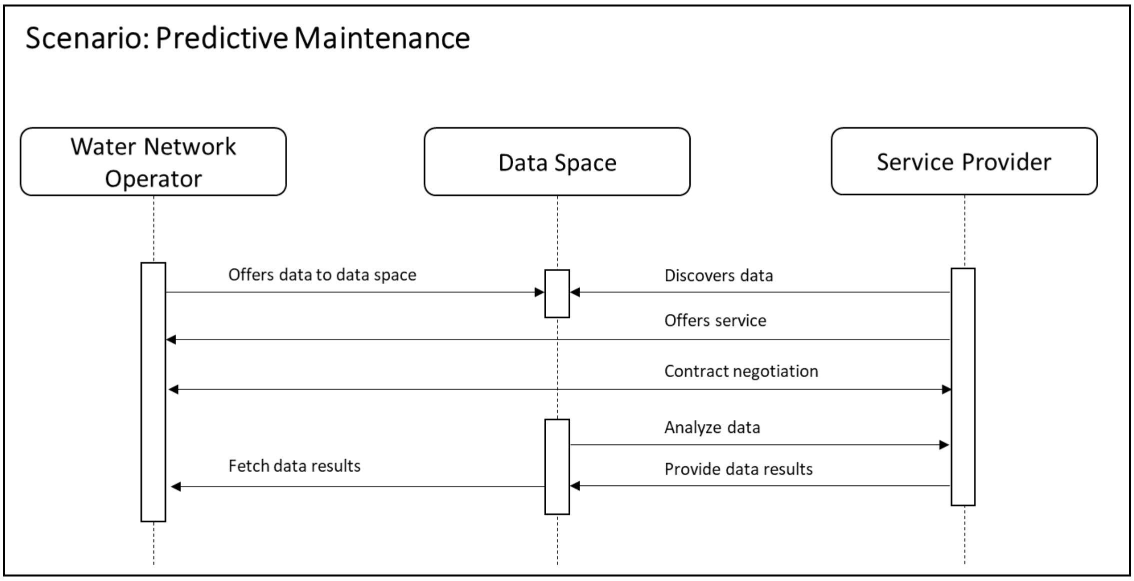

7.10.3 Technical details

7.10.3.1 Actors

Actors			
Grouping		Group description	
Harmonized electricity market role		The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.	
Actor name	Actor type	Actor description	Further information specific to this use case
System Operator	Role	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to	ASM Terni

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		meet reasonable demands for the distribution or transmission of electricity.	
Energy Service Company		A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	ENG
Party Connected to the grid		A party that contracts for the right to take out or feed in energy at an Accounting Point.	Water network operator

Actors			
Grouping		Group description	
Data space role model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS / GAIA-X	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	
Data Provider	Role. IDS / GAIA-X	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	

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Data Consumer	Role. IDS	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

Actors			
Grouping		Group description	
Information Systems			
Actor name	Actor type	Actor description	Further information specific to this use case
Connector of System Operator	System	Connects the Grid Operator/System Operator to the data space.	
Analysis systems of System Operator	System	Analyze given data in order to provide RES generation forecast and more.	
Connector of Water Network Operator	System	Connects the water network operator to the data space.	
Forecasting Service for Water Network Operator	System	Provides forecast for water demand to Water network operator	

7.10.3.2 References

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References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

7.10.4 Step by step analysis of use case

7.10.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
	Flexibility	In the flexibility scenario the DSO requests the water network operator to consume energy in case of network congestion				
	Predictive Maintenance	The predictive maintenance analysis shall identify maintenance need for water pumps to increase lifetime				

7.10.4.2 Steps-Scenarios

Scenario								
Scenario name:	Flexibility							
Step No.	Event	Name of process	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs

