The eDREAM project is co-founded by the EU's Horizon 2020 innovation programme under grant agreement No 774478

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

H2020 Grant Agreement Number: 774478

WP2 – User Requirements, Use Cases and System Specification

DELIVERABLE: D2.2 Use Case Analysis and application scenarios description V1

Authors: [Alessio Cavadenti]

Imprint

Use Case Analysis and application scenarios description V1, August 2018

Contractual Date of Delivery to the EC:	31.08.2018
Actual Date of Delivery to the EC:	31.08.2018

Author(s):	Alessio Cavadenti (ASM)
Participant(s):	Francesca Santori (ASM), Vincenzo Croce (ENG), Giuseppe Raveduto (ENG), Francesco Bellesini (EMOT), Giuseppe Mastandrea (E@W), Luigi D'Oriano (E@W), Antigoni Noula (CERTH), Dimosthenis Ioannidis (CERTH), Mircea Bukur (KIWI), Ugo Stecchi (ATOS), Tudor Cioara (TUC), Ionut Anghel (TUC), Andrei Ceclan (SVT), Benjamin Hunter (TU), Vladimir Vukovic (TU)

Project:	enabling new Demand Response Advanced, Market oriented and secure technologies, solutions and business models (eDREAM)
Work package:	WP2 – User Requirements, use cases and system specification
Task:	T2.2 – Use Cases and Applications Scenarios
Confidentiality:	public
Version:	1.0

Legal Disclaimer

The project enabling new Demand Response Advanced, Market oriented and secure technologies, solutions and business models (eDREAM) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774478. The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the Innovation and Networks Executive Agency (INEA) or the European Commission (EC). INEA or the EC are not responsible for any use that may be made of the information contained therein.

Copyright

Executive Summary

The deliverable D2.2, within the Work Package 2, identifies the first version of use cases and related application scenarios through which the eDREAM concept will be developed and validated.

From the eDREAM project point of view, the context will be 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 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 the D2.1 (T2.1) for requirements elicitation.

This document is organized in five sections in which the first version of use cases and scenarios has been collected describing, by means of templates 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 flexibility aggregation via smart contract”, 2. “Peer-to-peer local energy trading market” and 3. “Virtual power plant in energy community”.

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

Regarding the second scenario it is referring to 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 is considering the increasing need to optimize output from multiple local generation assets that serve primarily local communities and also have export connections at 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 on the overall objective maximizing functions.

The document aims at pointing out the benefits for exploiting local capacities in terms of generation, consumption, security, stability and quality of the services by new near real time demand response strategies.

Moreover, 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, the process has been characterized by an evolving approach – starting from high-level information, such as the name of the use case, to a detailed step-by-step analysis of the realization of the use case and of the actors involved.

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 during WP3-WP6. Two updates of this document (D2.7 and D2.9) will be delivered in M20 and in M30, respectively.

Table of Contents

List of Figures

List of Tables

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
M&V	Measurement and verification
P2P	Peer-to-peer
PV	Photovoltaic
RES	Renewable Energy Sources
TSO	Transmission System Operators
UC	Use Case
UML	Unified Modelling Language
VPP	Virtual Power Plant

1. Introduction

1.1 Purpose of the Document

The purpose of the Deliverable D2.2 is to clearly identify the use cases and application scenarios of the new decentralized and community-driven energy ecosystem envisaged by eDREAM. Starting with refining the eDREAM context, characterized by Micro-Grids (MG) and Virtual Power Plants (VPP) fully integrated in the local power distribution network, the document aims at identifying the benefits for 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. The eDREAM context is presented, in D2.2, identifying three specific scenarios, namely (1) *Prosumer flexibility aggregation via smart contracts*, (2) *Peer-to-peer local energy trading market* and (3) *VPP in energy community* and the corresponding use cases (UCs).

The document sets the foundation of the project and serves as the main starting point for the research and development activities of the eDREAM project. By means of a thorough analysis of the energy context, the new scenarios and the UCs, the purpose of the document is to blend energy, ICT and business skills during the process of UC elaboration in order to reach a holistic vision of the new decentralized and community-driven energy ecosystem.

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 during WP3-WP6.

1.2 Scope of the Document

D2.2 is produced within the Work Package 2 with the aim to define a range of application scenarios and use cases through which the eDREAM concept will be developed and validated. It represents the first version of the deliverable, in which the preliminary use cases and the related scenarios are clearly identified. Two updates of this document (D2.7 and D2.9) will be delivered in M20 and in M30, respectively.

This document records the collective knowledge produced through the cooperation of the partners within WP2 – each one contributing with his respective expertise – in order to define scenarios and use cases which contribute to determine the project architecture and 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 the D2.1 (T2.1) for requirements elicitation.

1.3 Structure of the Document

Deliverable 2.2 “Use Case Analysis and application scenarios description” is organised in five sections in which the first version of use cases 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 methodologies for the description of the process that is approached for scenario identification and use case 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 Use Cases Inventory; consolidation of a list of High Level Use Cases (HL-UCs) and related Low-Level Use Cases (LL-UCs) extrapolated by three internal rounds of contributions; description of the HL-UCs and LL-UC by means 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 demonstrating the eDREAM innovative approach.

