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enabling new Demand REsponse Advanced, Market oriented and secure technologies, solutions and business models

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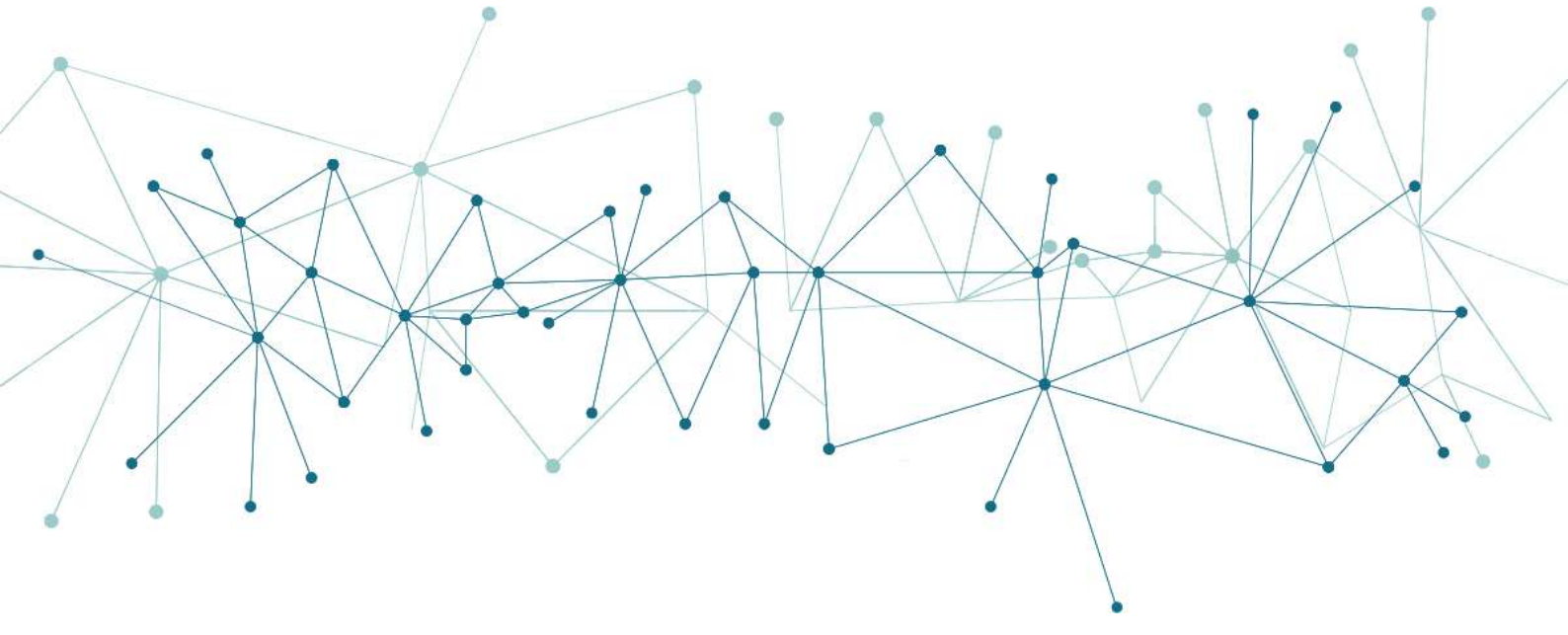
WP2 – User Requirements, Use Cases and System Specification

DELIVERABLE: D2.7 UC Analysis and application scenarios description V2



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Executive Summary

The deliverable D2.7, within the Work Package 2, presents the second version of UCs and related application scenarios through which the eDREAM concept is going to be developed and validated.

The context, in which the project is carried out, is a new decentralized and community-driven energy ecosystem, characterized by Micro-Grids (MG) and Virtual Power Plants (VPP) fully integrated in the local power distribution network.

The Use Cases (UCs) and the scenarios identified in D2.2 and refined in this document consider the needs of the end-users and the technology providers, by means of interactions with the activities related to D2.1 (T2.1) for requirements elicitation.

The consolidated set of UCs are presented according with the updated version of the conceptual architecture framework, actors and tools availability collected and elaborated during Task 2.4 lifespan and presented in D2.5.

This document is organized in four sections in which the second version of UCs and scenarios, this is done by means of templates, describing the set of interactions between the eDream subsystem and actors, in relation to a specific goal.

Three specific high-level scenarios have been identified and depicted:

1. Prosumers DR flexibility aggregation via smart contract,

2. Peer-to-peer local energy trading market,

3. Virtual power plant in energy community.

In the first scenario, prosumers are able to offer their flexibility resources via smart contracts. They can be involved directly or via enabling aggregators.

The second scenario addresses the eDREAM aim to define a mechanism for decentralized and localized energy trading, enabling prosumers to buy or sell energy by means of peer-to-peer transactions. This will enact the consumption of renewable energy close to the point of its generation contributing to the grid stability, and to the decarbonization of local energy micro-grids, rewarding the consumption of renewable energy.

Finally, the third scenario considers the increasing need to optimize output from multiple local generation assets that serve primarily local communities and that also have connections to the power distribution network. In this context, modelling the combined output of the generation assets as a virtual power plant is the best way to improve the overall objective.

The current document points out the benefits at exploiting local capacities in terms of generation, consumption, security, stability and quality of services by new near-real-time DR strategies.

The content of this document reflects the output produced by the close cooperation between eDREAM partners and will serve as input for refining the technical and functional specifications of the overall system in WP3-WP6.

Table of Contents

Executive Summary 3
List of Figures 7
List of Acronyms and Abbreviations 8
1. Introduction 9
1.1 Purpose of the Document 9
1.2 Scope of the Document 9
1.3 Structure of the Document 9
2. Methodology and Framework Conceptual Architecture 11
2.1 Methodology 11
2.2 Conceptual Architecture Framework 14
3. Context and Scenarios 18
3.1 Multiple decentralised active microgrids management and community-based virtual power plant 18
3.2 Actors involved 21
3.3 Scenarios 22
3.3.1 Scenario 1: Prosumer DR flexibility aggregation via smart contracts 22
3.3.2 Scenario 2: Peer-to-peer local energy trading market 24
3.3.3 Scenario 3: VPP in Energy Community 25
4. UCs refinement and update 27
2 30
4.1 High Level UC 01: Prosumers DR flexibility aggregation via smart contract 30
4.1.1 HL-UC01_LL-UC01: Prosumers enrolment in demand response programs 30
4.1.2 HL-UC01_LL-UC02: Contract Setting 33
4.1.3 HL-UC01_LL-UC03: Potential energy flexibility evaluation 36
4.1.4 HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility 39
4.1.5 HL-UC01_LL-UC05: Flexibility request 42
4.1.6 HL-UC01_LL-UC06: Flexibility offering 45
4.1.7 HL-UC01_LL-UC07: Flexibility acceptance 48
4.1.8 HL-UC01_LL-UC08: Flexibility provisioning 50
4.2 High Level UC 02: Peer-to-peer local energy trading market 53
4.2.1 HL-UC02_LL-UC01: Prosumers registration with the energy trading platform 53
4.2.2 HL-UC02_LL-UC02: Prosumers bids/offers submission 56
4.2.3 HL-UC02_LL-UC03: Energy clearing price determination 59

4.2.4 HL-UC02_LL-UC04: Transactions validation and financial settlement 61
4.3 High Level UC: VPP in Energy Community 63
4.3.1 HL-UC03_LL-UC01: Prosumers Profiling and Clusterization 63
4.3.2 HL-UC03_LL-UC02: VPP Capability Evaluation for Reserve services and for Frequency services 66
4.3.3 HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market 69
5. Conclusions 73
References 74

List of Figures

Figure 1 eDREAM Conceptual Architecture 15
Figure 2 Multiple decentralized active microgrids 19
Figure 3 Concept of Virtual Power Plant [4] 20

Table 1: UC Template 14
Table 2 List of identified architectural components, assigned tasks and partners responsibilities 17
Table 3: eDream Actors 22
Table 4: Refined UCs Inventory 27
Table 5 List of identified architectural components and the related UCs 28
Table 6 HL-UC01_LL-UC01: Prosumers enrolment in demand response programs 30
Table 7 HL-UC01_LL-UC02: Contract Setting 33
Table 8 HL-UC01_LL-UC03: Potential energy flexibility evaluation 36
Table 9 HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility 39
Table 10 HL-UC01_LL-UC05: Flexibility request 42
Table 11 HL-UC01_LL-UC06: Flexibility offering 45
Table 12 HL-UC01_LL-UC07: Flexibility acceptance 48
Table 13 HL-UC01_LL-UC08: Flexibility provisioning 50
Table 14 HL-UC02_LL-UC01: Prosumers registration with the energy trading platform 53
Table 15 HL-UC02_LL-UC02: Prosumers bids/offer submission 56
Table 16 HL-UC02_LL-UC03: Energy clearing price determination 59
Table 17 HL-UC02_LL-UC04: Transactions validation and financial settlement 61
Table 18 HL-UC03_LL-UC01: Prosumers Profiling and Clusterization 63
Table 19 VPP Capability Evaluation for Reserve services and for Frequency services 66
Table 20 HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market 69

List of Acronyms and Abbreviations

eDREAM	enabling new Demand Response Advanced, Market oriented and secure technologies, solutions and business models
CHP	Combined Heat and Power
DER	Distributed energy resources
DG	Distributed generation
DR	Demand Response
DSO	Distribution System Operator
DNO	Distribution Network Operator
EV	Electric Vehicle
ESCO	Energy Service COmpany
HL-UC	High Level Use Case
LL-UC	Low Level Use Case
LV	Low Voltage
MV	Medium Voltage
M&V	Measurement and verification
P2P	Peer-to-peer
PV	Photovoltaic
RES	Renewable Energy Sources
TSO	Transmission System Operators
UC	Use Case
UI	User interface
UML	Unified Modelling Language
VPP	Virtual Power Plant

1. Introduction

1.1 Purpose of the Document

The purpose of the Deliverable D2.7 is to provide a consolidated version of the UCs and application scenarios of the new decentralized and community-driven energy ecosystem envisaged by the eDREAM project. As in D2.2, the context of the project is provided, considering Micro-Grids (MG) and Virtual Power Plants (VPP) fully integrated in the local power distribution network. Moreover, three specific scenarios have been identified, namely (1) *Prosumer DR flexibility aggregation via smart contracts*, (2) *Peer-to-peer local energy trading market* and (3) *VPP in energy community* and the corresponding UCs (UCs). The document aims at identifying the benefits of exploiting local capacities in terms of generation, consumption, security, stability and quality of the services by new near-real-time demand response (NRT-DR) strategies. UC

The document exploits the outcomes of WP2 for consolidating the guidelines for the research and development activities of the eDREAM project. Based on the new version of the Conceptual Architecture Framework, as defined in D2.5, a refined set of UCs is provided, with the aim to blend energy, ICT and business skills during the process of elaborating UCs in order to reach a holistic vision of the new decentralized and community-driven energy ecosystem. In addition deployment guidelines will be provided by deliverable D2.8.

Finally, the content of this document reflects the output produced by the close cooperation of the participating partners and will serve as input for defining the technical and functional specifications of the overall system in WP3-WP6.

1.2 Scope of the Document

D2.7 is produced within WP2 with the aim to refine the range of application scenarios and UCs through which the eDREAM concept will be developed and validated. It represents the second version of the deliverable, in which the consolidated UCs and the related scenarios are clearly identified. D2.9 will update these contents and it will be delivered in M30.

This document involves the collective knowledge produced through the cooperation of the partners within WP2 – each one contributing with his respective expertise – in order to refine scenarios and UCs which contribute to determine the activities in the pilot sites.

The UCs and the scenarios identified in D2.2 consider the needs of the end-users and the technology providers, by means of interactions with the activities related to D2.1 (T2.1) for requirements elicitation.

1.3 Structure of the Document

Deliverable 2.7 “UC Analysis and application scenarios description V2” is organised in four sections in which the second version of UCs and scenarios have been collected and described, as follows:

- general introduction and description of the scope and the structure of the deliverable [Section 1];

- definition of the methods for the description of the process that is approached for scenario identification and UC definition and the relation with D2.1; short description of the overall Framework Conceptual Architecture of the eDREAM [Section 2];
- description of the context based on the eDREAM vision and identification of three related scenarios and all actors involved [Section 3];
- identification of a UCs Inventory; consolidation of a list of High Level UCs (HL-UCs) and related Low-Level UCs (LL-UCs) extrapolated by three internal rounds of contributions; description of the HL-UCs and LL-UC by means of templates [Section 4].

2. Methodology and Framework Conceptual Architecture

2.1 Methodology

This section gives and overview of the methodological approach followed within eDREAM, in order to identify specific UCs and application scenarios and eliciting requirements suitable for developing and demonstrating the eDREAM innovative approach.

With respect to the UC definition, the methodology already used for the D2.2 has been applied in this refined version. The UC Methodology has been originally defined in IEC 62559-2:2015 [1] to cover the needs of the software engineering, and it has been extensively used in the smart grid sector. More specifically [2]:

- It offers a systematic manner for gathering all necessary information regarding functionalities, processes and respective actors;
- It facilitates the coordination among various stakeholders as it ensures the common understanding of complex processes;
- It forms the basis for further development of the functionalities of the system under study.

Depending on the amount of information and level of details, the UCs can be classified under different categories. According to [2], two categories were adopted, each one with a different level of abstraction and different level of granularity:

- High level UC (HL-UC): describes a general idea of a function;
- Low level UC (LL-UC): addressing functional requirements implemented in a specific sub-system characterized by a defined boundary.

In eDREAM three high-level scenarios are addressed.

Each scenario has been produced as preparatory work to develop the project architecture in compliance with the IEEE guideline (ISO/IEC/IEEE 42010:2011). The scenarios can be considered as the starting point for the definition of the UCs, which represent the low-level specifications, describing in detail the functionalities and the set of interactions between the eDREAM subsystem and actors, in relation to a specific goal.

The UC Methodology includes a template (Table 1) where all necessary information for a specific process is described: from high-level information, such as the name of the UC, to a detailed step-by-step analysis of the realization of the UC as well as the actors involved. UCThe initial list of UCs and the related scenarios were defined through an internal consultation of the partners responsible for the pilots with the internal technology providers and with the external experts from other H2020 project consortia. A specific template has been adopted for the definition of the UCs and it was circulated among the project partners to identify the first set of UCs. The template was based on the “basic UC template” as in [3] and descriptions provided by partners have been included in this document.

In order to properly organize the development of the project, the UC template, used by this document, is enriched with a "Specific description"; it describes the relevance to eDREAM WPs as well as the Main Tasks and partners Involved in the development. Moreover, D 2.7 enhances UC description and highlights the relationship among functionalities and actors; notably, it provides UML sequence diagrams for each one of the Low Level UCs, as in D2.5, as in Table 1.

Modelling in an essential part in software development and can be described as the design process before the software coding. The usage of a model helps the responsible stakeholders to check for functionalities completeness, the definition of end-user needs and the correct dynamic view of the components and communication among themselves. Identify these requirements in the design phase ensures that issues can be addressed before the actual implementation, when changes are more expensive to be addressed.

The *Unified Modeling Language (UML)* is the industrial standard for describing software artefacts.

Using a standard modeling language helps the communication among projects stakeholders and removes the ambiguities. Since 2005, UML is an approved ISO standard [ref: https://www.iso.org/standard/32620.html] even if it is being used in industry from its initial definition in 1994. The standardization has further extended the language usefulness, widening the target audience. A UML *sequence diagram* depicts the relation among system *Actors*, *Objects*, or *Entities* in terms of messages. The description of interactions among objects provided by a sequence diagram is useful to describe a scenario and, for this reason, it is sometimes called *event scenario*.

Description	
UC Name	UC name Uniquely identifies the UC (e.g. unique identifier), having an achievable goal
Version	Represents the stage a UC has reached.
Last Update	Date of the last update
Authors	Who created and documented the UC
Brief Description	Description of the series of steps for the UC in a clear concise manner. Including what the eDREAM system shall do for the involved actor to achieve a particular goal.
Assumptions & Pre-Conditions	The conditions that generally do not change during the execution and should be true for successfully terminate the UC. Pre-conditions define all the conditions that must be met (i.e., it describes the state of the

	system) to meaningfully cause the initiation of the UC.
Target	The ultimate aim and end condition(-s) of the UC
Effects/Post-Conditions	The state of the world upon successful completion
Involved Actors	Who are the actors involved in the UC? The same actor may play two different roles in the same UC. An actor may be a person, a device, another system or sub-system, or time.
UC Initiation	This refers to the potential triggers or events that could initiate the UC. The type of trigger can be temporal, internal or even in respond to an external event. Normally, the initiation of a UC shall take into account also the pre-conditions, e.g. checking them prior the execution of the UC.
Alternate Courses	Description of the alternative course of events.
Relationships with other UCs	Indication of connection with other UCs
Architectural Elements / Services Involved	Indication of eDREAM elements involved
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	e.g. WP3 & WP4 e.g. T3.1, T3.2, T4.1, T4.3 & T4.4 e.g. CERTH, TU, ATOS, TUC, E@W & EMOT
Notes (Optional)	-
UML Sequence Diagram	

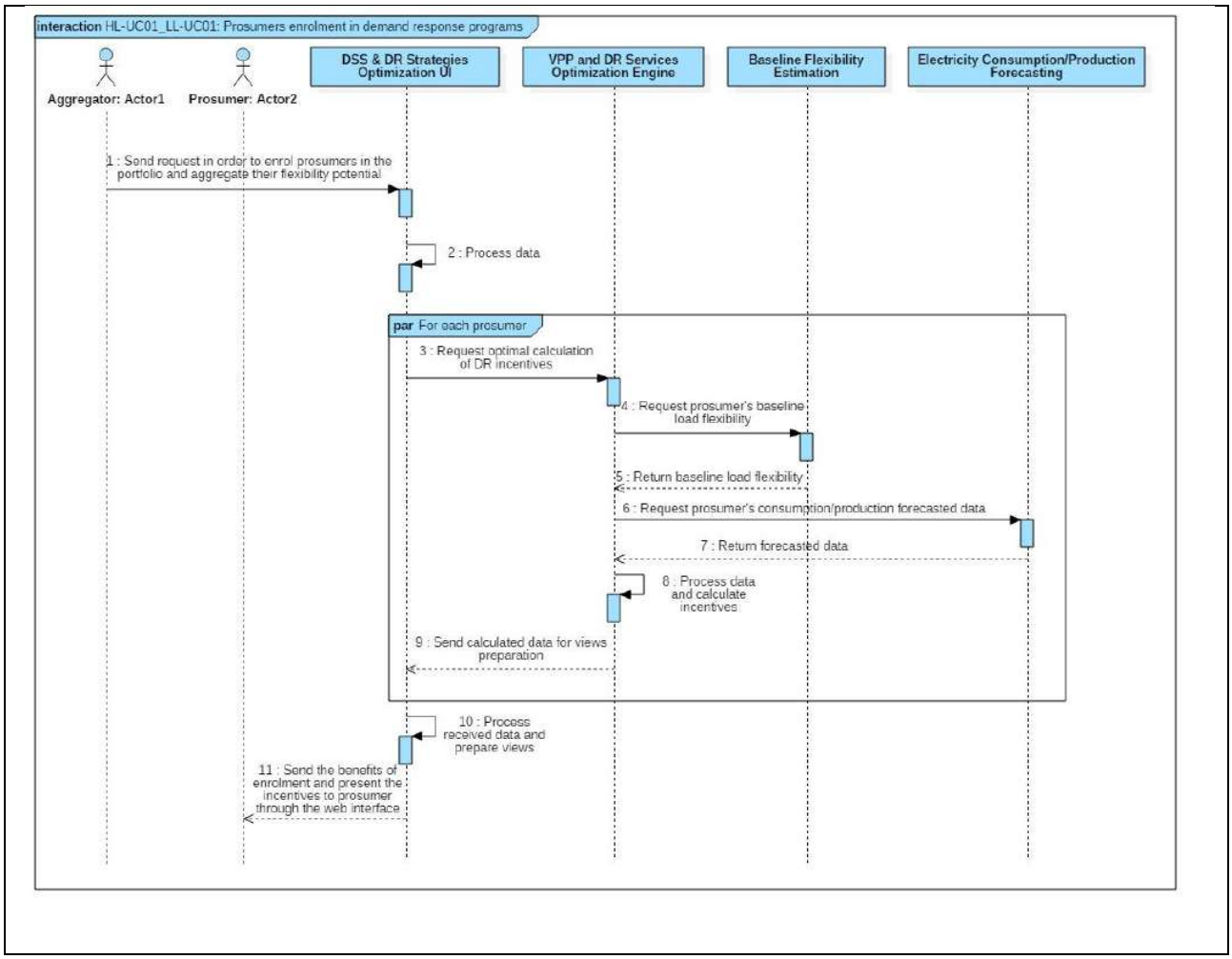


Table 1: UC Template

2.2 Conceptual Architecture Framework

An overview of the eDREAM conceptual architecture is provided, introducing the major layers and sub-layers of the eDREAM platform along with the included architectural components. The aim of the description is to provide reference to the that are presented in Section 4. eDREAM aims to develop, validate and deliver a decentralized and secure a closed-loop DR ecosystem, enabling the seamless cooperation between DSOs and aggregators in the scope of maximizing exploitation of the flexibility potential of a large variety of heterogeneous loads and generation assets. During the lifetime of the project, novel functionalities and services will be researched and examined by using the principles of Internet of Things (IoT), the concepts of Demand Response programs and the blockchain-driven technology. Figure presents the conceptual architecture of the eDREAM platform.