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		activity						
1		Forecast	Forecast electrical power and loads		System operator			P5C -F-02
2		Flexibility demand	Announce request to use water pumps to provide flexibility		System operator		I-1	
3		Flexibility offer	Water grid provider determines possible power that can be shifted		Water network operator		I-2	
4		Flexibility contract	Confirmation by system operator to use the power accordingly		System operator			
5		Flexibility provision	Water grid provider uses pumps according to previous agreement		Water network operator			P5C -F-03

Scenario								
Scenario name:	Predictive Maintenance							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs

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1		Data provision	Water grid operator offers data via data space		Water grid operator		I-3	P5C-F-01
2		Service offering	Energy Service Company offers smart predictive maintenance service at data space		Energy Service Company	Water grid operator		
3		Contract agreement	Water grid operator and smart service provider agree on contract		Water grid operator	Energy Service Company		
4		Data analysis	Energy Service Company is conducting predictive maintenance		Energy Service Company			
5		Result distribution	Energy Service Company distributes the results back with limited access rights to allow only water network operator to see the data		Energy Service Company	Water grid operator	I-4	

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7.10.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	FlexDemand	Demand of flexibility	
I-2	FlexPotential	Potential flexibility from water network to be provided	
I-3	PumpSCADA	SCADA data of water pumps in network	
I-4	PredMtceResults	Results of predictive maintenance analysis	

7.10.6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
F	Functional	Functional requirements
Requirement RID	Requirement name	Requirement description
P5C-F-01	Edge management	Pre-process smart meter data in order to increase data quality
P5C -F-02	Energy consumption and production forecast	Forecast the consumption and generation in the distribution system for a given time
P5C -F-03	Optimize grid operation	Optimize the operation of the grid with the available flexibility information

Requirements		
Categories ID	**Category name for requirements**	**Category description**

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NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P5C-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P5C -NF-02	Data Accessibility	Grant access to data in accordance with usage policies and access rights
P5C -NF-03	Code quality	Code should be well documented and understandable
P5C -NF-4	Visualisation interpretability	Visualizations should be well understandable and interpretable
P5C -NF-5	Elapsed time response requirements for exchanging data	Less than 1 minute

7.10.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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7.11 Pilot 6

This pilot is currently subject to change. The use case description will be added in an updated version of this document.

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7.12 Pilot 7 – Use case 7 - Cross-value chain services for energy-data driven green financing

7.12.1 Description of the Use Case

7.12.1.1 Name of the use case

Use case identification		
ID	Area / Do- main(s)/ Zone(s) [OPTIONAL]	Name of the use case
P7-LV		Cross-value chain services for energy-data driven green financing

7.12.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
0.1	17.10.2022	Linda Rülicke, Volker Berkhout, Marie Eberhard Aija Zucika, Iveta Muceniece	Initial creation	

7.12.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Green financing for energy efficiency services for strengthening debt and equity financing of energy efficiency investments, providing investors and project developers the opportunity to easily evaluate key performance indicators of future projects. The scope of this use case stems from the need of providing innovative services which will be based on Data Spaces, counting on cross-value chain stakeholder data-driven services, at the interplay among smart meters data and financing.
Objective(s)	o Make the data from two financing schemes for renewable energy and energy efficiency calls available to the dataspace: o **Ministry of Environmental protection*,** Latvian environmental investment fund: EKII-6 (Call) Reducing greenhouse gas emissions from households - support for the use of renewable energy sources

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	○ **Ministry of Economics***, Department of Energy Financial Instruments, programs (2) for the renovation of one-apartment residential houses and two-apartment residential houses and for increasing energy efficiency and solar PV installation ○ Automatically anonymize data in order to use it compliantly ○ Calculate cost efficiency KPIs to allow consumers to calculate their return on invest and energy savings ○ Forecast energy production if the RES technology is installed ○ Integrate analysis results into homepage of the Ministry of Energy and climate in the form of app with the aim to **raise awareness** of the households of the energy efficiency actions and RES technology instalment possibilities as well as **do the initial assessment** if the households want to apply for support programs. * **Departments from the** Ministry of Environmental protection and Ministry of Economics are planned to be merged creating the Ministry of Energy and climate.
Related business case(s)	Create information for public reporting and controlling of success in RE and Energy Efficiency funding schemes, adjustment of funding condition according to empirical data