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

The overall eDREAM context consists of three high-level scenarios.

Each scenario has been produced as a 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 use cases, 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 Use Case 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. The initial list of use cases and the related scenarios, were defined through an 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. A specific template has been adopted for the definition of the use cases and it was circulated among the project partners to identify the first set of use cases. The template was based on the "basic use case template" suggested by Alistair Cockburn [3]and descriptions provided by partners has been included in this document.

The iterative approach applied for refining scenarios and UCs was based on a day-by-day interaction among end-users and IT specialists via e-mail, phone and web-conferences; two dedicated workshops were also held in Terni and in Cluj-Napoca to discuss progresses and relations with the other tasks and WPs.

Description	
Use Case Name	Use Case name, which uniquely identifies the UC (e.g. unique identifier), having an achievable goal
Version	To inform the user the stage a use case has reached.
Last Update	Date of the last update
Authors	Who created and who documented the Use Case
Brief Description	Description of the series of steps for the defined use case 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 does not change during the execution and should be true to successfully terminate the use case. Moreover, 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 use case.
Target	The ultimate aim and end condition(-s) of the Use Case
Effects/Post Conditions	The state of the world upon successful completion
Involved Actors	Who are the actors involved in the use case? The same actor may play two different roles in the same use case. An actor may be a person, a device, another system or sub-system, or time. Actors represent different roles that something outside has in its relationship with the system,

	functional requirements of which are being specified.
Use Case Initiation	This refers to the potential triggers or events that could initiate the use case. 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 Use Cases	Indication of connection with other use cases
Architectural Elements / Services Involved	Indication of eDREAM elements involved

Table 1: Use Case Template

2.2 Framework Conceptual Architecture

The main objective of the eDREAM conceptual architecture is to develop a secure near-real time closed-loop DR management framework comprising innovative tools and services for the system's stakeholders, thus enabling secure, autonomous and scalable power grid operation based on decentralized decision-making processes. The deployment of blockchain technology, self-enforcing smart-contracts and consensus-based validation algorithms will ensure secure, near-real time and decentralized energy transactions.

The process for the definition of eDREAM architectural system should receive as inputs the stakeholders' (internal and external) requirements and the use cases.

The use cases were formulated according to project's envisioned objective and the relevant business needs extracted from the first phase of requirements elicitation procedure. The eDREAM conceptual architecture should support the underpinning system's macro-functionalities, which as described on D2.1 encompass the fundamental functionalities for the realization of the project's objectives.

The fundamental part of the system architecture is the Core Backbone Platform, which interact with field data aggregation and multilevel and multifactor visualization framework layers and consists of three sub-layers and it is the core section where all the innovative system's components and algorithms to be developed will perform their functions. The three sub-layers are:

- 1st layer: Techniques for DR and Energy Flexibility Assessment
- 2nd layer: Next Generation Services for Aggregators and Customers
- 3rd layer: Decentralized Network Control Optimization and DR Verification

The 1st layer comprises the components and functionalities enabling the effective formulation and deployment of DR strategies through the use of drones to assess the potential application of DR in a specific zone and the use of energy consumption/production forecasting tools to forecast the production/consumption for each prosumer and evaluate the baselines on different scales as well as reward mechanisms for the end users.

This means that in this layer, baseline load calculations and flexibility estimation are performed and provide valuable input to the components of the next layer.

At this point, it should be pointed out that there are two forecasting components in the platform which operate different processes. One performs calculations at pilot site level (field level) and the other, which is located in the Front-End layer, performs calculations at aggregator level.

The 2nd layer addresses innovative techniques of big data science for customer clustering and segmentation which will contribute to decision making and DR optimization functionalities. Load profile patterns are identified according to the selected demand response strategy. The employment of these techniques will improve the Micro-Grid's flexibility assessment and the VPP's services. Thus, the system user will be able to control and to optimize energy balance in multiple local distributed generation assets and manage prosumers' flexibility potential.

The 3rd layer is mostly oriented to the innovative development of decentralized blockchain-driven control of low voltage network for flexibility management and secure peer-to-peer energy trading transactions via smart contracts using the distributed ledger framework. DR financial transactions can be executed, verified and settled in a real-time and decentralized framework based on the inputs from the blockchain-driven components and from the 2nd layer.

The functional layers of the system platform which are oriented to services provision receive as inputs real-time data from the Field Data Aggregation layer. The core backbone platform's components can also request historical data, data from weather services and respective KPIs from the Decentralized Multi-Purpose Repository in order to perform properly their calculations taking into account all the related parameters.

The communication and data transfer between the platform's layers are carried out through appropriate APIs and the eDREAM distributed ledger.

Figure 1 depicts a high-level correlation of system's architectural platform with the macro-functionalities and stakeholders' requirements as defined in the D2.1 and use cases.