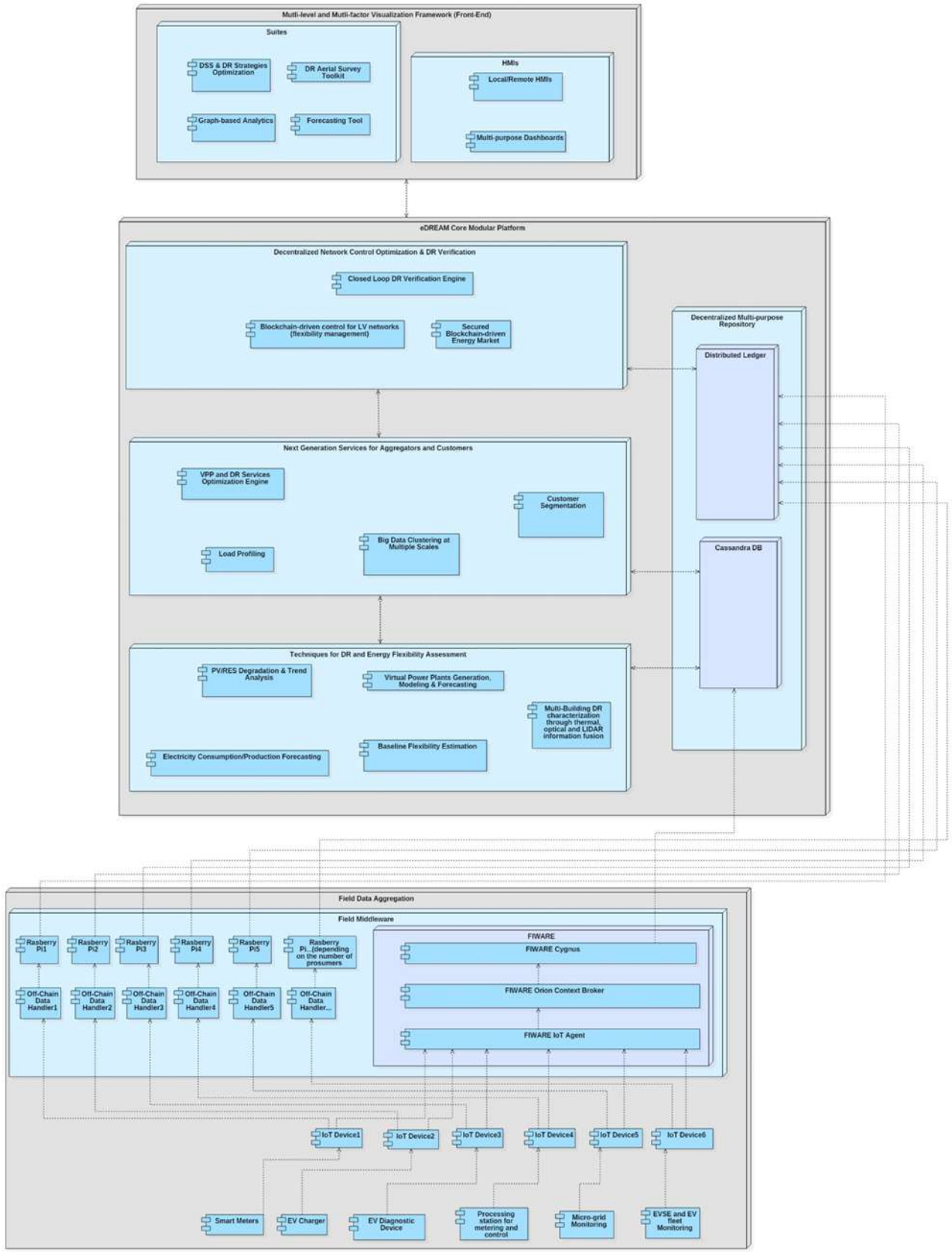


Figure 1 eDREAM Conceptual Architecture

The main layers and sub-layers of the eDREAM platform are described in brief below:

- The first layer of the architecture is **Field Data Aggregation,** which is the interface with the physical world through smart metering devices and communication interfaces. Thanks to the use of IoT devices, this layer will forward the necessary real-time information to the upper layers of the platform. The information exchange will be based on open communication specifications (based on XSD data schemas and REST services) that realize the Machine2Machine (M2M) communication through which the data, information and actions are dispatched to the appropriate field device or upper layer of the platform.

- The main layer is the **Core Backbone Platform** which is the fundamental part of the conceptual framework. It includes all the necessary components and mechanisms to support the structure of a decentralized ecosystem for closed-loop DR programs. This layer includes the following hierarchical connected sub-layers.

    - ***Techniques for DR and Energy Flexibility Assessment (WP3)*** Aiming to provide innovative electricity consumption and production forecasting mechanisms for registered prosumers in the aggregator's portfolio, in addition with advanced models for multiple types of distributed generation resources creating optimal coalitions and providing more reliable aggregated supply, enabling small prosumers, such as households of 1kW capacity generation to participate in DR programs. Furthermore, aerial surveys techniques will be designed and developed giving to aggregators valuable insights for the improvement of their business plans.
    - ***Next Generation Services for Aggregators and Customers (WP4)*** This sub-layer provides to the system stakeholders (Aggregators, DSO etc.) all the necessary services to calculate and extract the parameters related to load and generation profiling for their customers at different scales and they will help aggregators towards optimal DR strategies classification and scheduling. Thanks to innovative machine learning techniques for load profiling and disaggregation (e.g. micro-grid level, virtual power plants and in lower loads related to Distributed Energy Resources), A Big Data Analytics Engine analyzing large streams collected from customers and, big data clustering techniques at multiple scales , creating customers' clusters with specific load and generation profile patterns.
    - ***Decentralized Network Control Optimization & DR Verification (WP5)*** This sub-layer will mostly focus on research and development concepts for decentralized network control and financial transactions. It investigates the use of blockchain platforms in DR modelling, distributed control and validation. A blockchain at grid level ensure secure and reliable storage of energy transactions and DR flexibility services. In addition this layer enables the definition and implementation of self-enforcing smart contracts for tracking and controlling energy transactions and DR flexibility services in smart energy grids . Finally, Proof-of-Stake consensus-based algorithms for closed-loop DR programs execution, verification and financial settlement will be examined.

- The upper layer **HMIs and Front-end for end-users and operators (WP4 & WP6)** contains accessible and easy-to-use HMIs (e.g. accessible by mobile phone through lightweight visualizations) for end-users and operators that enables vertical collaboration (from the DSO and aggregators to prosumers/consumers) and horizontal collaboration (using virtual topologies, such as the community-based VPPs) within the eDREAM architectural framework, allowing a bidirectional data flow.

- The Core Platform is connected with a **Decentralized Multi-purpose Repository (WP5)** which allows data exchanges within eDREAM core framework. This component provides the necessary place for storage and maintenance of data from field devices, data models/profiles for supporting the functions of core components and information from third parties' services.

The list of architectural components along with the assigned tasks and associated partners responsibilities is presented in the Table 2.

Table 2 List of identified architectural components, assigned tasks and partners responsibilities

Component	Related Task	Responsible partner	Contributing partners
Electricity Consumption/Production Forecasting	T3.1	TUC & CERTH	TU, ENG
PV/RES Degradation & Trend Analysis	T4.1	TU & CERTH	ENG, SVT
Baseline Flexibility Estimation	T3.2	TU	TUC, E@W, EMOT
Virtual Power Plants Generation Modeling & Forecasting	T3.3	TUC	EMOT, ENG, ASM
Multi-building DR characterization through thermal, optical and LIDAR information fusion	T3.4	TU & CERTH	KIWI
Load Profiling	T4.2	ATOS & CERTH	E@W, KIWI, ASM
Big Data Clustering at Multiple Scales	T4.2	ATOS & CERTH	E@W, KIWI, ASM
Customer Segmentation	T4.2	ATOS & CERTH	E@W, KIWI, ASM
VPP and DR Services Optimization engine	T4.1	TU & CERTH	ENG, SVT
Distributed Ledger	T5.1	ENG	TUC, E@W, ASM
Blockchain-driven control for LV networks	T5.2	TUC	ENG, EMOT, ASM
Secured Blockchain-driven Energy Market	T5.2	TUC	ENG, EMOT, ASM
Closed loop DR Verification Engine	T5.3	ENG	TUC, E@W, ASM
Graph-based Analytics	T4.3 & T4.4	CERTH	TU, ATOS, E@W, KIWI, ASM
HMIs	T4.3, T4.4 & T6.2	CERTH	ATOS, TU, E@W, ENG, KIWI, ASM, EMOT
DSS (Decision Support System) & DR Strategies Optimization	T4.1, T4.3, T4.4 & T6.2	TU & CERTH	TU, E@W, ENG, SVT, EMOT

DR Aerial Survey Toolkit	T3.4 & T6.2	TU & CERTH	KIWI, ATOS
Forecasting Tool	T3.1 & T6.2	TUC & CERTH	TU, ENG, ATOS

3. Context and Scenarios

3.1 Multiple decentralised active microgrids management and community-based virtual power plant

Electric microgrids are defined as aggregations of electric loads and distributed generation units, interconnected so as to form a single entity, with well-defined boundaries, regulating and controlling by itself the flow of electrical energy in and out of its boundaries[i]. This definition can be extended by the definition of *Energy microgrids*: performing the same regulation and control operations of the electric microgrid, operating direct or indirect energy flows even of a different nature from electricity (e.g. thermal energy).

In this context, we define *smart grids* as integrated electrical systems, where the actions of all users connected to the grid are coordinated with each other, in order to allow an efficient, sustainable and safe use of energy.

eDREAM is considering the emerging neighbourhood market of energy and energy flexibility services, in the setting of active microgrids which aim to maximize local self-consumption, reducing the energy exchange to the higher-level grid. The microgrid represents a suitable option to manage the grid portion of small-scale prosumer systems and it has possibility of adopting solutions in different types of distribution networks (radial or mesh) or with different operating assets. Microgrids have been identified as the key component of the Smart Grid for improving service reliability and power quality, increasing system energy efficiency. Moreover, it could provide grid-independence to individual end-users.

A microgrid is usually connected to the local distribution power network in order to operate in either grid-connected or island-mode, depending on situation of energy production and consumption. Putting in operation these units, characterized by the flexibility given by the internal aggregation of multiple loads and generation as well as the two-way operating modes, can foster the integration of distributed and renewable energy sources in the power distribution network. The benefits are i) reducing peak loads and power losses, ii) reaching the balance between production and consumption, iii) supplying ancillary services to the bulk power system and iv) handling sensitive loads and the variability of renewables locally. End-user needs can be targeted by ensuring energy supply for critical loads, controlling power quality and reliability at the local level, and promoting customer participation through demand-side management and community involvement in electricity supply. The three most relevant strengths of the microgrids are improved reliability,

efficient local solution and strong social integration of energy production and distribution; however, some weaknesses have been identified, such as the increased complexity of the infrastructure and risk of internal faults [3].

eDREAM will consider an environment where the power distribution grid comprises several microgrids, which are defined active in terms of self-reliance and self-government due to the active participation of the end-users; in other words the microgrid can, autonomously, "self-manage" stability by balancing load and generation during the operation depending on own powers or resources (*Figure 2*).

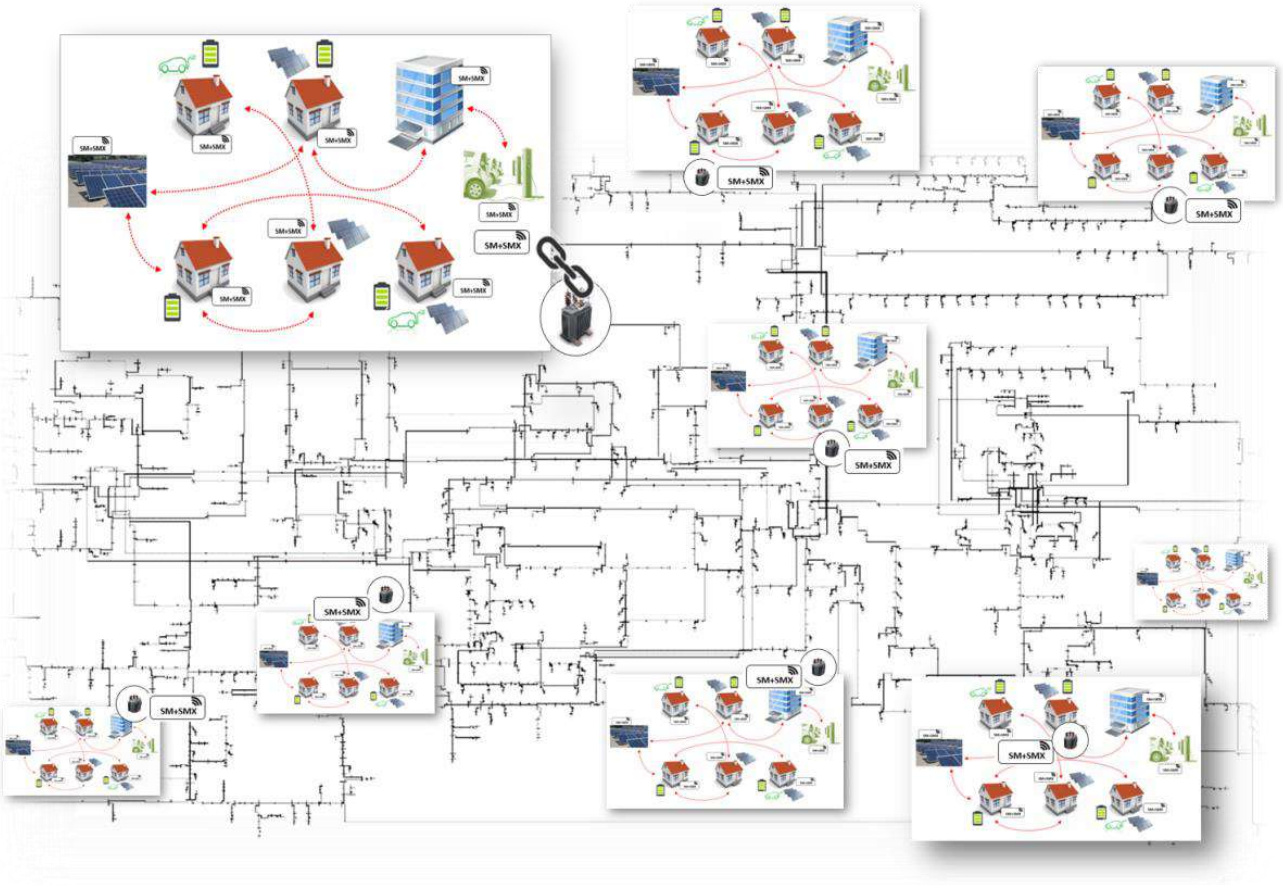


Figure 2 Multiple decentralized active microgrids

In this context, flexibility of energy resources can be evaluated as the capability of power adjustments provided by a microgrid connected to the power distribution network by means of the regulation of generators, the curtailment of load and the charge/discharge of storage systems. Using forecasting engines together with trend analysis tools integrated in a cross modular platform, the DSO can access microgrid resources, especially stationary and mobile storage systems and loads, exploiting microgrid flexibility in order to guarantee smart grid stability, providing flexibility-as-a-service through smart contracts. By using prediction methods to forecast the electricity production and consumption, the DSO can control the state of the distribution grid and therefore manage the flexibility of single prosumers or consumers, controlling the neighbourhood market of energy and energy services and guaranteeing stability and security to the whole smart grid. All information will be stored in a tamper-proof manner through blockchain distributed ledgers and the blockchain will

be also utilized to execute the smart contracts in charge of regulating the flexibility and energy marketplaces.

Together with the microgrid resources, the DSO and third parties can take advantage of the aggregation of distributed generators called virtual power plant (VPP) (*Figure 3*).

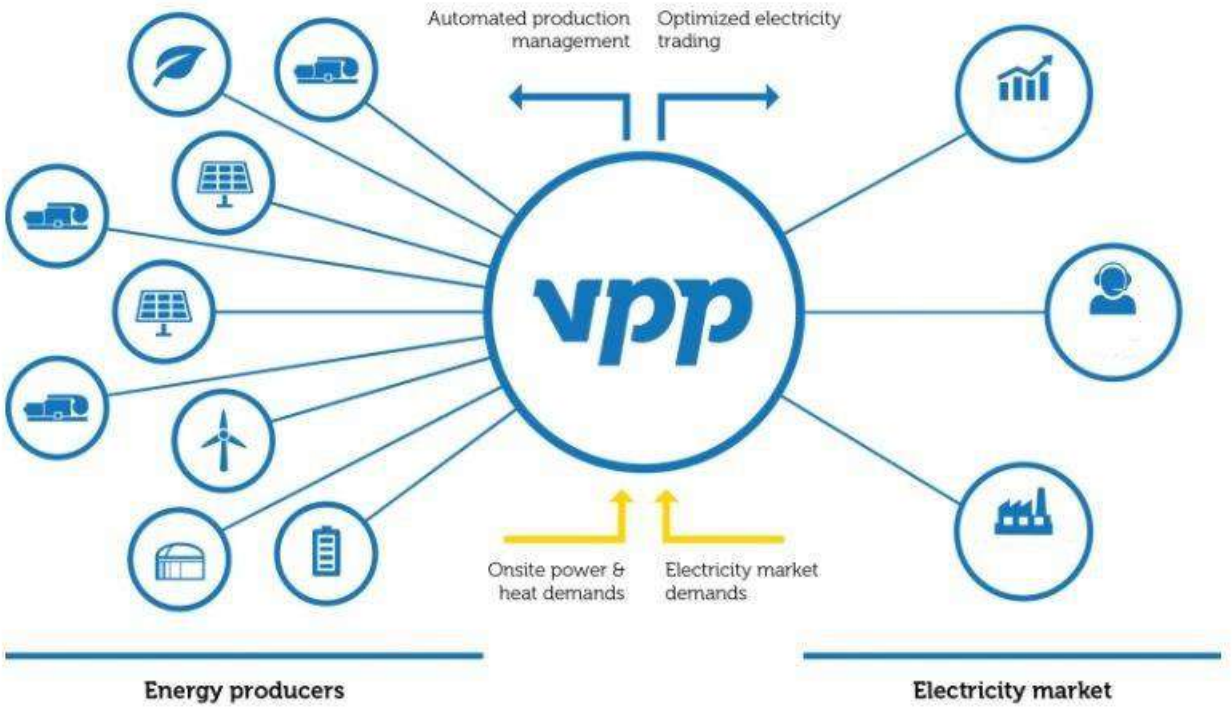


Figure 3 Concept of Virtual Power Plant Errore. L'origine riferimento non è stata trovata.