7.12.1.4 Narrative of Use Case

Narrative of Use Case
Short description
The aim of this pilot is to create a solid framework through cross-sectoral integration of data on financial performance of energy efficiency projects. The scope is to strengthen debt and equity financing of energy efficiency investments, providing investors and project developers the opportunity to easily evaluate key performance indicators of future projects. Besides traditional AI-based green financing analytics services, in the context of this pilot the evaluation of energy data sharing to other sectors and the exploitation of how this pilot concept should evolve to become a more generic data sharing solution will be further investigated.
Complete description

7.12.1.5 Key performance indicators (KPI)

Key performance indicators (KPI)			
ID	**Date**	**Description**	**Reference to mentioned use case objectives**
O7-2	01.01.2025.	Number of non-energy sectors that benefit from data space	Water; electrical

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1-SO2	01.03.2025.	% of cost reduction in the energy bill for individuals / consumers	Households
2-ET1	01.12.2023	% increase of data assets accessible and reusable through the Data Space	Open data sets from the financial instruments
2-SO1	01.03.2025.	% of carbon emission reduction due to energy efficiency and energy consumption advices services and non-energy services which leverage on larger shares of energy data accessible and reusable	Indirectly
6-ET2	01.03.2025.	Energy system cost reduction	Households

7.12.1.6 Use case conditions

Use case conditions
Assumptions
• Weather data is available under an Open Data License. • Data on energy efficiency and/or Solar PV instalment projects (300) are available (programs (2) for the renovation). • Equipment data will be available as data stream in mid 2023 (EKII call). • Static equipment(master data) data is available
Prerequisites

7.12.1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases (include, extend, invoke, or associate)
Level of depth
High – Level Use Case (HLUC)
Prioritization
Mandatory
Generic, regional or national relation
National
Nature of the use case
Process
Further keywords for classification

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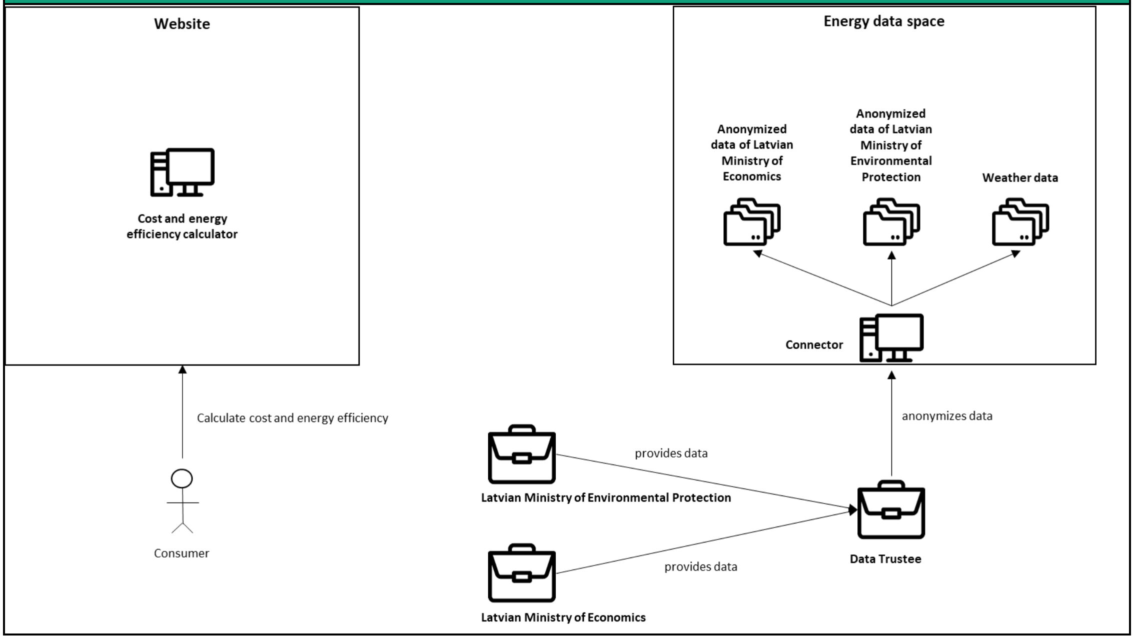
PV forecast, anonymization, funding scheme, reporting, public relations