The VPP is defined as a coalition of dispatchable and non-dispatchable distributed energy generation resources, energy storage elements and controllable loads together with information and communication technologies to form a single imaginary power plant that plans, monitors the operation and coordinates the power flows between its components to minimize the generation costs, increase the overall grid stability, minimize the production of greenhouse gases, maximize profits, and enhance trade inside the electricity market **Errore. L'origine riferimento non è stata trovata.**. As different types of generation assets have different generation profiles throughout the day and different response times to control signals, there are benefits in staking them up in a single portfolio. The resulting curve will have different profile from that of any of its individual components and therefore may be used in a new way – depending also on how fast and within what bandwidth the assets can respond to external signals. From the aggregation perspective, this creates the premises of maximizing the revenue from flexibility services by always using the aggregated portfolio in the most profitable service and contributing to grid overall stability by providing a more steady aggregated renewable energy generation

Running both VPP and microgrids in the power distribution network by means of a secure blockchain-based near-real-time distributed ledger will allow reaching a novel decentralized and community-driven energy system, fully exploiting the local energy capacities and the active role of

the energy customers. In the meantime, the DSO will be able to guarantee a more stable and secure smart grid as well as the quality of the services provided.

3.2 Actors involved

In order to establish a common understanding and language regarding the actors involved in the UCs defined within eDREAM, a list of actors is defined (Table 3). Each one can belong to one of four types (device, application, person, organization) and can be implicated in the UC directly or indirectly.

Actor	Description	Actor type
DSO	*Distribution System Operator*. The entity responsible for: distribution network planning and development; the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; procurement of flexibility services.	Organisation
DNO	A *Distribution Network Operator* is a company licensed to distribute electricity in the UK. These companies own and operate the system of cables and towers that bring electricity from the national transmission network to consumers and prosumers.	Organisation
Aggregator	A *Aggregator* accumulates energy or flexibility from prosumers and Consumers and sells it to the Supplier, the DSO or the TSO.	Organisation
EV fleet manager	*Electric Vehicle Fleet Manager*. An organization that operates and controls an EV fleet; it is interested in participating in DR campaigns to benefit from the advantages of providing flexibility by charging electric vehicles.	Organisation
EV owner	A person who owns an electric vehicle and is interested in participating in DR campaigns to benefit from the advantages of providing flexibility by charging his electric vehicle.	Person
ESCO	*Energy Service COmpany*. Offers auxiliary energy-related services to prosumers.	Organisation
Charging stations manager	An organization that operates and controls charging stations; it acts as an aggregator to provide flexibility to the DSO during DR campaigns by engaging electric vehicles.	Organisation
Prosumer	An entity that consumes and produces energy connected to the distribution grid. No distinction is made between residential end-users, small and medium-sized enterprises or industrial users.	Person

Consumer	An entity connected to the distribution grid, that consumes energy, i.e. a prosumer without any production capabilities.	Person
VPP Energy Manager	An entity responsible for managing the VPP. For instance, can decide in which mode the VPP should function – maximise revenue or maximising local energy usage (can shift between the 2). Responsible for assuring the revenue stream for the actors owning the assets participating in the VPP.	Organisation

Table 3: eDream Actors

3.3 Scenarios

In order to extensively validate the eDREAM concept, three scenarios have been identified and depicted. Apart from the scenario description, in this section the following information per scenario is presented: the actors involved and the eDREAM tools employed.

3.3.1 Scenario 1: Prosumer DR flexibility aggregation via smart contracts

In this scenario, prosumers can offer via smart contracts their flexibility resources, both production and loads modulation. The scenario will be tested in the Italian pilot, located in ASM Terni living lab. In this scenario, by means of specific mechanisms enabling both supply-demand matching and decentralized coordinated control, the DSO will be able to assess and trace the share of contracted flexibility services, activated in real time by the aggregators at the grid level with the results of:

1. maintaining the balance of supply and demand in a decentralized environment,
2. achieving the goal of reducing the overloading,
3. reaching power network stability by means of the flexibility provided by active microgrids.

The LV distribution network comprises microgrids which are connected via blockchain technologies both internally (energy exchange in the neighbourhood, behind the MV/LV transformer) and externally (flexibility needed for keeping the power network stable and secure).
A main objective of the eDREAM project in this scenario is to transform the system into decentralised system and to ensure system stability by balancing load and generation during the operation in island mode.
The balance between energy demand and energy production is managed by the corresponding DSO's substation, which is a node in the network. The DSO can analyse the actual state of the distribution grid and forecast the needs for energy flexibility to deal with potential distribution grid level congestion problems; the aim will be to identify grid issues and actors that can solve them providing flexibility. Regarding this scenario, the DSO aims to access microgrid resources taking advantage of microgrid flexibility in order to guarantee smart grid stability and making available flexibility-as-a-service through smart contracts.
The microgrid operator can work in both grid-connected or island mode; prosumers/consumers make available their energy flexibility, they are registered to the DR programs and can sign/accept smart contracts.

In this scenario, each prosumer or consumer of the microgrid is enabled offering his flexibility via smart contracts to specific aggregators. On the one hand, the aggregator calculated energy demand forecasting and it shares this information with the DSO; on the other hand, the DSO identifies a critical section of its grid, in which a congestion may happen considering the foreseen demand and network availability, and declares it in the Common Reference Operator (CRO) registry.
If a congestion is foreseen, the DSO sends a flex request to the Flexibility Marketplace and aggregators respond to this flexibility request by placing a flexibility offer in the Flexibility Marketplace; DSO can accept one or multiple flexibility offers and sends a flexibility order; then, Aggregators will adjust the load of its prosumers to fulfil the flexibility need.
The smart contracts enable managing the levels of energy demand flexibility (i.e. from aggregators and enrolled prosumers on one side and from aggregators to the DSO on the other side), associating incentive and penalty rates. The corresponding smart contracts can be evaluated after estimating the difference between the expected energy flexibility curve and the flexibility actually delivered (as relived by monitored energy values). If relevant deviations occur, specific actions will be taken to rebalance energy demand with energy production, thus, smart contracts act as a decentralized control mechanism.
Based on this approach, the automatic selection of each prosumer in a DR event is regulated using a self-enforcing smart contract. Such contracts compare the decentralized energy prosumer's baseline energy profile with the actual monitored energy values, including the expected adjustments in terms of the amount of energy flexibility to be shifted during DR event time intervals. The power baseline profile is a regular energy profile of an energy prosumers, determined as an average of past measured energy values; it reflects how much energy the prosumers may have consumed in the absence of DR event.
The aggregators will inject individual control signals (i.e. upon the DSO request) which requests to regulate prosumers energy profile by shifting energy flexibility. Aggregators will evaluate the difference between the total amount of energy flexibility actual activated, normalized to the baseline energy consumption of each distributed energy prosumer.
The DR actions to be performed, on the basis of the specific DR program, is received by prosumer that is recorded in the ledger, thus, the smart contract verifies in near real time the monitored energy consumption data against the DR signal to detect any significant deviations and notifies the aggregator. The smart contract will be comprehensible for the end-users thanks to specific visualization framework.
In case of notable positive or negative deviations the smart contract calculates the associated penalties for prosumer. Otherwise, the prosumer is rewarded, considering the DR revenue rates and how much of the prosumer energy demand profile has been adapted during a DR event. The incentive and penalties are established by the aggregator considering the energy flexibility order received at its turn from the DSO. To determine how much a prosumer has adapted its energy demand to the DR, having as reference its Baseline Energy Profile, it is possible to use a metric power curve adaptability, as in [4], to monitor the actual adjusted energy demand during the DR event time interval.

With respect to the incentives, the smart contracts manage incentives. These are calculated for each kWh of energy shifted, during a DR event, and can be provided as a daily revenue or a discount rate on the regular electricity bill, as in [5]

3.3.2 Scenario 2: Peer-to-peer local energy trading market

The eDREAM project aims to investigate the appropriateness of using a blockchain, based mechanism for decentralized energy trading, enabling prosumers to buy or sell energy by means of peer-to-peer energy transactions.

The market transactions will be triggered by price variations caused by the availability of local renewable energy in the grid and notified through price signal notifications.

The price signal notification will operate as stimulus for prosumers' transactions because in correspondence to an exceeding production of energy there is a signal of price reduction that could trigger the activation of shiftable or curtailable loads.

The envisioned energy marketplace will enact any prosumer to directly participate in a market auction. This is of crucial importance in the context of integrating many small-scale distributed energy prosumers, providing opportunities for competitive or cooperative procurement models. The market will match consumers with energy producers and will rely on energy tokens for rewarding the consumption of renewable energy when it is available. The market will make use of self-enforcing smart contracts to implement, in a programmatic manner, the potential P2P energy trading between energy prosumers and energy consumers.

Self-enforcing smart contracts are distributed at the level of peer prosumer each voluntarily enrolled with the marketplace and stipulate the expected energy production/demand levels, energy price in tokens or the associated token-based incentives for rewarding prosumers consuming the renewable energy when available. During a market session each prosumer will submit bids and offers (i.e. from their contracts) representing the amount of energy they are willing to buy or sell. The use of smart contracts will allow participants to submit bids and offers automatically; the validity checks are done by the smart contract themselves to ensure that market session rules are not violated.

Smart contracts will programmatically deal with market operation processes such as the match between bids and offers, and energy clearing price calculation per session. For clearing price calculation, the produced energy offers are aggregated and sorted in ascending order and the demanded energy bids in descending order. The intersection point between the two curves gives the market-clearing price. The bids and offers are matched as follows: the offers (supply) with the price lower than the clearing price and the bids (demand) with the price higher than the clearing price. Other clearing price calculation-greedy algorithms could be investigated, implemented and evaluated (i.e. graph-based). Prosumers may accept or reject the matched offers/bids. The acceptance of an offer/bid implies the market participant's commitment to inject/withdraw the quantity of energy specified in the offer/bid, or, in case of partial acceptance of the offer/bid, the corresponding share, in a prefixed time frame. As a result, energy transactions are generated, replicated in all the nodes and validated but they are not fully confirmed until a new block containing them will be added to the blockchain.

Once issued, the energy transactions are registered and replicated in blockchain blocks across all the nodes in the network. The consensus mechanisms implemented in the blockchain system, keeps

track of all these changes and validates at each point the corresponding state updates. Thus, instead of having one authority for keeping all energy transactions centralized, like the DSO, the responsibility is equally shared among every peer node of the network. Each transaction is tracked and validated by each peer locally before unanimously accepting it in the history. This way, the market implements a completely replicated and highly reliable decentralized validation process, where each node is responsible to validate the integrity of the registered market actions: tokens issued, bids and offers, market clearing price computation, monitored values, settled price, green energy consumer rewards and brown energy consumer penalties. The results of each prosumer node computation will determine whether the actions contained in the block are valid and whether the block will be added as a valid block in the chain history. As a result, the decision on the actual share of green energy which has been effectively delivered or consumed by each peer and associated financial incentives in form of tokens will be unanimously agreed upon by all the other network peers through consensus.

3.3.3 Scenario 3: VPP in Energy Community

This scenario is considering the increasing need to optimize output from multiple local generation assets and prosumers in general that serve primarily local communities and also have export connections at power distribution network.

In this context, modelling the combined output of the generation assets as a VPP is the best way to improve on the overall objective maximizing functions because different types of generation assets have different generation profiles throughout the selected period of time and different response times to control signals and staking them up in a single portfolio generates benefits.

The resulting curve will have different profile from that of any of its individual components and therefore may be used in a new way – depending also on how fast and within what bandwidth the assets can respond to external signals.

In essence, the VPP will have to allocate capacity based on a number of cost- and effort criteria.

The desired objective would be a VPP operating on a profit maximizing function and providing flexibility services to the TSO/DNO, active on the wholesale market while supporting the need of local prosumers and consumers. To deliver on its objective, this scenario deals with the role of the aggregator as manager of several distributed resources, enabling the participation of selected assets of its clients' portfolio. When considering a heterogeneous energy community, there could be many options to compose the VPP coalition, according to involved actors and the market needs. The aggregator will take advantage of some eDREAM core modular platform services to identify the prosumers allowed to participate in a generic market request. Through a procedure involving a forecasting module and big-data layer modules (Load Profiling, Big Data Clustering at Multiple Scale and Customer Segmentation), the aggregator will be able to know the set (cluster) of prosumers that better address the market request, so the selection of the assets will be based on prosumers grouped in accordance to their profile and some other business criteria that might change according to the market request.

When considering a specific market request as ancillary services (reserve and frequency), a different set of SW components from the eDREAM platform should be involved. In this case the objective is

to calculate the optimal coalition of prosumers with the proper flexibility to be exported in a given response time. Passive customers also can be involved in case of curtailment capacity. The VPP Generation Modelling & Forecasting and the VPP & DR service optimization engine will play a crucial role respectively for assessing the coalition and calculating the optimal set points for the assets. The combined contribution from other modules like Baseline Flexibility Estimation, PV/RES degradation and trend analysis and Electricity consumption/production forecasting will support the estimation of the flexibility capacity of the coalition for the time-slot in advance.

Finally, in case of intraday or imbalance market participation (only for prosumers and generators), it is necessary to calculate the export capacity of the community that would require an estimation in a shorter time. In this case the VPP Generation Modelling & Forecasting and the VPP & DR service optimization engine will be supported by the forecasting module for the assessment of the of the capacity output to be exported.

UCThe scenarios above described aim to maximize the profit of the combined generation or the flexibility services within a local microgrid through the use of a VPP, which will bring its capacity to the optimum paying service at any time, containing locale usage of energy, cooperating to the wholesale market and capacity market.

The eDREAM solution acts as (1) a flexibility service provider to TSO or DNO; (2) a wholesale capacity provider on the wholesale or capacity market; (3) a utility provider for the local prosumers, as well as (4) a provider of forecasts and measurement and verification (M&V) for all these activities. All these markets have different requirements in terms of M&V methods, data sampling rates and data accuracy, response time and maximum dispatch (participation) duration. These criteria have shaped up the specific details of the high-level and low-level UCs provided in the next section.

4. UCs refinement and update

For each of the three scenarios presented in Section 4, one high-level UC has been developed as well as several low-level UCs (Table 2). Each of the UCs is presented in detail. The UCs have been developed through internal consultation of the partner responsible of the pilots by the internal technology providers and of the consultation of the external expert from other H2020 project consortia. In comparison with D2.2, the new set of UCs is firmly anchored to the tools available in the project and more coherent with the conceptual architecture as well as the scenarios.

Their description has been enriched adding a specific description (i.e., relevance to eDREAM WPs, main Tasks Involved, main Technical Partners Involved) and the UML Sequence Diagram.

eDREAM UCS INVENTORY
HL-UC01: Prosumers DR flexibility aggregation via smart contract
HL-UC01_LL-UC01: Prosumers enrolment with the aggregator
HL-UC01_LL-UC02: Contract settings
HL-UC01_LL-UC03: Potential energy flexibility evaluation
HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility
HL-UC01_LL-UC05: Flexibility request
HL-UC01_LL-UC06: Flexibility offering
HL-UC01_LL-UC07: Flexibility acceptance
HL-UC01_LL-UC08: Flexibility provisioning
HL-UC02: Peer-to-peer local energy trading market
HL-UC02_LL-UC01: Prosumers registration with the energy trading platform
HL-UC02_LL-UC02: Prosumers bids/offers submission
HL-UC02_LL-UC03: Energy clearing price determination
HL-UC02_LL-UC04: Transactions validation and financial settlement
HL-UC02_LL-UC05: Prosumers buy/sell energy tokens
HL-UC03: VPP in Energy Community
HL-UC03_LL-UC01: Prosumers Profiling and Clusterization
HL-UC03_LL-UC02: VPP capability evaluation for Reserve services and for Frequency services
HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market

Table 4: Refined UCs Inventory

The dynamic view analysis of the system provides insights and defines how the system actually works within runtime environment and how it performs in response to external (or internal) signal. The interactions between the system's actors and system's components are usually data flows representing the information exchanged in parallel or sequential execution of internal tasks.

The eDREAM UCs were firstly defined and analyzed in deliverable "D2.2 UC Analysis and application scenarios description V1". In the context of the WP2 activities, technical teleconferences on UCs/functional analysis were carried out in the scope of identifying all the dependencies between the key architectural components and the data exchanged during the system's functions or procedures. The logic of these complex operations are presented through **Sequence Diagrams** defining the functionalities of each of the key architectural components and the execution flows within each UC. A version revision of the eDREAM UCs has been presented in the deliverable D2.4, where the sequence diagrams have been introduced. In this version, further updates on UCs description and sequence diagrams have been performed due to inconsistencies during the activities of the technical WPs 3, 4 and 5 and the interconnection plan of WP6. Finally, based on outcomes of D2.5, the relationship among UCs and architectural components is identified and reported in *Table 5*.

Table 5 List of identified architectural components and the related UCs

Component	Related Task	Responsible partner	Contributing partners	HL-UC01 Related UCs	HL-UC02 Related UCs	HL-UC03 Related UCs
Electricity Consumption/Production Forecasting	T3.1	TUC & CERTH	TU, ENG	LL-UC01 LL-UC02 LL-UC04 LL-UC05	LL-UC02	LL-UC01 LL-UC02 LL-UC03
PV/RES Degradation & Trend Analysis	T4.1	TU & CERTH	ENG, SVT	LL-UC04		LL-UC02
Baseline Flexibility Estimation	T3.2	TU	TUC, E@W, EMOT	LL-UC01 LL-UC02 LL-UC03 LL-UC04 LL-UC05		LL-UC02
Virtual Power Plants Generation Modeling & Forecasting	T3.3	TUC	EMOT, ENG, ASM			LL-UC02 LL-UC03
Multi-building DR characterization through thermal, optical and LIDAR information fusion	T3.4	TU & CERTH	KIWI	LL-UC03		
Load Profiling	T4.2	ATOS & CERTH	E@W, KIWI, ASM			LL-UC01

Big Data Clustering at Multiple Scales	T4.2	ATOS & CERTH	E@W, KIWI, ASM	LL-UC06		LL-UC01
Customer Segmentation	T4.2	ATOS & CERTH	E@W, KIWI, ASM			LL-UC01
VPP and DR Services Optimization engine	T4.1	TU & CERTH	ENG, SVT	LL-UC01		LL-UC02 LL-UC03
Distributed Ledger	T5.1	ENG	TUC, E@W, ASM	LL-UC02 LL-UC06 LL-UC08	LL-UC01 LL-UC02 LL-UC03 LL-UC04	
Blockchain-driven control for LV networks	T5.2	TUC	ENG, EMOT, ASM	LL-UC02 LL-UC05 LL-UC06 LL-UC07 LL-UC08		
Secured Blockchain-driven Energy Market	T5.2	TUC	ENG, EMOT, ASM		LL-UC01 LL-UC02 LL-UC03 LL-UC04	
Closed loop DR Verification Engine	T5.3	ENG	TUC, E@W, ASM	LL-UC06 LL-UC08	LL-UC01 LL-UC04	
Graph-based Analytics	T4.3 & T4.4	CERTH	TU, ATOS, E@W, KIWI, ASM			LL-UC01
HMIs	T4.3, T4.4	CERTH	ATOS, TU, E@W, ENG, KIWI, ASM, EMOT	LL-UC02 LL-UC08	LL-UC01 LL-UC02 LL-UC04	
DSS (Decision Support System) & DR Strategies Optimization	T4.1, T4.3, T4.4	TU & CERTH	TU, E@W, ENG, SVT, EMOT	LL-UC01 LL-UC05 LL-UC06 LL-UC07		LL-UC02 LL-UC03
DR Aerial Survey Toolkit	T3.4	TU & CERTH	KIWI,	LL-UC03		
Forecasting Tool	T3.1	TUC & CERTH	TU, ENG,	LL-UC04		

2

4.1 High Level UC 01: Prosumers DR flexibility aggregation via smart contract

The defined UC involves DSOs, aggregators and prosumers. Its main objective is to establish a mechanism for aggregating flexibility and detecting in near real time the amount of flexibility actually provided by each prosumer.

The aggregation of the flexibility potential provided by multiple prosumers and the management of the individual deviations will avoid grid level congestion points, solving potential grid issues. To do so, prosumers are enrolled with aggregators, who knows their flexibility availability through current and forecasted data from power production and load demands.

When the DSO identifies day-ahead or intraday potential issues on the grid (e.g. congestion and reverse flow), a flexibility request is sent to the aggregator through the marketplace. Thanks to a preliminary assessment of his customers portfolio, the aggregator is able to evaluate or keep updated the general flexibility capacity of his prosumers through novel techniques and technologies. Based on the received flexibility request, the aggregator inquires its enrolled prosumers to identify the subset which may deliver the expected flexibility, creating an offer on the marketplace. The consolidated flexibility request curves are being injected into the prosumers self-enforcing smart contracts by the aggregator, then the deviation among the prosumer actual energy consumption and the expected profile for the DR event is measured. In case of significant deviations, other prosumers (from the enrolled ones) will be identified, to provide the missing amount of flexibility. The deviating prosumers (if any) will be penalized while the prosumers operating as expected will be rewarded through incentives.

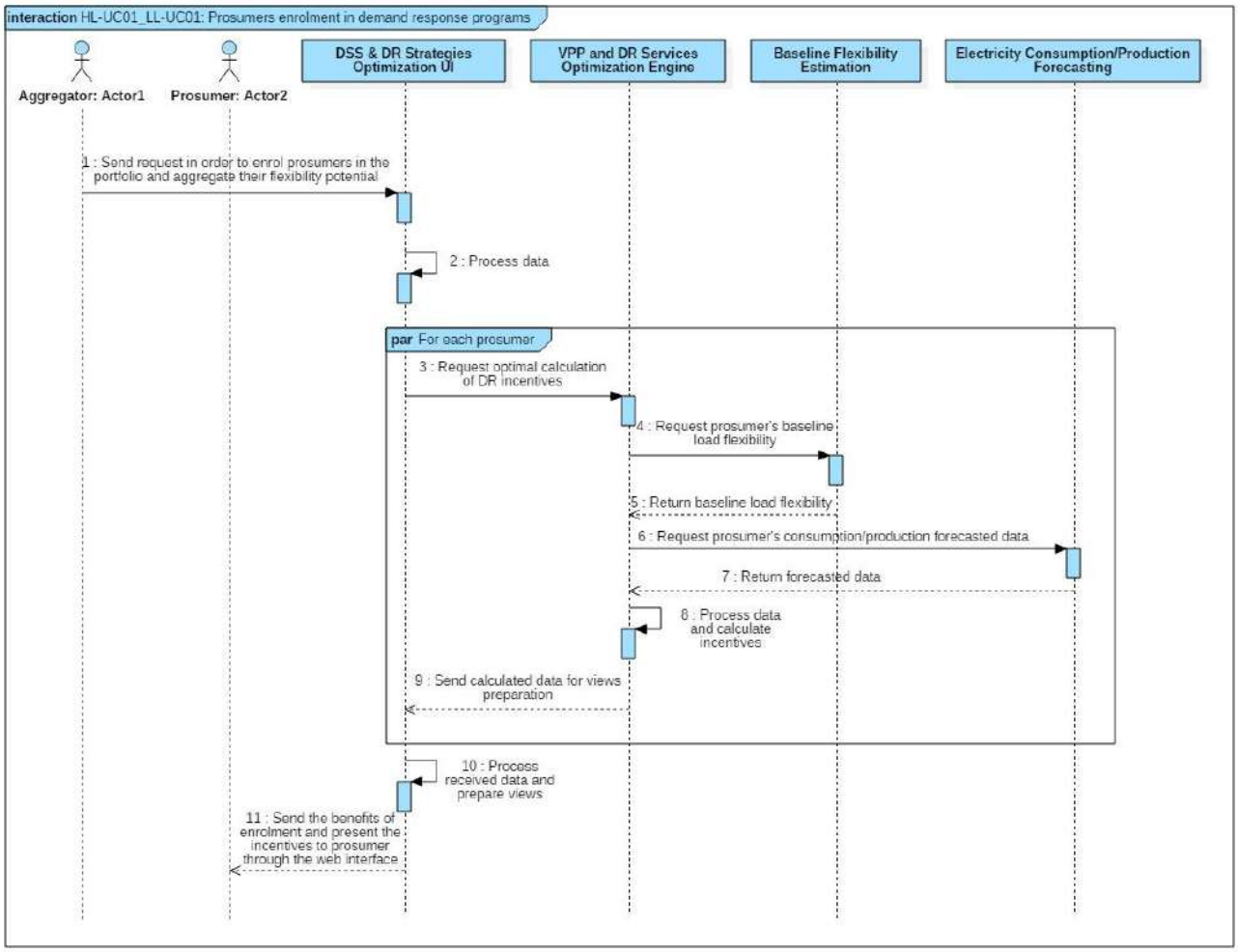
4.1.1 HL-UC01_LL-UC01: Prosumers enrolment in demand response programs

Table 6 HL-UC01_LL-UC01: Prosumers enrolment in demand response programs

Generic Description	
UC Name	**HL-UC01_LL-UC01: Prosumers enrolment in demand response programs**
Version	V0.5
Authors	E@W, TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator negotiate with his/her customers (prosumers) showing the benefits through interactive multi-purpose visualization tool for user interaction. A first step towards the aggregation of flexibility on the Aggregator's side is to inform properly his/her prosumers about the benefits of enrolment in

	demand response programs. Through interactive visualization interface, potential incentives are sent to prosumers. These incentives are formulated mainly taking into account the "Customer Baseline Load (CBL)" through the component of Baseline Flexibility Estimation and forecasted data about consumption and production.
Assumptions and Pre-Conditions	A web interface is available for the Aggregator. The interconnection of the necessary components has been established, thus the decision support system can have access to prosumer's baseline load data.
Goal (Successful End Condition)	Establish a mechanism for enrolling prosumers and make available their flexibility.
Post-Conditions	Prosumers are enrolled.
Involved Actors	Aggregator, Prosumers
UC Initiation	The aggregator needs to enrol prosumers for flexibility availability.
Main Flow	Begin 1. The aggregator sends request via the interactive visualization framework, in order to obtain the optimal DR incentives that should be sent to prosumers. 2. The DSS (Decision Support System) & DR Strategies Optimization UI receives the request and processes the settings/preferences. 3. The DSS (Decision Support System) & DR Strategies Optimization UI component requests the optimal calculation of DR incentives from the component VPP and DR Services Optimization Engine. 4. The VPP and DR Services Optimization Engine requests the baseline load flexibility for each prosumer. 5. The Baseline Flexibility Estimation returns the requested data. 6. The VPP and DR Services Optimization Engine requests consumption/production forecasted data for each prosumer. 7. The Electricity Consumption/Production Forecasting returns the requested data. 8. The VPP and DR Services Optimization Engine processes the received data and calculates the incentives.

	9. The VPP and DR Services Optimization Engine sends the calculated data to DSS (Decision Support System) & DR Strategies Optimization UI for views preparation. 10. The DSS (Decision Support System) & DR Strategies Optimization UI processes the received data and prepare views. 11. The aggregator, though the web interface of DSS (Decision Support System) & DR Strategies Optimization, sends the incentives to prosumer.
Alternative Courses	-
Relationships with other UCs	HL-UC01_LL-UC02, HL-UC01_LL-UC03
Architectural Elements / Services Involved	DSS (Decision Support System) & DR Strategies Optimization UI (Graph-based Analytics considered); VPP and DR Service Optimization Engine; Baseline Flexibility Estimation; Electricity Consumption/Production Forecasting;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 & WP4 T3.1, T3.2, T4.1, T4.3 & T4.4 CERTH, TU, ATOS, TUC, E@W & EMOT
Notes (Optional)	-
UML Sequence Diagram	



4.1.2 HL-UC01_LL-UC02: Contract Setting

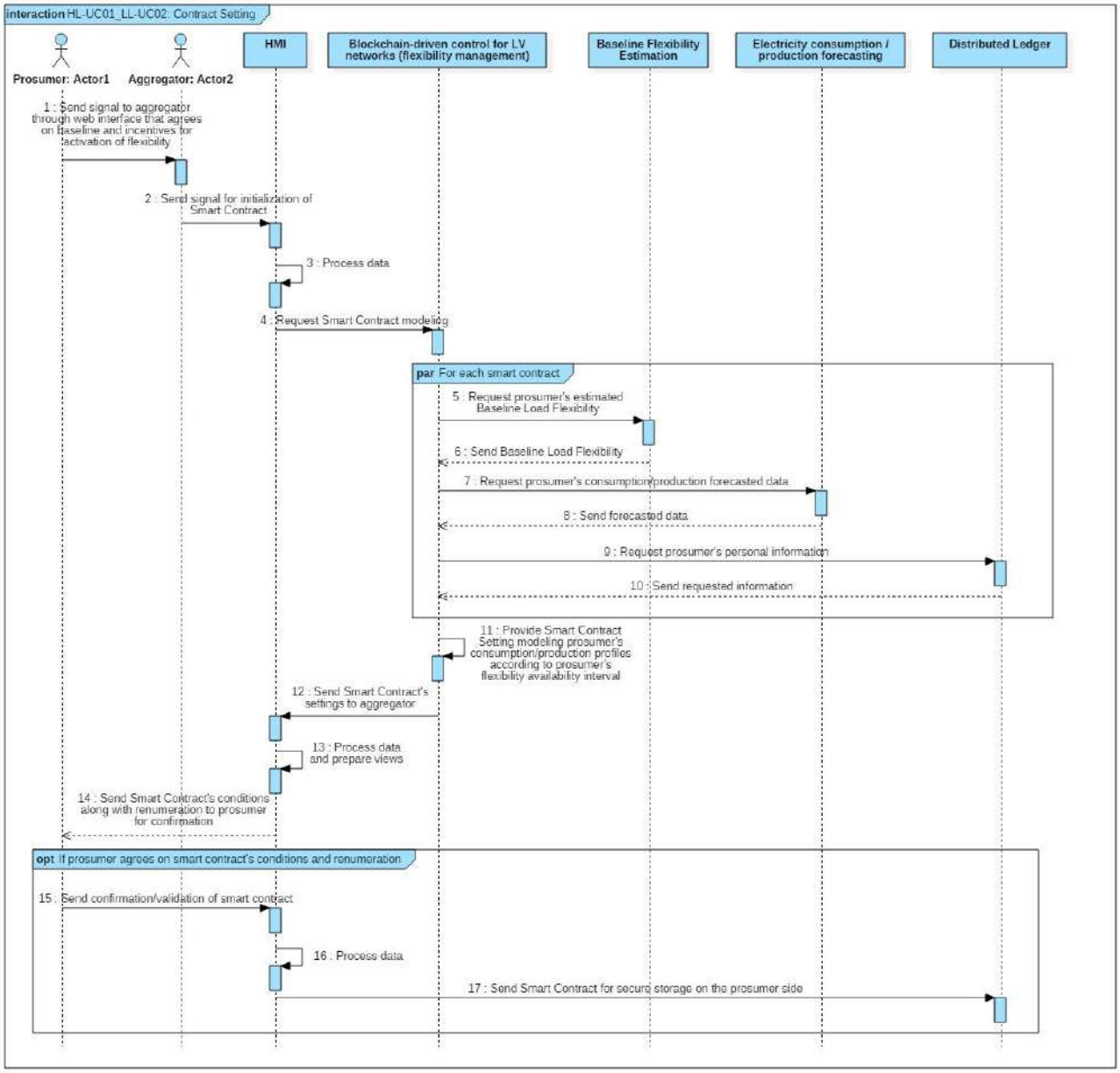
Table 7 HL-UC01_LL-UC02: Contract Setting

Generic Description	
UC Name	**HL-UC01_LL-UC02: Contract Setting**
Version	V0.5
Authors	E@W, TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7

Brief Description	Aggregator and prosumers agree on baseline and incentives for activation of flexibility through the initialization of self-enforcing smart contract in which the prosumers provide their energy flexibility availability interval. The self-enforcing smart contract is defined as a distributed mean of transaction and specifies the contracted baseline energy consumption or production levels (curves).
Assumptions and Pre-Conditions	A web interface should be available for the prosumer. The smart metering energy devices can properly communicate with the eDREAM platform The smart contract can be stored in a secured way on the prosumer's side.
Goal (Successful End Condition)	The aim of this UC is the setting of transactions' conditions between the aggregator and prosumers.
Post-Conditions	Prosumers activate their flexibility availability interval in case of request.
Involved Actors	Aggregator, Prosumers
UC Initiation	Aggregator and prosumers agree on baseline and incentives for flexibility activation.
Main Flow	Begin 1. The prosumer agrees on baseline and incentives and sends signal to aggregator through web interface. 2. The aggregator sends signal for initialization of smart contract through the HMI. 3. The HMI receives the aggregator's request and processes the input data. 4. The HMI sends the request to the component Blockchain-driven control for LV networks (flexibility management), in order to perform calculations for smart contract modelling. 5. The Blockchain-driven control for LV networks requests prosumer's estimated baseline load flexibility from the component Baseline Flexibility Estimation. 6. The Baseline Flexibility Estimation sends the requested data. 7. The Blockchain-driven control for LV networks requests prosumer's consumption/production forecasted data from the component Electricity Consumption/Production Forecasting.

	8. The Electricity Consumption/Production Forecasting returns the requested data. 9. The Blockchain-driven control for LV networks requests prosumer's personal information from the Distributed Ledger. 10. The Distributed Ledger returns the requested information. 11. The component Blockchain-driven control for LV networks sets the conditions for smart contract modelling. 12. The Blockchain-driven control sends the modelled smart contract to aggregator through the HMI. 13. The HMI processes the received data and prepare views for the aggregator. 14. The aggregator sends the smart contract's conditions along with the remuneration to prosumer for confirmation through web interface of the HMI. 15. The prosumer sends the confirmation/validation of smart contract to aggregator's HMI through web interface. 16. The HMI receives and processes the input data. 17. The HMI sends smart contract for secure storage on the prosumer side.
Alternative Courses	Some prosumers do not agree on baseline and incentives for activation of flexibility (initialization of Smart Contract).
Relationships with other UCs	HL-UC01_LL-UC01
Architectural Elements / Services Involved	HMI; Blockchain-driven control for LV networks; Baseline Flexibility Estimation; Electricity consumption/production forecasting; Distributed Ledger;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3, WP4 & WP5 T3.1, T3.2, T4.3, T5.1 & T5.2 TUC, ENG, E@W, CERTH, TU, ATOS
Notes (Optional)	-

UML Sequence Diagram



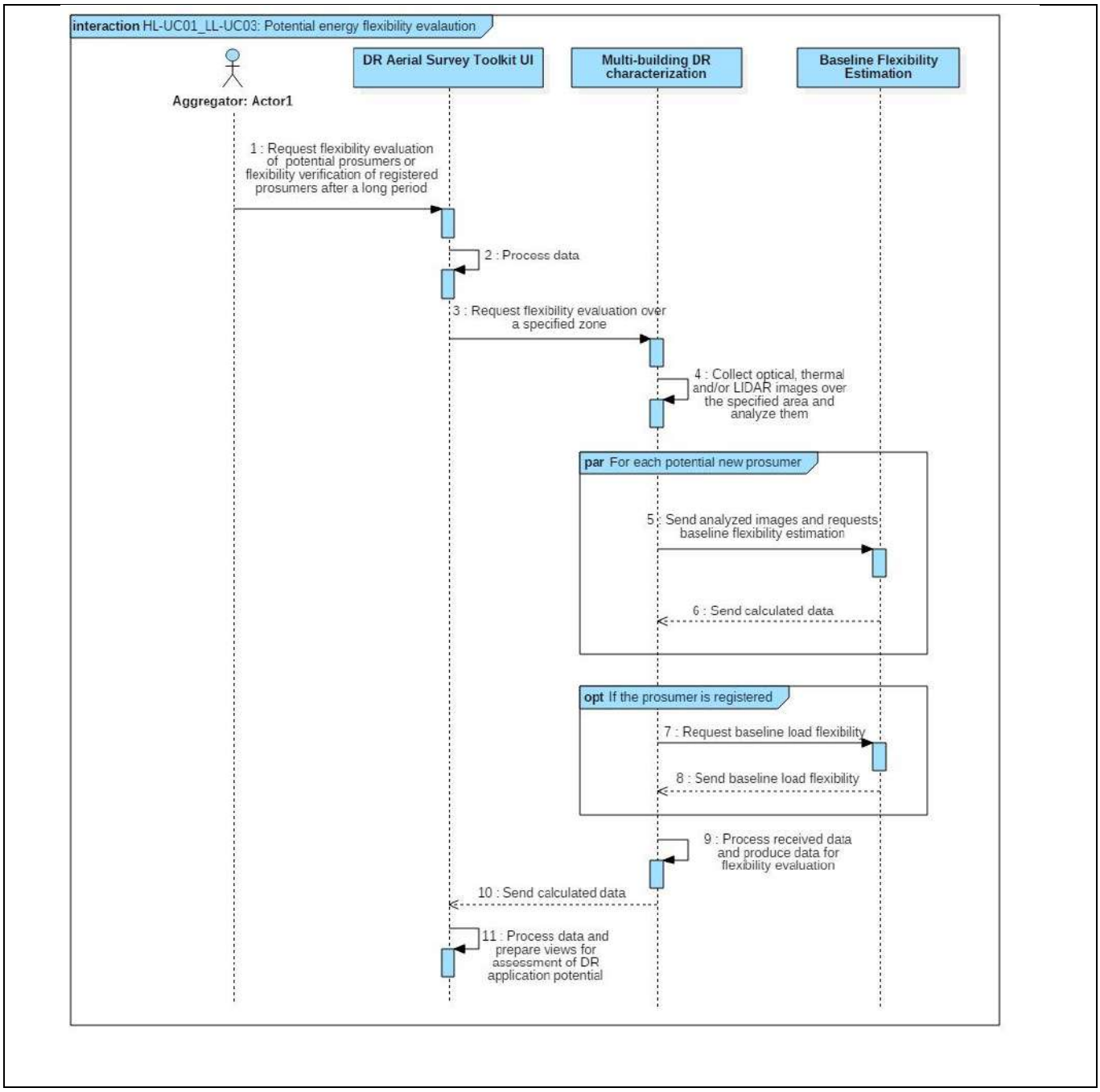
4.1.3 HL-UC01_LL-UC03: Potential energy flexibility evaluation

Table 8 HL-UC01_LL-UC03: Potential energy flexibility evaluation

Generic Description	
UC Name	**HL-UC01_LL-UC03: Potential energy flexibility evaluation**
Version	V0.5
Authors	ENG, TUC, E@W

Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator evaluates the potential energy flexibility guaranteed by prosumers using drones for aerial surveying with optical and thermal imaging and laser scanning to assess the application of Demand Response in a specific zone.
Assumptions and Pre-Conditions	A web interface should be available for the aggregator. The drone should be properly equipped with optical, thermal and laser cameras. The DR Aerial Survey Toolkit interface should communicate in an appropriate way with the eDREAM platform.
Goal (Successful End Condition)	The aim of this UC is to obtain an energy consumption and production baseline flexibility estimation of potential prosumers or already registered prosumers after a long period.
Post-Conditions	The aggregator identifies new qualified prosumers. Concerning the registered prosumers, the aggregator receives a quick estimation of their flexibility after a long period of time.
Involved Actors	Aggregator, Prosumers
UC Initiation	The aggregator sends request for flexibility evaluation.
Main Flow	Begin 1. The aggregator requests flexibility evaluation of potential prosumers or flexibility verification of registered prosumers (after a long period) through the UI of the DR Aerial Survey Toolkit. 2. The DR Aerial Survey Toolkit UI receives the request and processes the input data. 3. The DR Aerial Survey UI requests flexibility evaluation over a specified area of building assets from the component Multi-building DR characterization. 4. The component Multi-building DR characterization collects optical, thermal and/or LIDAR images over the specified area and analyses them.