7.12.2 Diagrams of use case

In this section of the use case template, diagrams of the use case are provided as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case


7.12.3 Technical details

7.12.3.1 Actors

Actors	
Grouping	**Group description**
Harmonized electricity market role	The Role Model has been developed in order to facilitate the dialogue between the market participants from different countries through the designation of a single name for each role and domain that are prevalent within the electricity market. Its focus is essentially to enable a common terminology for IT development.

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Actor name	Actor type	Actor description	Further information specific to this use case
Consumer	Role	A party that consumes electricity	This is a Type of Party Connected to the Grid.
Market Information Aggregator	Role	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use.	LEIF
Energy Service Company	Role	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.	NTUA

Actors			
Grouping		Group description	
Data Space Role Model		Roles from the data value chain that can be taken by energy and non-energy actors.	
Actor name	Actor type	Actor description	Further information specific to this use case
Data Owner	Role. IDS	Original author or legal owner of a Data Asset. A Data Asset has a usage license. Further, the Data Owner can attach Usage Control Policies to restrict access and use. In that sense, the Data Owner retains self-sovereign control over the data.	

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Data Provider	Role. IDS	Makes data available for being exchanged between a Data Owner and a Data Consumer. The Data Provider is in most cases identical with the Data Owner, but not necessarily.	
Data Consumer	Role. IDS	The Data Consumer receives data from a Data Provider. From a business process modeling 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.	
Service Consumer	Role. GAIA-X	Services are offered by a Service Provider and consumed by a Service Consumer.	

Actors			
Grouping		Group description	
Information Systems		Technology systems that send, edit, save or delete data	
Actor name	Actor type	Actor description	Further information specific to this use case
Market Information Aggregator Connector	System	Connects the Market Information Aggregator to the data space.	
Energy Service Provider Connector	System	Connects the Energy Service Provider to the data space	

7.12.3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organization	Link

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7.12.4 Step by step analysis of use case

7.12.4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Anonymization	Anonymize the provided data in order to protect privacy rights of citizens participating in the funding calls	Market Information Aggregator			
2	PV forecast	Forecast energy production of PV modules	Energy Service Company			
3	Cost and energy efficiency calculation	Integrate a cost and energy calculator into the website of Latvian government	Energy Service Company			

7.12.4.2 Steps-Scenarios

Scenario								
Scenario name:	Anonymization							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Information producer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs

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1		Data Provision	Provide data to Energy Service Company		Market Information Aggregator	Energy Service Company	I-1-I-22	
2		Anonymization	Anonymize provided data based on defined parameters		Energy Service Company		I-1-I-22	P7-F-02
3		Data Space Data Provision	Provide anonymized data to data space with open usage policy		Energy Service Company	Open	I-25	P7-F-03

Scenario								
Scenario name:	PV forecast							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1		Consumer input data	Consumer inserts data on location and planned PV asset capacity		Consumer			
2		Data Access	Access weather data via energy data space		Energy Service Company		I-23	P7-F-01
3		Forecast	Forecast a range of realistic energy		Energy Service Company		I-24	P7-F-05

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			production of PV modules for one year					
4		Provide forecast results to data space	Provide forecast data to dataspace for further use in process		Energy Service Company		I-24	P7-F-07