	5. The Multi-building DR characterization sends the analysed images to Baseline Flexibility Estimation and requests baseline flexibility estimation for each potential new prosumer. 6. The Baseline Flexibility Estimation returns the requested data. 7. In case of registered prosumer, the Multi-building DR characterization requests the prosumer's baseline load flexibility. 8. The Baseline Flexibility Estimation returns the requested data. 9. The Multi-building DR characterization processed the received data and produces data for flexibility evaluation. 10. The Multi-building DR characterization sends the calculated data to DR Aerial Survey Toolkit. 11. The DR Aerial Survey UI processes the received data, prepare view for assessment of DR application potential and present them to aggregator.
Alternative Courses	Other methods are used for the identification of new prosumers. The flexibility evaluation of registered prosumers is only performed through metering devices and suitable calculations.
Relationships with other UCs	HL-UC01_LL-UC01
Architectural Elements / Services Involved	DR Aerial Survey Toolkit UI; Multi-building DR characterization through thermal, optical and LIDAR information fusion; Baseline Flexibility Estimation;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 T3.2 & T3.4 TU, CERTH, KIWI, E@W, TUC
Notes (Optional)	-
UML Sequence Diagram	



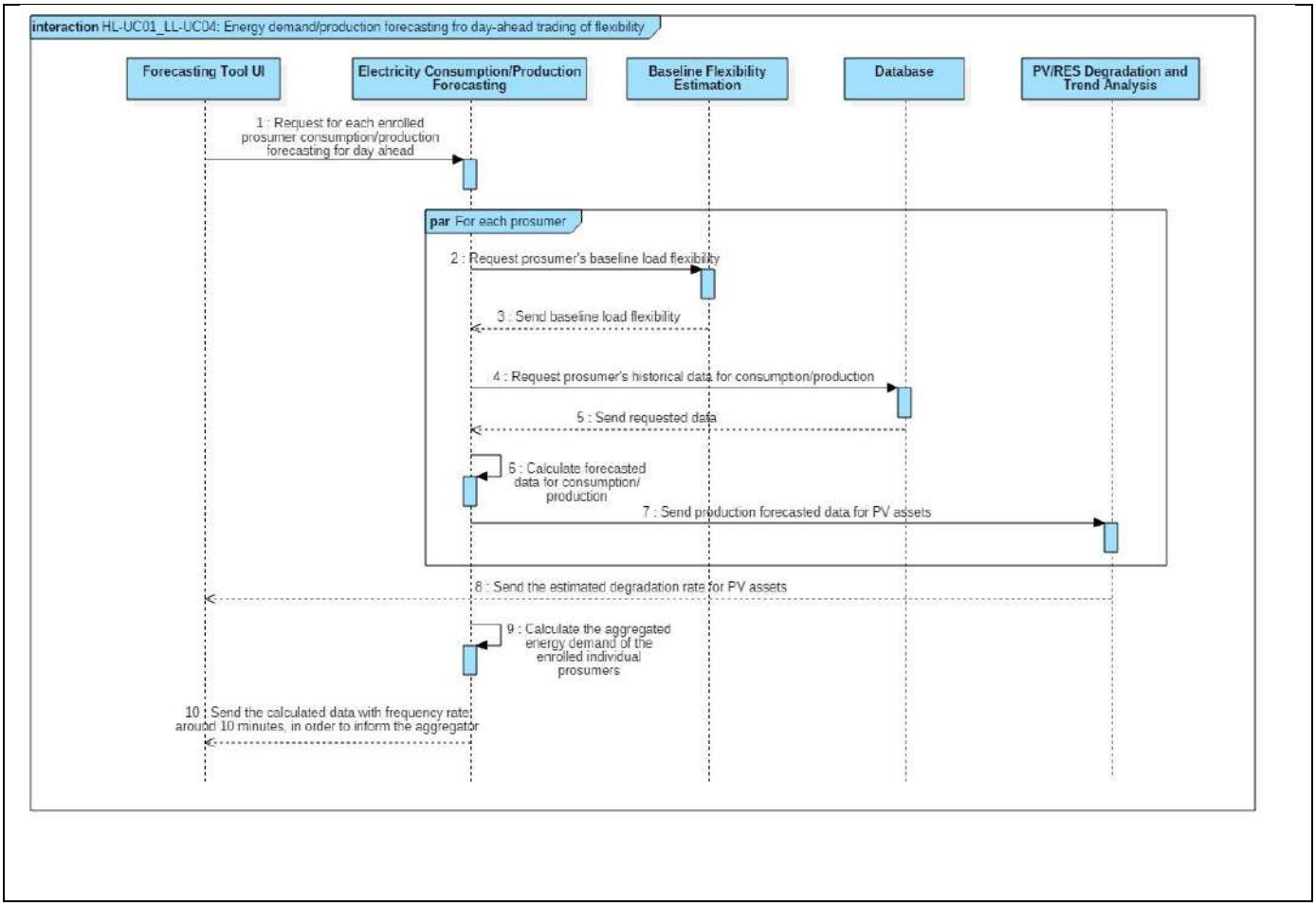
4.1.4 HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility

Table 9 HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility

Generic Description	
UC Name	**HL-UC01_LL-UC04: Energy demand/production forecasting for day-ahead trading of flexibility**
Version	V0.5

Authors	ENG, TUC, E@W
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator receives from each prosumer enrolled the individual energy demand/production values for the next day. Then he/she creates and sends a forecast of the aggregated energy demand of all individual customers to the DSO, who uses it to forecast future congestion points. Forecasting tools have to provide the next-days prediction at different granularity (prosumer, aggregator, DSO). The HMI has to show these values with frequency rate around 10 minutes (5 min or one hour are also possible sample rates).
Assumptions and Pre-Conditions	Prosumers are enrolled with the aggregator. Prosumer's historical data about consumption/production are available.
Goal (Successful End Condition)	The aim of this UC is to obtain forecasted values for production/consumption at individual prosumer level.
Post-Conditions	The Aggregator can inform the DSO about the total forecasted energy demand of all the registered prosumers.
Involved Actors	Aggregator, Prosumers, DSO
UC Initiation	The UC is automatically initiated as Forecasting Tool UI have to present consumption/production forecasting with frequency rate around 10 minutes.
Main Flow	Begin 1. The Forecasting Tool UI requests for each prosumer enrolled consumption/production forecasted data for day ahead with a frequency rate around 10 minutes from the component Electricity Consumption/Production Forecasting. 2. The component Electricity Consumption/Production Forecasting requests prosumer's baseline load flexibility from the component Baseline Flexibility Estimation. 3. The Baseline Flexibility Estimation returns the requested data. 4. The Electricity Consumption/Production Forecasting requests prosumer's historical data for consumption/production from the Database. 5. The Database returns the requested data.

	6. The Electricity Consumption/Production Forecasting calculates consumption/production forecasted data for each prosumer. 7. The Electricity Consumption/Production Forecasting sends production forecasted data for PV assets to PV Degradation and Trend Analysis. 8. The PV Degradation and Trend Analysis sends the estimated degradation rate for PV assets to the Forecasting tool UI. 9. The Electricity Consumption/Production Forecasting calculates the aggregated energy demand of the enrolled individual prosumers. 10. The Electricity Consumption/Production Forecasting sends the calculated data with frequency rate around 10 minutes, in order to inform the aggregator.
Alternative Courses	-
Relationships with other UCs	HL-UC01_LL-UC05
Architectural Elements / Services Involved	Forecasting Tool UI; Electricity Consumption/Production Forecasting; Baseline Flexibility Estimation; Decentralized Repository; PV/RES Degradation and Trend Analysis;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 & WP4 T3.1, T3.2 & T4.1 TUC, TU, E@W, CERTH, ENG
Notes (Optional)	-
UML Sequence Diagram	



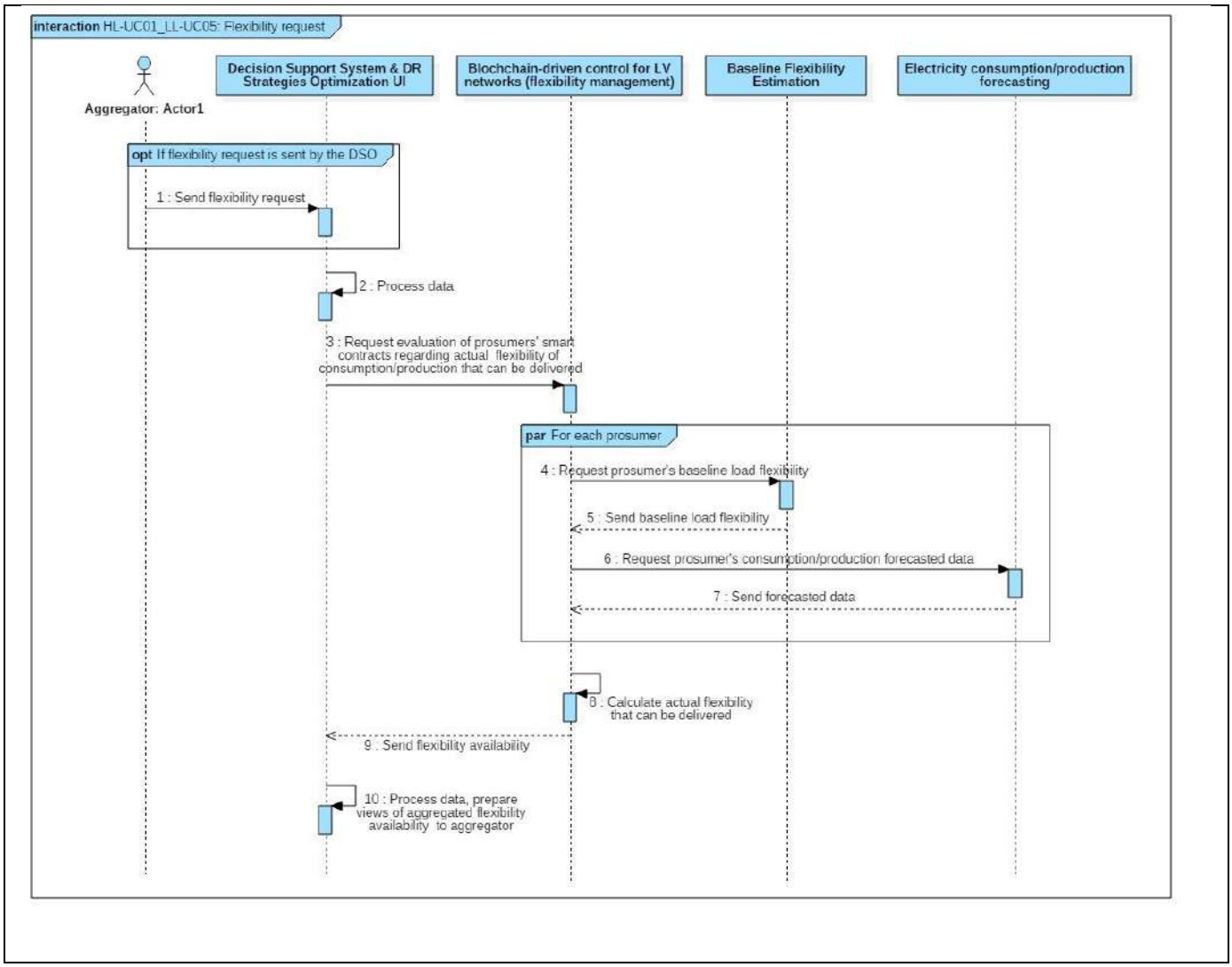
4.1.5 HL-UC01_LL-UC05: Flexibility request

Table 10 HL-UC01_LL-UC05: Flexibility request

Generic Description	
UC Name	**HL-UC01_LL-UC05: Flexibility request**
Version	V0.5
Authors	E@W, TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	DSO creates a forecast of the total load on the critical branches of the network (i.e. parts of the grid for which a congestion is expected) and in case congestion is forecasted, he/she sends a flex request to a Flexibility Marketplace (only between DSO and Aggregators) with associated incentives

	(intraday: step is repeated). Then, the Aggregator requests the flexibility availability of the registered prosumers.
Assumptions and Pre-Conditions	Congestion point/s has/have been forecasted by the DSO. The Aggregator is properly informed by the DSO. The Aggregator's UI is connected with eDREAM core platform.
Goal (Successful End Condition)	Through this UC, the Aggregator aims to define the actual aggregated flexibility that can deliver to DSO.
Post-Conditions	Aggregator's total flexibility offer is accepted by the DSO.
Involved Actors	Aggregator, DSO
UC Initiation	The UC is initiated by the Aggregator in case of previous request by the DSO (forecasted congestion point/s).
Main Flow	Begin 1. The aggregator sends flexibility request through the UI of the component Decision Support System & DR Strategies Optimization in case that a previous request have been sent by the DSO. 2. The Decision Support System & DR Strategies Optimization receives and processes the input data. 3. The Decision Support System & DR Strategies Optimization sends request for evaluation of prosumers' flexibility availability to the component Blockchain-driven control for LV networks (flexibility management). 4. The Blockchain-driven control for LV networks requests baseline load flexibility for each registered prosumer. 5. The Baseline Flexibility Estimation returns the requested data. 6. The Blockchain-driven control for LV networks requests prosumer's consumption/production forecasted data from the component Electricity consumption/production forecasting. 7. The Electricity consumption/production forecasting returns the forecasted data. 8. The Blockchain-driven control for LV networks calculates the actual aggregated flexibility that can be delivered.

	9. The Blockchain-driven control for LV networks sends the aggregated flexibility availability to the Decision Support System & DR Strategies Optimization. 10. The Decision Support System & DR Strategies Optimization processes data and prepares views of total flexibility availability to aggregator.
Alternative Courses	DSO applies traditional methods of peak loads reduction.
Relationships with other UCs	HL-UC01_LL-UC04, HL-UC01_LL-UC06
Architectural Elements / Services Involved	Decision Support System & DR Strategies Optimization UI; Blockchain-driven control for LV networks (flexibility management); Baseline Flexibility Estimation; Electricity Consumption/Production Forecasting;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3, WP4 & WP5 T3.1, T3.2, T4.1, T4.3 & T5.2 TUC, TU, E@W, CERTH, ENG, ATOS
Notes (Optional)	-
UML Sequence Diagram	



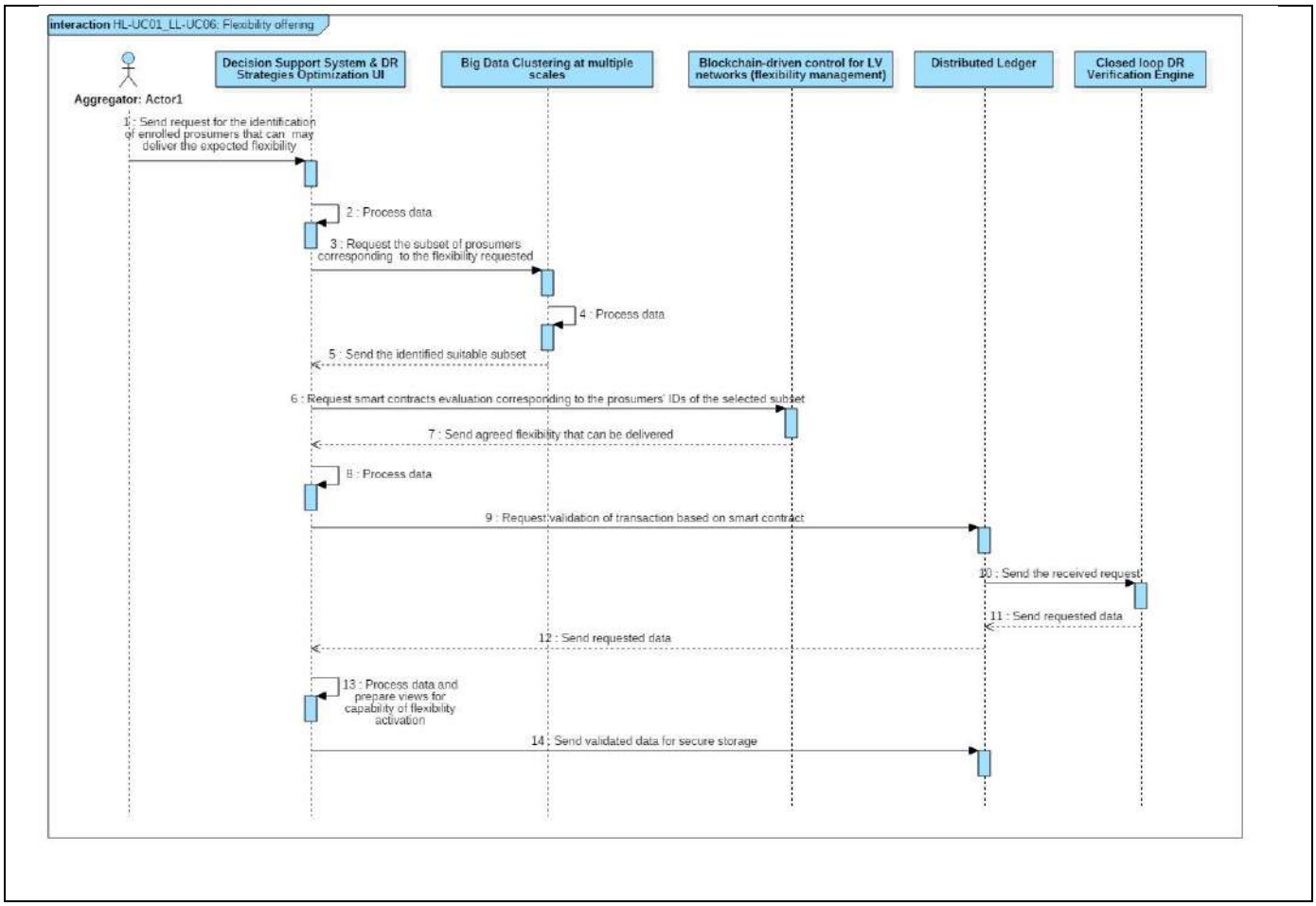
4.1.6 HL-UC01_LL-UC06: Flexibility offering

Table 11 HL-UC01_LL-UC06: Flexibility offering

Generic Description	
UC Name	**HL-UC01_LL-UC06: Flexibility offering**
Version	V0.5
Authors	E@W, TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7

Brief Description	Based on the received flexibility request, the Aggregator inquires its enrolled prosumers to identify the subset which may deliver the expected flexibility.
Assumptions and Pre-Conditions	The Aggregator had received flexibility request by the DSO. The Smart Contracts' conditions are available and accessible.
Goal (Successful End Condition)	Through this UC, the Aggregator aims to define the subset of enrolled prosumers that may deliver the expected flexibility.
Post-Conditions	The Aggregator is ready for delivering flexibility in case the DSO sends the flexibility order.
Involved Actors	Aggregator, Prosumers
UC Initiation	The UC is initiated by the Aggregator in order to identify the suitable subset of prosumers for expected flexibility delivery.
Main Flow	Begin 1. The aggregator sends request though the UI of Decision Support System & DR Strategies Optimization for identification of the suitable subset of prosumers. 2. The Decision Support System & DR Strategies Optimization UI receives the request and processes the input data. 3. The Decision Support System & DR Strategies Optimization UI requests the subset of prosumers from the component Big Data Clustering at multiple scales. 4. The Big Data Clustering at multiple scales receives the request and indicates the identified subset. 5. The Big Data Clustering at multiple scale sends the identified subset to the Decision Support System & DR Strategies Optimization UI. 6. The Decision Support System & DR Strategies Optimization UI requests smart contracts evaluation of the prosumers belonging to the identified subsets. 7. The Blockchain-driven control for LV networks returns agreed flexibility that can be delivered. 8. The Decision Support System & DR Strategies Optimization UI processes the received data.

	9. The Decision Support System & DR Strategies Optimization UI sends request for validation of transaction to the Distributed Ledger. 10. The Distributed Ledger sends the received request to the Closed Loop DR Verification Engine. 11. The Closed loop DR Verification Engine returns the requested data to the Distributed Ledger. 12. The Distributed Ledger sends the received data to the Decision Support System & DR Strategies Optimization. 13. The Decision Support System & DR Strategies Optimization UI processes received data and prepares views for capability of flexibility activation to the aggregator. 14. The Decision Support System & DR Strategies Optimization UI sends the validated data for secure storage to the component Distributed Ledger.
Alternative Courses	The identified prosumers do not agree to deliver their flexibility.
Relationships with other UCs	HL-UC01_LL-UC05, HL-UC01_LL-UC07
Architectural Elements / Services Involved	Decision Support System & DR Strategies Optimization UI; Big Data Clustering at multiple scales; Blockchain-driven control for LV networks (flexibility management); Closed loop DR Verification Engine; Distributed Ledger;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP4 & WP5 T4.1, T4.2, T5.1, T5.2 & T5.3 TU, ENG, E@W, TUC, EMOT
Notes (Optional)	-
UML Sequence Diagram	

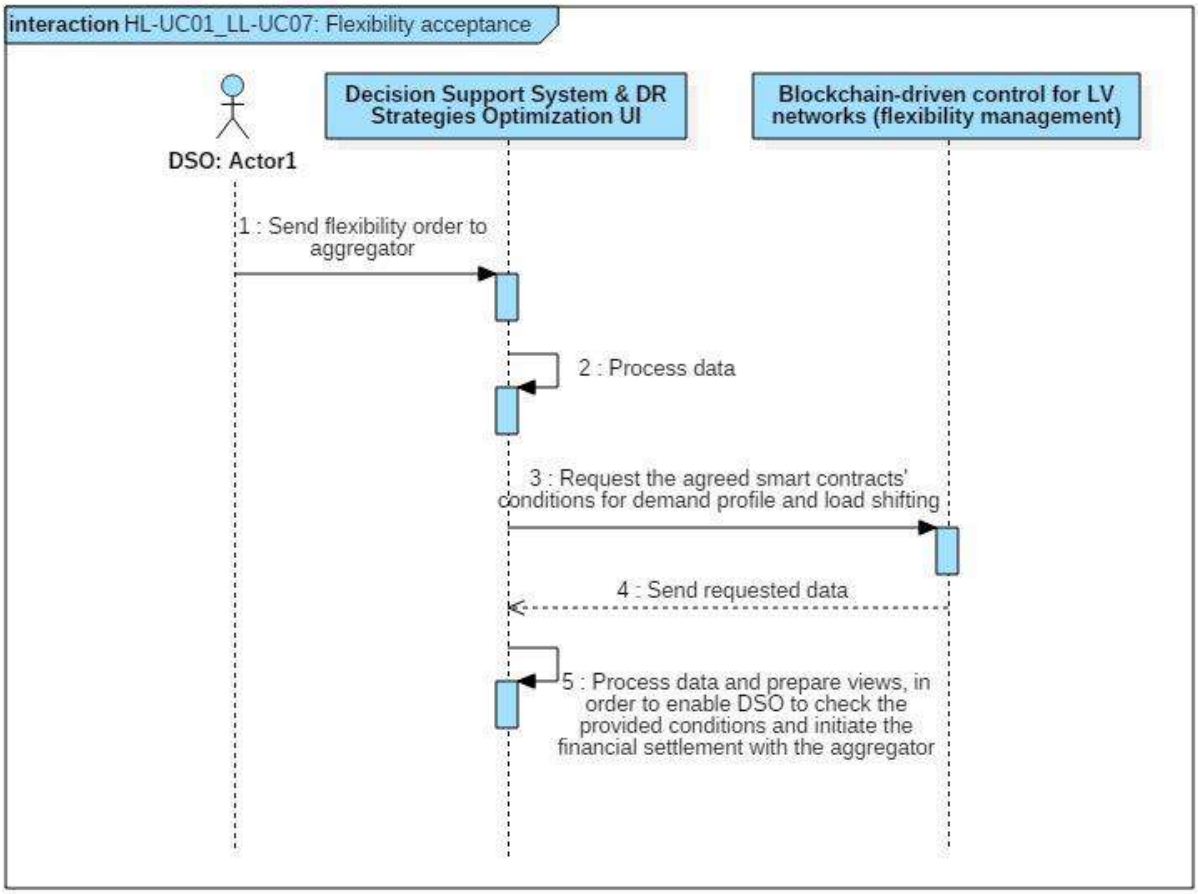


4.1.7 HL-UC01_LL-UC07: Flexibility acceptance

Table 12 HL-UC01_LL-UC07: Flexibility acceptance

Generic Description	
UC Name	**HL-UC01_LL-UC07: Flexibility acceptance**
Version	V0.5
Authors	E@W, TUC, ENG
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	DSO accepts one or multiple flexibility offers and, if so, the DSO sends a flexibility order.
Assumptions and Pre-Conditions	The DSO accepted flexibility offers. Specific flexibility offer/s are selected by the DSO.

Goal (Successful End Condition)	The DSO aims to inform properly the Aggregator that his/her flexibility offer/s are accepted.
Post-Conditions	The Aggregator is ready for initiating the flexibility provisioning.
Involved Actors	DSO, Aggregator
UC Initiation	The Aggregator's flexibility offers are successfully accepted by the DSO.
Main Flow	Begin 1. The DSO sends flexibility order to aggregator through the web interface of the component Decision Support System & DR Strategies Optimization. 2. The Decision Support System & DR Strategies Optimization UI receives the request and processes the preferences. 3. The Decision Support System & DR Strategies Optimization UI requests from the component Blockchain-driven control for LV networks the smart contracts' conditions concerning demand profile and load shifting (that is going to be activated). 4. The Blockchain-driven control for LV networks returns the requested data. 5. The Decision Support System & DR Strategies Optimization UI processes data and prepares views, in order to enable DSO to check the provided conditions.
Alternative Courses	The Aggregator's flexibility offer/s are rejected by the DSO.
Relationships with other UCs	HL-UC01_LL-UC06, HL-UC01_LL-UC08
Architectural Elements / Services Involved	Decision Support System & DR Strategies Optimization UI; Blockchain-driven control for LV networks (flexibility management);
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP4 & WP5 T4.1, T4.3, T4.4 & T5.2 TUC, TU, CERTH, ENG, ATOS, E@W, EMOT
Notes (Optional)	-
UML Sequence Diagram	



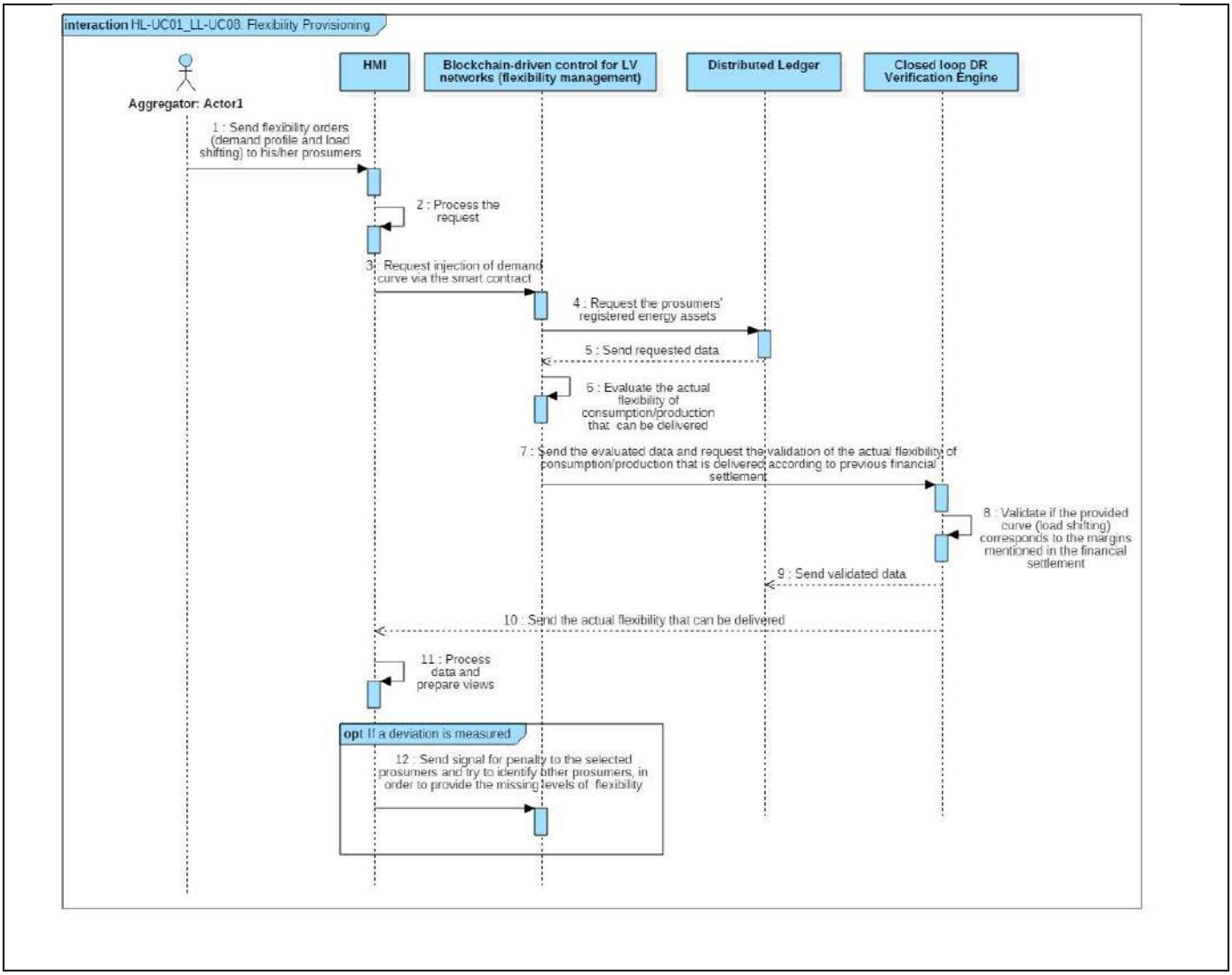
4.1.8 HL-UC01_LL-UC08: Flexibility provisioning

Table 13 HL-UC01_LL-UC08: Flexibility provisioning

Generic Description	
UC Name	**HL-UC01_LL-UC08: Flexibility provisioning**
Version	V0.5
Authors	E@W, TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator sends the flexibility orders to his/her prosumers (injection of demand/supply curve via a smart contract), in order to adjust the load/generation of his/her clients and fulfil the flexibility need. The prosumers, that followed the provided curve by shifting their load, will receive

	payment from the aggregator for the flexibility provision based on their flexibility contract (settlement).
Assumptions and Pre-Conditions	The Aggregator received a flexibility order by the DSO.
Goal (Successful End Condition)	The aim of this UC is to deliver the appropriate agreed flexibility to the DSO.
Post-Conditions	The Aggregator provides the appropriate agreed flexibility to the DSO leveraging on its prosumers.
Involved Actors	Aggregator, Prosumers
UC Initiation	The Aggregator receives a flexibility offer by the DSO.
Main Flow	Begin 1. The Aggregator sends flexibility orders (demand profile and load shifting) to his/her prosumers through the HMI. 2. The HMI receives the request and processes the input preferences. 3. The HMI requests injection of demand curve via the smart contract from the component Blockchain-driven control for LV networks (flexibility management). 4. The Blockchain-driven control for LV networks requests the prosumers' registered energy assets from the component Distributed Ledger. 5. The Distributed Ledger sends the requested data. 6. The Blockchain-driven control for LV networks evaluates the actual flexibility of consumption/production that is delivered. 7. The Blockchain-driven control for LV networks requests the actual flexibility that is delivered from the component Closed loop DR Verification Engine. 8. The Closed loop DR Verification Engine validates if the provided curve corresponds to the margins mentioned in the previous financial settlement. 9. The Closed loop DR Verification Engine returns the validated data to the Distributed Ledger for secure storage. 10. The Closed loop DR Verification Engine sends the actual flexibility that can be delivered to the HMI.

	11. The HMI processes input data and prepare views. 12. If a deviation is measured, the Aggregator though the HMI penalizes the selected prosumers and sends request to the Blockchain-driven control for LV networks, in order to identify other prosumers to provide the missing levels of flexibility.
Alternative Courses	The prosumers do not deliver the ordered amount of flexibility to the aggregator.
Relationships with other UCs	HL-UC01_LL-UC07
Architectural Elements / Services Involved	HMI; Blockchain-driven control for LV networks (flexibility management); Distributed Ledger; Closed loop DR Verification Engine;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP4 & WP5 T4.3, T5.1, T5.2 & T5.3 TUC, ENG, E@W, EMOT
Notes (Optional)	-
UML Sequence Diagram	



4.2 High Level UC 02: Peer-to-peer local energy trading market

In this scenario, the eDREAM project considers a blockchain based mechanism for decentralized energy trading (price-driven) which enables prosumers to buy or sell energy directly by means of peer-to-peer energy transactions. Prosumers that are willing to buy or sell energy should register with the blockchain based energy trading platform.

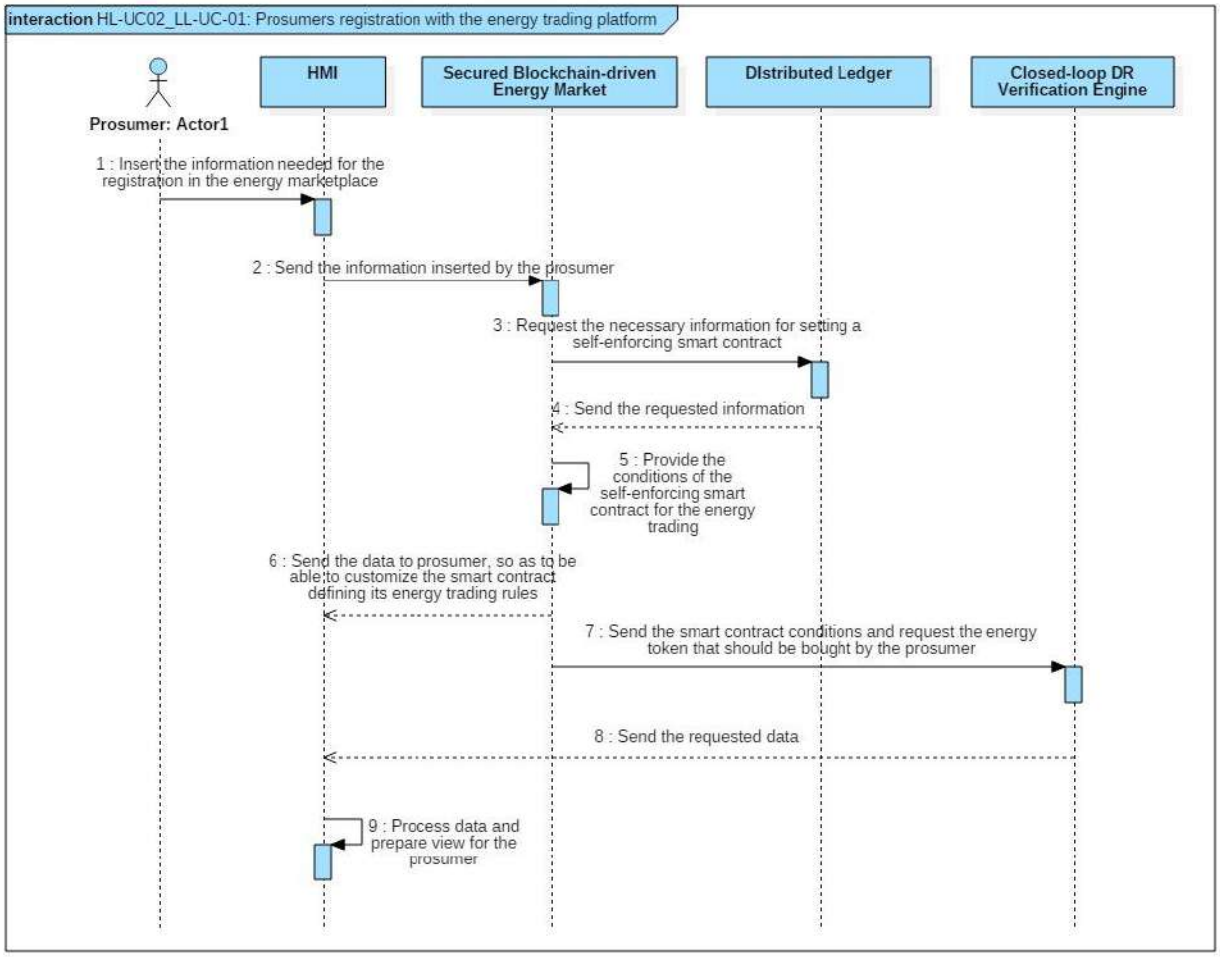
4.2.1 HL-UC02_LL-UC01: Prosumers registration with the energy trading platform

Table 14 HL-UC02_LL-UC01: Prosumers registration with the energy trading platform

Generic Description	
UC Name	**HL-UC02_LL-UC01: Prosumers registration with the energy trading platform**
Version	V0.3
Authors	TUC

Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Prosumers register with the peer to peer energy market providing their information that will be validated through self-enforcing smart contracts. Prosumers must be able to buy energy tokens needed to transact energy, which will be deposited in their wallets and to customize the smart contract for the definition of their energy trading rules.
Assumptions and Pre-Conditions	Data about the prosumer identification and energy demand/production is available. The energy trading platform is operational.
Goal (Successful End Condition)	The aim of this UC is to establish a mechanism for enrolling prosumers with the energy trading market.
Post-Conditions	The prosumer is registered with the energy trading market.
Involved Actors	Prosumers
UC Initiation	Prosumer is willing to trade energy with the blockchain based energy market.
Main Flow	Begin 1. Prosumer uses the web interface of the energy market HMI to provide the information needed for registration in the energy marketplace. 2. The HMI sends the information inserted by the prosumer to the component Secured Blockchain-driven Energy Market. 3. The Secured Blockchain-driven Energy Market requests necessary information for setting a self-enforcing smart contract from the Distributed Ledger. 4. The Distributed Ledger returns the requested data. 5. The Secured Blockchain-driven Energy Market provides the conditions of the self-enforcing smart contract for the energy trading. 6. The Secured Blockchain-driven Energy Market sends the data to prosumer through the HMI, so as to be able to customize the smart contract conditions.