Scenario								
Scenario name:	Cost and energy efficiency calculation on homepage							
Step No.	Event	Name of process activity	Description of process/ activity	Service	Informationproducer (actor	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1		Consumer input data	Consumer inserts data for cost and energy efficiency calculation		Consumer	Energy Service Company	I1-I15	
2		Run calculation	Calculate efficiency gains and associated costs.		Energy Service Company			
3		Visualise results	Provide results on a website		Energy Service Company	Consumer	I-1 – I-22	P7-F-04

7.12.5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

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Information exchanged			
Information exchanged, ID	Name of information	Description of information ex- changed	Requirement, R-IDs
I-1	Mean temperature	Average daytime outdoor temperature in several cities in Latvia	
I-2	Power of technology	One time information about technology and power installed	
I-3	Electricity consumption in household	energy consumption by homeowner	
I-4	Electricity production by solar PV	energy production by homeowner	
I-5	Initial Energy efficiency class	One time information about existing situation before the project realization	
I-6	Initial Thermal energy consumption for heating	One time information about existing situation before the project realization	
I-7	Initial Energy consumption	One time information about existing situation before the project realization	
I-8	Initial Assessment of carbon dioxide emissions	One time information about existing situation before the project realization	
I-9	Initial heat energy consumption	One time information about existing situation before the project realization	
I-10	Carrying out construction works in the enclosing structures	Implemented activities	
I-11	Renovation or reconstruction of engineering systems (for example, heating and ventilation equipment)	Implemented activities	
I-12	Installation of a new water heating system	Implemented activities	
I-13	Installation of heat installations to	Implemented activities	

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	ensure the production of heat from renewable energy sources		
I-14	Other activities, if they are necessary for increasing energy efficiency together with the above-mentioned measures	Implemented activities	
I-15	Other activities	Implemented activities	
I-16	Final Energy efficiency class	After the renovation	
I-17	Final Thermal energy consumption for heating	After the renovation	
I-18	Final Energy consumption	After the renovation	
I-19	Final Assessment of carbon dioxide emissions	After the renovation	
I-20	Final heat energy consumption	After the renovation	
I-21	Final building energy costs	After the renovation	
I-22	Final building technical parameters	After the renovation	
I-23	Open Weather Data Latvia		
I-24	Energy Production Forecast of PV-modules	Forecast based on AI algorithms that forecasts the energy production of PV modules	
I-25	Anonymized data set	The dataset is based on the information ID I-1 to I-22. It is anonymized to protect the privacy rights of participating Latvian citizens	

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7.12.6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
F	Functional	Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P7-F-01	Provide open weather data to the data space	
P7-F-02	Anonymize data	The provided raw data shall be anonymized to protect privacy rights of Latvian citizens, who participated in the funding programs.
P7-F-03	Provide anonymized data to the data space as Open Data	The anonymized data shall be made available via the data space
P7-F-04	Integrate energy and cost efficiency calculator	The energy and cost calculator shall be integrated on the website in order to enable users to calculate financial KPIs for their investment.
P7-F-05	Calculate PV-forecast with ML	
P7-F-06	Provide forecast data to the data space	

Requirements		
Categories ID	**Category name for requirements**	**Category description**
NF	Non-Functional	Non-Functional requirements
Requirement R-ID	**Requirement name**	**Requirement description**
P7-NF-01	Data Reliability	Data shall be consistent, reliable, transparent and accessible only to authorized users
P7-NF-02	Data Accessibility	Store data in a safe and tamperproof manner
P7-NF-03	Data Protection	Handle personal data according to GDPR guidelines
P7-NF-04	Code quality	Code should be well documented and understandable
P7-NF-05	Visualisation interpretability	Visualizations should be well understandable and interpretable
P7-NF-06	Elapsed time response requirements for interaction of the web application	Less than 30 seconds

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P7-NF-07	Commonly used techniques for meeting quality of service requirements of this data exchange	Failure detection; Automatic restart; Automatic failover to second source of data or function; Automatic failover of communication channels to secondary channel; Backup of data Transaction rollback;

7.12.7 Common terms and definitions

Common terms and definitions	
Term	Definition

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