	7. The Secured Blockchain-driven Energy Market sends the smart contract conditions and request the energy token that should be bought by the prosumer from the Closed Loop DR Verification Engine. 8. The Closed Loop DR Verification Engine sends the energy token needed to the HMI, in order to inform the prosumer. 9. The HMI processes the received data and prepare views.
Alternative Courses	Prosumers are not willing to buy or sell energy in a decentralized (blockchain based) market.
Relationships with other UCs	HL-UC02_LL-UC02
Architectural Elements / Services Involved	HMI; Secured Blockchain-driven energy market; Distributed Ledger; Closed loop DR Verification Engine;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP4 & WP5 T4.3, T5.1, T5.2 & T5.3 TUC, ENG, E@W, EMOT
Notes (Optional)	-
UML Sequence Diagram	



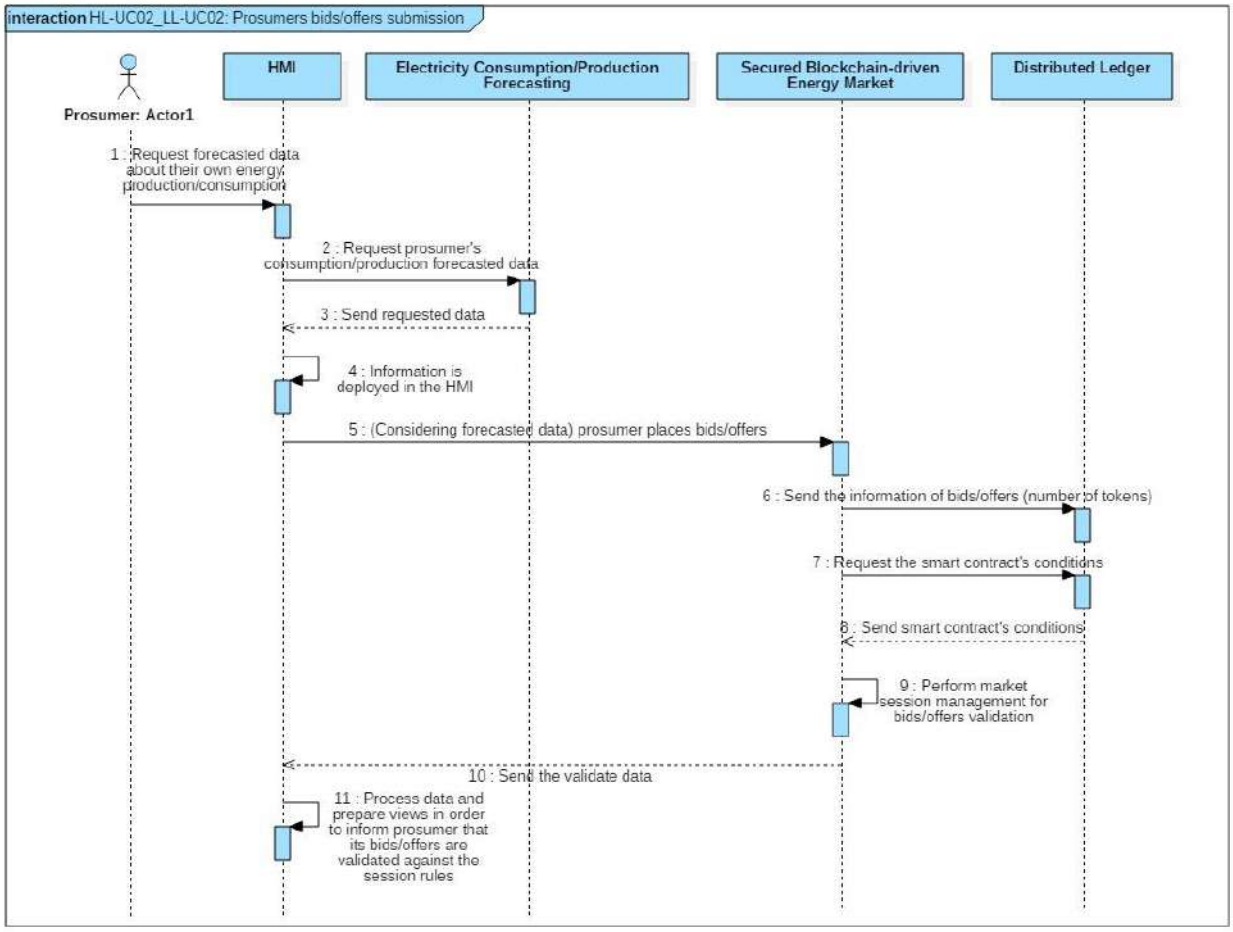
4.2.2 HL-UC02_LL-UC02: Prosumers bids/offers submission

Table 15 HL-UC02_LL-UC02: Prosumers bids/offer submission

Generic Description	
UC Name	**HL-UC02_LL-UC02: Prosumers bids/offer submission**
Version	V0.3
Authors	TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Prosumers submit bids/offers associating the number of tokens equivalent with their amount of energy (e.g. 1 token = 1 Kw). Prosumers use the energy

	demand and generation forecasted data to construct the bids/offers for the next market session.
Assumptions and Pre-Conditions	The prosumer is registered with the energy trading market.
Goal (Successful End Condition)	The aim of this UC is to empower the prosumers to submit their bids/offers of energy.
Post-Conditions	The bids/offers are submitted.
Involved Actors	Prosumers
UC Initiation	The prosumer would like to submit energy bids/offers with the blockchain based energy market.
Main Flow	Begin 1. Prosumer get forecasted data about its own production/consumption through the web interface of the HMI. 2. The HMI requests prosumer's consumption/production forecasted data from the component Electricity Consumption/Production Forecasting. 3. The Electricity Consumption/Production Forecasting returns the requested data. 4. The information is deployed in the HMI. 5. (Considering forecasted data) prosumer places bids/offers in the energy market through the component Secured Blockchain-driven Energy Market. 6. The Secured Blockchain-driven Energy Market sends the information of bids/offers (number of tokens) to the Distributed Ledger. 7. The Secured Blockchain-driven Energy Market requests the smart contract's conditions from the Distributed Ledger. 8. The Distributed Ledger returns the requested data. 9. The Secured Blockchain-driven Energy Market performs market session management actions for bids/offers validation. 10. The Secured Blockchain-driven Energy Market sends the validated data to the HMI.

	11. The HMI processes the received data and prepares views, to inform prosumer about the list of validated bids/offers.
Alternative Courses	-
Relationships with other UCs	HL-UC02_LL-UC01, HL-UC02_LL-UC03
Architectural Elements / Services Involved	HMI; Electricity Consumption/Production Forecasting; Secured Blockchain-driven energy market; Distributed Ledger;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3, WP4 & WP5 T3.1, T4.1, T5.1 & T5.2 TUC, ENG, E@W, EMOT, CERTH, TU
Notes (Optional)	-
UML Sequence Diagram	

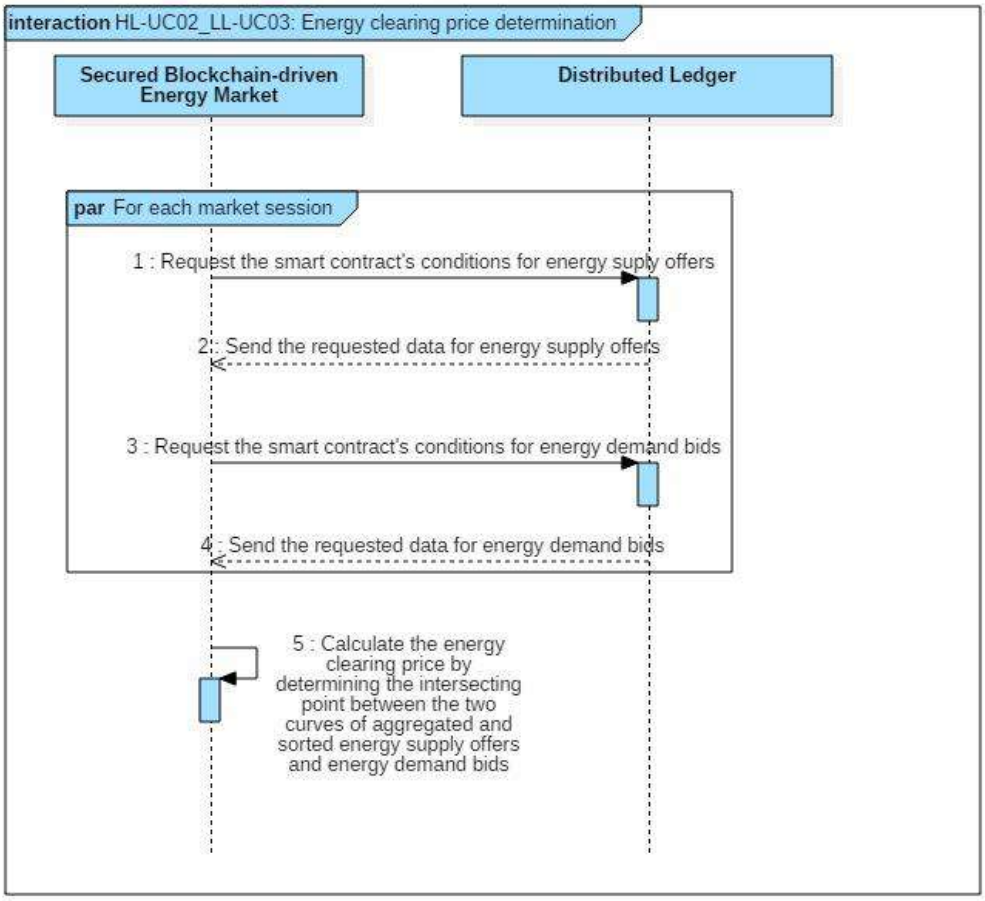


4.2.3 HL-UC02_LL-UC03: Energy clearing price determination

Table 16 HL-UC02_LL-UC03: Energy clearing price determination

Generic Description	
UC Name	**HL-UC02_LL-UC03: Energy clearing price determination**
Version	V0.3
Authors	TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	The energy trading price is determined by intersecting the two curves obtained aggregating and sorting respectively the energy supply offers and energy demand bids.
Assumptions and Pre-Conditions	Market session is opened and bids/offers have been submitted.
Goal (Successful End Condition)	The aim of this UC is to determine the energy trading price per market session.
Post-Conditions	The energy trading price is determined.
Involved Actors	-
UC Initiation	End of market session.
Main Flow	Begin 1. The Secured Blockchain-driven Energy Market requests the smart contract's conditions for energy supply offers (for each market session) from the component Distributed Ledger. 2. The Distributed Ledger returns the requested data. 3. The Secured Blockchain-driven Energy Market requests the smart contract's conditions for energy demand bids (for each market session) from the component Distributed Ledger. 4. The Distributed Ledger returns the requested data. – (Steps 1 & 2 are executed in parallel with the steps 3 &4).

	5. The Secured Blockchain-driven Energy Market calculates the energy clearing price by determining the intersection point between the two curves (energy supply offers in ascending order and energy demand bids in descending order).
Alternative Courses	Other greedy algorithms for clearing price calculations can be used (i.e. graph based).
Relationships with other UCs	HL-UC02_LL-UC02, HL-UC02_LL-UC04
Architectural Elements / Services Involved	Secured Blockchain-driven energy market; Distributed Ledger;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP5 T5.1 & T5.2 TUC, ENG, E@W, EMOT, CERTH, TU
Notes (Optional)	-
UML Sequence Diagram	

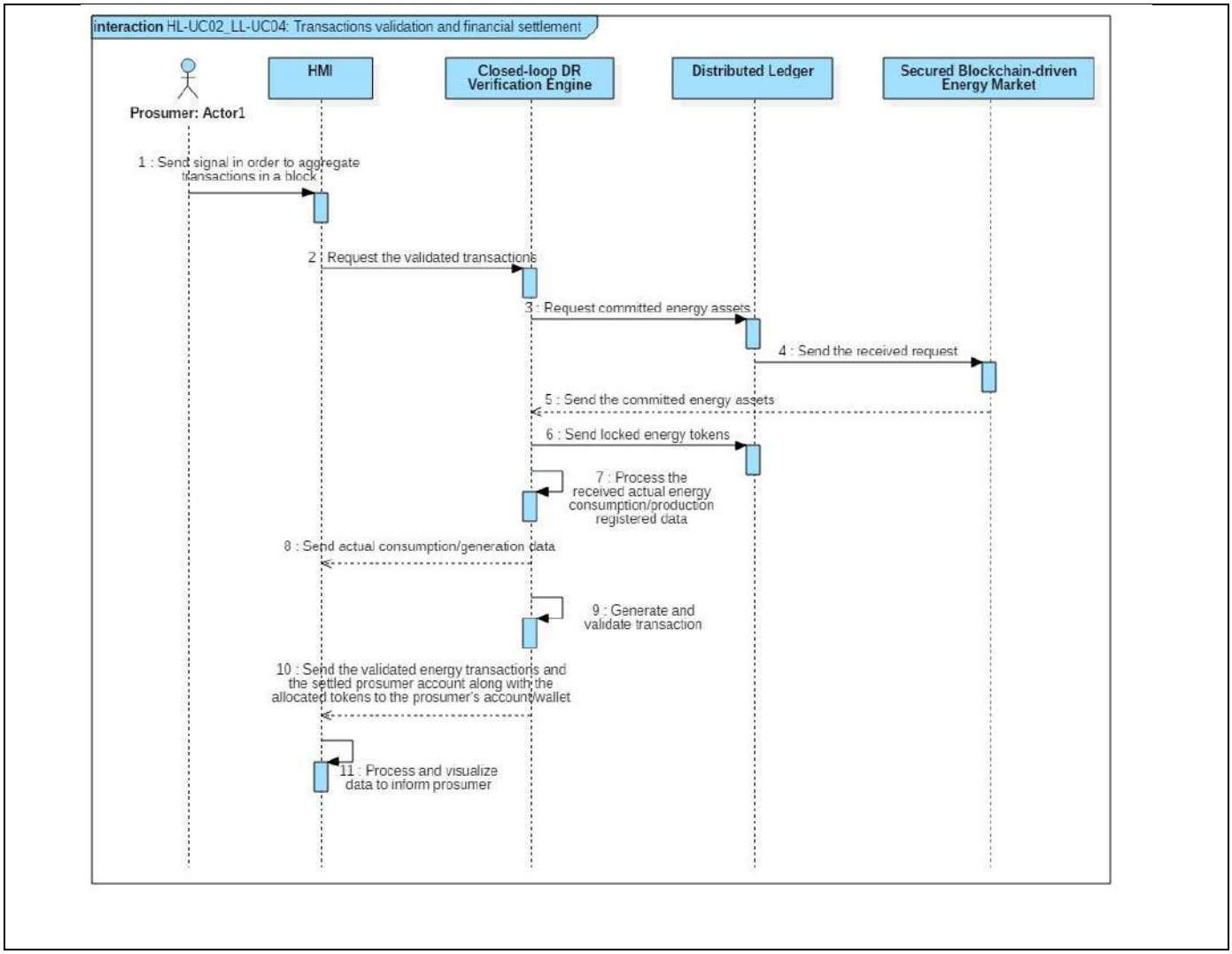


4.2.4 HL-UC02_LL-UC04: Transactions validation and financial settlement

Table 17 HL-UC02_LL-UC04: Transactions validation and financial settlement

Generic Description	
UC Name	**HL-UC02_LL-UC04: Transactions validation and financial settlement**
Version	V0.3
Authors	TUC
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	The energy transactions are validated and the prosumer accounts settled allocating tokens to the prosumers accounts/wallets.
Assumptions and Pre-Conditions	Market session is ended.
Goal (Successful End Condition)	The aim of this UC is to allocate tokens to the prosumers' accounts/wallets.
Post-Conditions	Tokens are allocated to prosumers.
Involved Actors	Prosumers
UC Initiation	After the end of market session, 1 prosumer is selected as block miner.
Main Flow	Begin 1. The prosumer requests for validation of the energy transactions through the web interface of the HMI. 2. The HMI requests the validated transactions from the component Closed-loop DR Verification Engine. 3. The Closed-loop DR Verification Engine requests the committed energy assets from the component Distributed Ledger. 4. The Distributed Ledger sends the received request to the Secured Blockchain-driven Energy Market. 5. The Secured Blockchain-driven Energy Market sends the committed energy assets to the Closed-loop DR Verification Engine.

	6. The Closed-loop DR Verification Engine sends the locked energy tokens to the Distributed Ledger. 7. The Closed-loop DR Verification Engine processes the received actual energy consumption/production data. 8. The Closed-loop DR Verification Engine sends the actual consumption/generation data to the HMI. 9. The Closed-loop DR Verification Engine generates and validates transaction. 10. The Closed-loop DR Verification Engine sends the validated energy transactions and the settled prosumer's account to the HMI. 11. The HMI processes and visualizes the received data, in order to inform prosumer.
Alternative Courses	-
Relationships with other UCs	HL-UC02_LL-UC02, HL-UC02_LL-UC03
Architectural Elements / Services Involved	HMI; Closed-loop DR Verification Engine; Secured Blockchain-driven energy market; Distributed Ledger;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP4 & WP5 T4.3, T5.1, T5.2 & T5.3 TUC, ENG, E@W, EMOT,
Notes (Optional)	-
UML Sequence Diagram	



4.3 High Level UC: VPP in Energy Community

This scenario is considering the increasing need to optimize output from multiple local generation assets (e.g. wind-turbines, small hydro, photovoltaic and back-up generators) that serve primarily local communities and also have export connections at power distribution network.

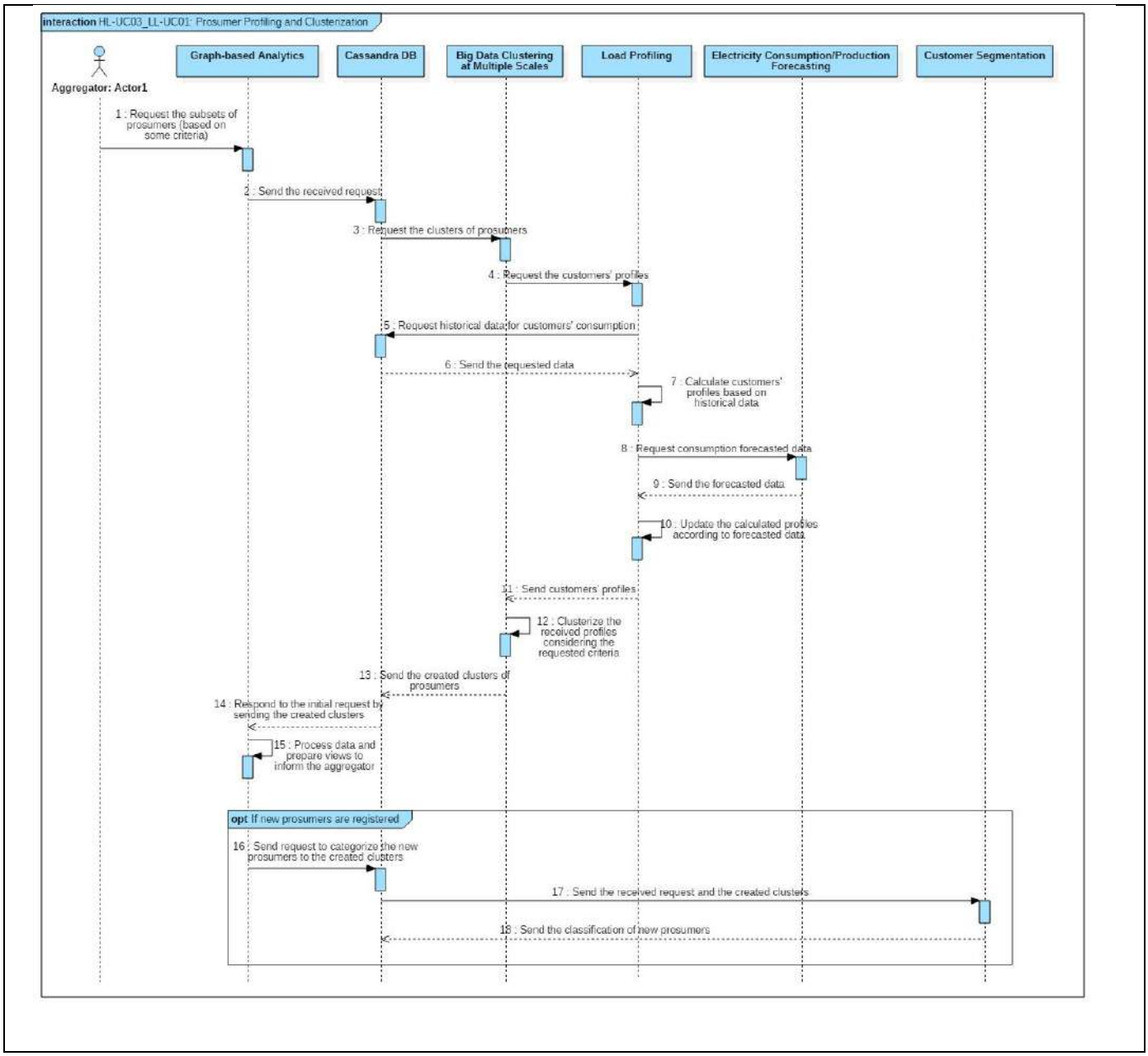
4.3.1 HL-UC03_LL-UC01: Prosumers Profiling and Clusterization

Table 18 HL-UC03_LL-UC01: Prosumers Profiling and Clusterization

Generic Description	
UC Name	**HL-UC03_LL-UC01: Prosumers Profiling and Clusterization**
Version	V0.4
Authors	ATOS, ENG, E@W, ASM, KIWI
Last Update	1st Version in D2.2 2nd Version in D2.4

	3rd Version in D2.5 4th Version in D2.7
Brief Description	The Aggregator requests clusters of prosumers according to some criteria, in order to categorize their participation in ancillary and balance markets.
Assumptions and Pre-Conditions	Prosumers have accepted to participate in Demand Response programs.
Goal (Successful End Condition)	The aim of this UC is to enable the Aggregator to manage properly prosumers with similar energy profiles considering also some other business and market criteria.
Post-Conditions	Prosumers are grouped into clusters.
Involved Actors	Aggregator, Prosumers
UC Initiation	The Aggregator requests the clusters of its prosumers.
Main Flow	Begin 1. The Aggregator requests the subsets of prosumers according to some criteria through the web interface of the Graph-based Analytics. 2. The Graph-based Analytics sends the request to the database (Cassandra DB). 3. The database requests the clusters of prosumers from the Big Data Clustering component. 4. The Big Data Clustering requests the customers' profiles from the Load Profiling component. 5. The Load Profiling requests historical data for customers' consumption from the database. 6. The database sends the requested data. 7. The Load Profiling calculates customers' profiles based on historical data. 8. The Load Profiling requests consumption forecasted data from the Electricity Consumption/Production Forecasting component. 9. The Electricity Consumption/Production Forecasting sends the requested data.

	10. The Load Profiling updates the calculated profiles according to forecasted data. 11. The Load Profiling sends customers' profiles to the Big Data Clustering. 12. The Big Data Clustering clusterizes the received profiles considering the requested criteria. 13. The Big Data Clustering sends the created clusters to the database. 14. The database sends the received clusters to the Graph-based Analytics, in order to be visualized. 15. The Graph-based Analytics processes the received data and informs the Aggregator. 16. If new prosumers are registered, the Aggregator, through the web interface, sends a request to the database to categorize the new prosumers to the created clusters. 17. The database sends the received request and the created clusters to the Customer Segmentation. 18. The Customer Segmentation sends the classification of new prosumers to the database.
Alternative Courses	-
Relationships with other UCs	HL-UC03_LL-UC02, HL-UC03_LL-UC03
Architectural Elements / Services Involved	Graph-based Analytics; Database (Cassandra DB); Big Data Clustering at multiple scales; Load Profiling; Electricity Consumption/Production Forecasting; Customer Segmentation;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 & WP4 T3.1, T3.2, T3.4, T4.2, T4.3 TU, ATOS, CERTH, TUC, E@W
Notes (Optional)	-
UML Sequence Diagram	



4.3.2 HL-UC03_LL-UC02: VPP Capability Evaluation for Reserve services and for Frequency services

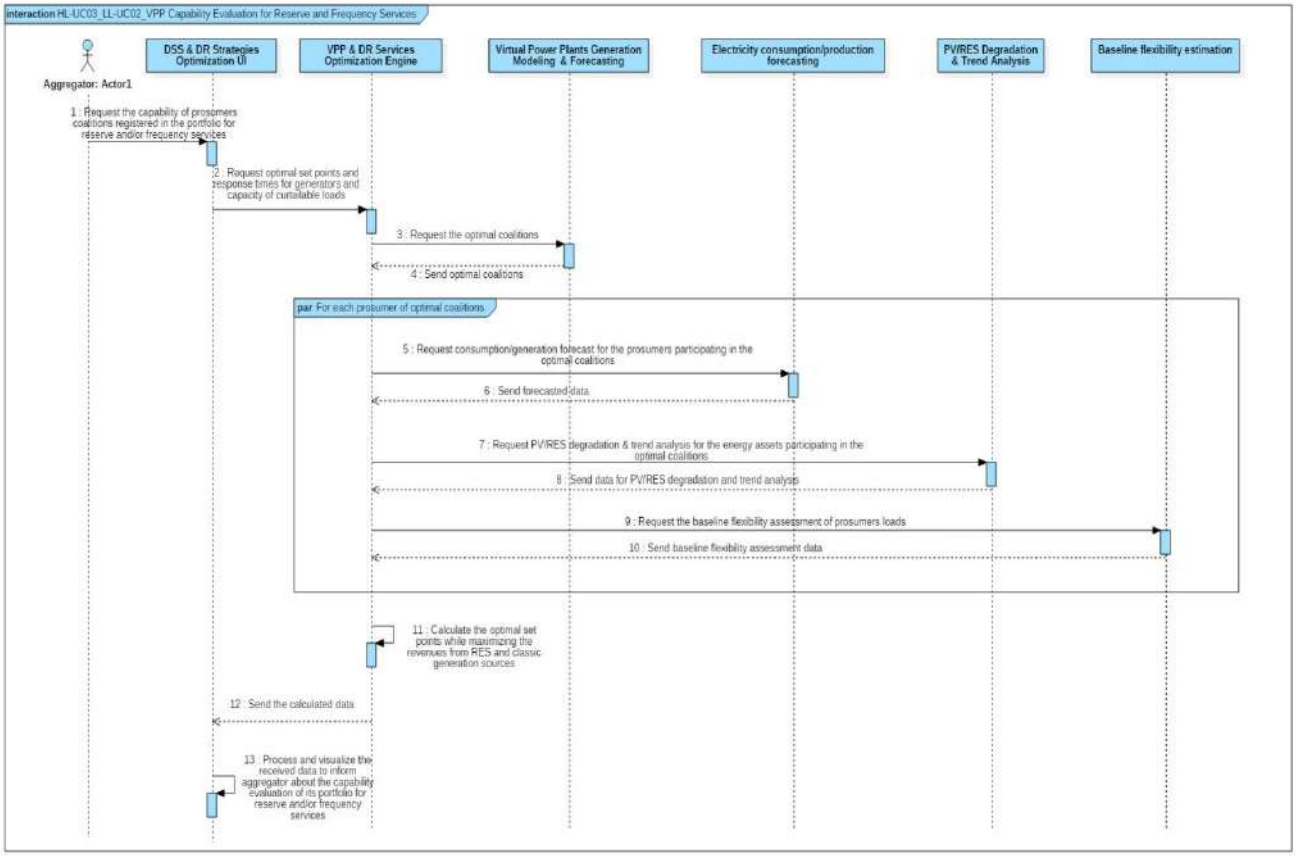
Table 19 VPP Capability Evaluation for Reserve services and for Frequency services

Generic Description	
UC Name	**HL-UC03_LL-UC02: VPP Capability Evaluation for Reserve services and for Frequency services**
Version	V0.4
Authors	ATOS, ENG, E@W, ASM, KIWI
Last Update	1st Version in D2.2 2nd Version in D2.4

	3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator estimates the capability of its portfolio of prosumers for ancillary services market participation: • ***VPP for Reserve services:*** Aggregator estimates the capability of its portfolio of prosumers maximizing the utilization and revenues from RES and classic generation sources through accessing Reserve markets as an aggregated portfolio. By combining different types of RES, a more stable export, that is easier to predict and to be assigned to specific products in the Reserve market. • ***VPP for Frequency services:*** Aggregator estimates the capability of its portfolio of prosumers for frequency services. Generation and turn-down assets which do not meet the response time requested by the Frequency markets are excluded from the portfolio and the qualified assets are assigned to specific services (Dynamic, Static, Enhanced) based on their generation profile.
Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers, participating in Energy Community programmes with different RES and classic generation sources.
Goal (Successful End Condition)	Maximize utilization and revenues from RES and classic generation sources through accessing Reserve and Frequency markets as an aggregated portfolio.
Post-Conditions	The Aggregator knows the capability of its portfolio considering optimal set points and response times of dispatchable generators and capacity of curtailable loads.
Involved Actors	Aggregator, Prosumers
UC Initiation	The Aggregator needs to know the capability, in order to provide ancillary services, such as reserve services or frequency services.
Main Flow	Begin 1. The Aggregator requests the capability of prosumers coalitions registered in the portfolio for reserve and/or frequency services through the web interface of the DSS & DR Strategies Optimization UI. 2. The DSS & DR Strategies Optimization requests optimal set points and response times for generators and capacity of curtailable loads from the VPP and DR Services Optimization Engine.

	3. The VPP and DR Services Optimization Engine requests the optimal coalitions from the Virtual Power Plants Generation Modeling & Forecasting. 4. The Virtual Power Plants Generation Modeling & Forecasting sends the optimal coalitions. For each prosumer of optimal coalitions, the steps 5-10 are repeated. 5. The VPP and DR Services Optimization Engine requests consumptio/production forecast for the prosumers participating in the optimal coalitions. 6. The Electricity Consumption/Production Forecasting sends the forecasted data. 7. The VPP and DR Services Optimization Engine requests PV/RES degradation rate for the energy assets participating in the optimal coalitions. 8. The PV/RES Degradation & Trend Analysis sends the requested data. 9. The VPP and DR Services Optimization Engine requests baseline flexibility assessment of prosumers' loads. 10. The Baseline Flexibility Estimation sends the requested data. 11. The VPP and DR Services Optimization Engine calculates the optimal set points. 12. The VPP and DR Services Optimization Engine sends the calculated data to the DSS & DR Strategies Optimization. 13. The DSS & DR Strategies Optimization processes the received data and visualizes them, in order to inform the aggregator about the capability of his/her portfolio.
Alternative Courses	The Aggregator is not able to achieve the capability required for implementation of ancillary services.
Relationships with other UCs	HL-UC03_LL-UC01
Architectural Elements / Services Involved	DSS & DR Strategies Optimization UI; VPP and DR Services Optimization Engine; Virtual Power Plants Generation Modeling & Forecasting; Electricity Consumption/Production Forecasting; PV/RES Degradation & Trend Analysis;

	Baseline Flexibility Estimation;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 & WP4 T3.1, T3.2, T3.3, T3.4, T4.1, T4.2, T4.3 TUC, ENG, ASM, EMOT, CERTH, TU
Notes (Optional)	-
UML Sequence Diagram	



4.3.3 HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market

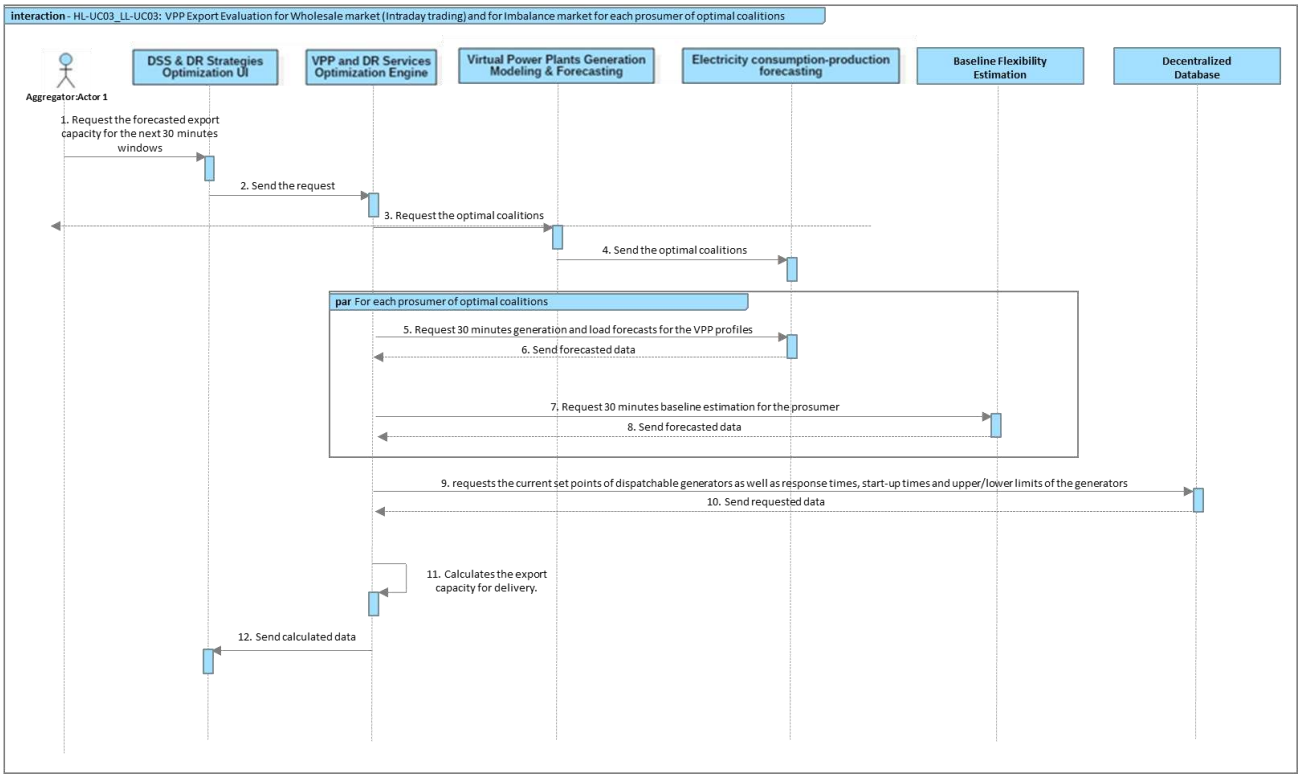
Table 20 HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market

Generic Description	
UC Name	**HL-UC03_LL-UC03: VPP Export Evaluation for Wholesale market (Intraday trading) and for Imbalance market**
Version	V0.4

Authors	ENG, E@W, ASM, KIWI
Last Update	1st Version in D2.2 2nd Version in D2.4 3rd Version in D2.5 4th Version in D2.7
Brief Description	Aggregator accurately estimates 30 minutes' generation and load forecasts to perform big data analysis in order to profile loads to be shed and to identify set points of dispatchable generators as well as response times from each type of generation asset. Aggregator need to know the VPP export capacity to implement trading services such as intraday trading and imbalance market. These trading services are described in brief below: • VPP for Wholesale market (Intraday trading): VPP launches an offer on the wholesale market for the next 30 minutes' slot. The offer is based on the forecasted generation and flexibility availability for a 30 minutes trading window received one hour ahead. At the end of the 30 minutes trading interval, the offer is locked, price is cleared and the VPP received a committed capacity order for the market which is delivered over the next 30 minutes. If clearing price is still above the thresholds, back to step 1 for the next 30 minutes' window. If not, VPP export availability is handed over to other markets. A reference to a price forecasting module is needed and we can assume that the Aggregator already has / it's provided by a third party. • VPP for Imbalance market: VPP launches an offer to its partners trading on the imbalance market to provide capacity under the settlement price for the next 30 minutes' period. At the end of the 30 minutes trading interval, the offer is locked, price is cleared and the VPP received a committed capacity order from its partner which is delivered over the next 30 minutes. If imbalance settlement price forecast is still above the threshold for the next 30 minutes' period, back to step 1 for the next 30 minutes' window. If not, VPP export availability is handed over to other markets.
Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers, participating in Energy Community programmes with different RES and classic generation sources. The Aggregator has also a supply license or an agreement with a supplier to be allowed to bid in the Wholesale and Imbalance market.

Goal (Successful End Condition)	Maximize utilization and revenues from RES and classic generation sources through accessing Wholesale and Imbalance markets as an aggregated portfolio.
Post-Conditions	The Aggregator knows the forecasted export capacity of the VPPs for the next 30 minutes window.
Involved Actors	Aggregator, Prosumers
UC Initiation	The Aggregator needs to know the forecasted capacity, in order to implement trading services, such as intraday trading and trading in the imbalance market.
Main Flow	Begin 1. The Aggregator requests the forecasted export capacity of VPP for the next 30 minutes window through the web interface of the DSS & DR Strategies Optimization UI. 2. The DSS & DR Strategies Optimization UI sends the request to the VPP and DR Services Optimization Engine. 3. The VPP and DR Services Optimization Engine requests the VPP optimal coalitions from the Virtual Power Plants Generation Modeling & Forecasting. 4. The Virtual Power Plants Generation Modeling & Forecasting sends the requested data. For each prosumer of optimal coalitions, the steps 5-8 are repeated. 5. The VPP and DR Services Optimization Engine requests next 30 minutes consumption/production forecast for the prosumer 6. The Electricity Consumption/Production Forecasting sends the forecasted data. 7. The VPP and DR Services Optimization Engine requests next 30 minutes baseline estimate for the prosumer. 8. The Baseline Estimation sends the requested data. 9. The VPP and DR Services Optimization Engine requests the current set points of dispatchable generators as well as response times, start-up times and upper/lower limits of the generators. 10. Decentralized Repository (Database) sends the requested data 11. The VPP and DR Services Optimization Engine calculates the export capacity for delivery. 12. The VPP and DR Services Optimization Engine sends the calculated data to the DSS & DR Strategies Optimization UI, in order to inform aggregator.

Alternative Courses	The Aggregator is not able to achieve the capability required for implementation of trading services.
Relationships with other UCs	HL-UC03_LL-UC01
Architectural Elements / Services Involved	DSS & DR Strategies Optimization UI; VPP and DR Services Optimization Engine; Virtual Power Plants Generation Modeling & Forecasting; Electricity Consumption/Production Forecasting;
Specific Description	
Relevance to eDREAM WPs *Main Tasks Involved* *Main Technical Partners Involved*	WP3 & WP4 T3.1, T3.3, T4.1, T4.2, T4.3 TUC, ATOS, CERTH, TU
Notes (Optional)	-
UML Sequence Diagram	



5. Conclusions

The purpose of this document was to consolidate the set of UCs (presented in section four) and relative scenarios (section three). It has been refined a description of the emerging neighbourhood market of energy and energy services, in the setting of active microgrids which aim to maximize local self-consumption reducing the energy exchange to the higher-level grid. UCs and scenarios will be used to define the system technical and functional requirements, driving the components design. This is the second version of the document, and the final version of the UCs and scenarios will be presented in due course, notably, the third and final version will report on work to clearly collect the user requirements (D.2.9, M30).

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