It is worth mentioning that in Figure 1, the basic connections between the system's functionalities are presented, so as to address the high-level architectural framework. The connections and dependencies can vary according to the use cases to be applied.

Some of the components and functionalities of the architecture can be adjusted, improved or reconsidered during the project lifetime as the processes of requirements elicitation and use cases elaboration proceed, but keeping in consideration the architecture's basic concepts and principles already defined.

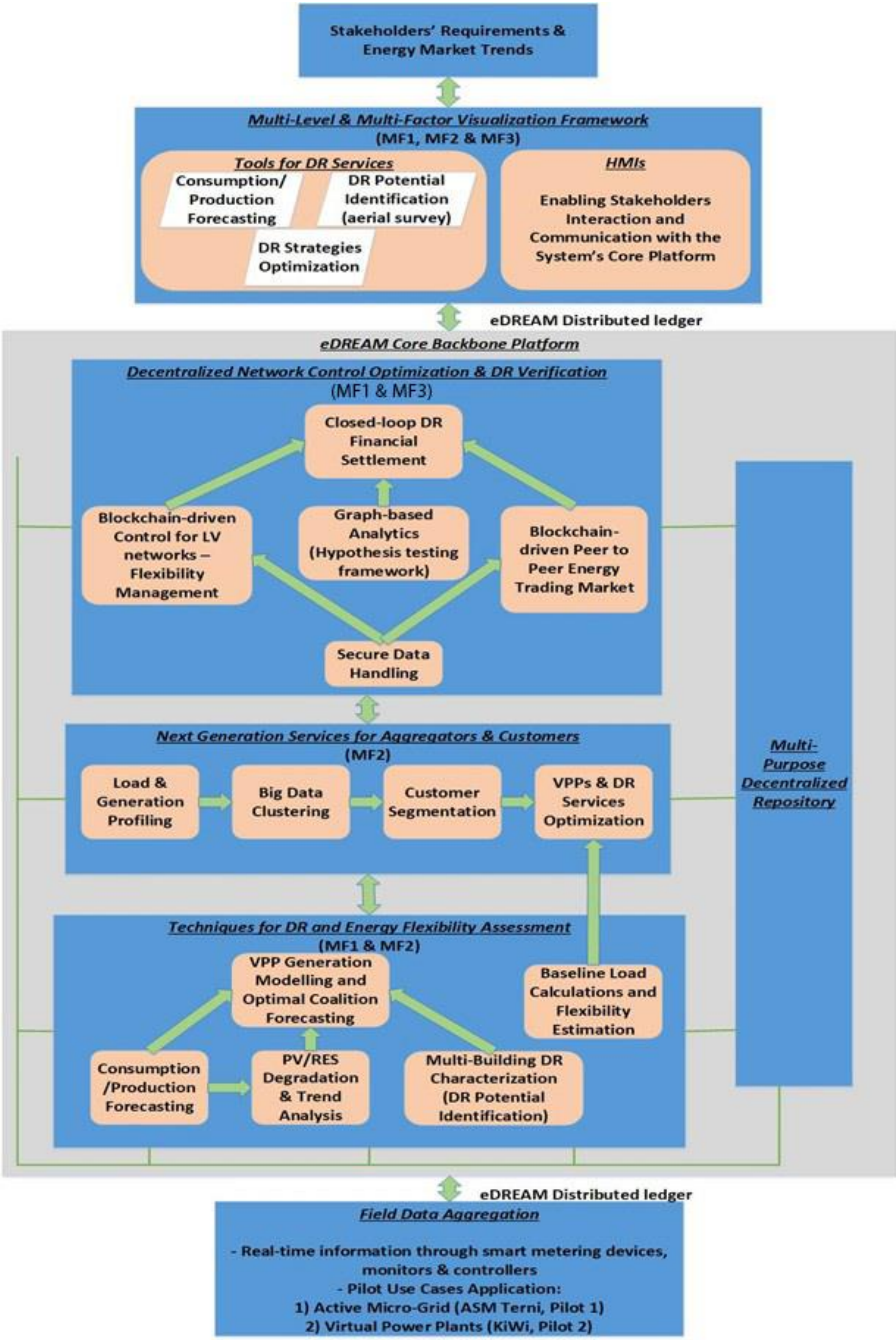

Figure 1 High Level Description Architecture

3. Context and Scenarios

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

According to the U.S. Department of Energy [4]definition, the microgrid can be considered as a group of interconnected loads and distributed energy resources within clearly defined electrical borders, acting as a single controllable entity with respect to the power distribution grid.

The electrical grid is currently undergoing rapid change with the development of Smart Grid and microgrid technologies, as well as the increased use of renewable generation and distributed generation, also aggregated in Virtual Power Plants (VPP). As the grid moves from the "Edison Era" to the "Google Era" new opportunities to build a more secure, resilient and efficient grid currently exist. In particular, the energy customer is now an active player of the energy environment, leading to a new decentralized and community-driven energy system. The *active* microgrids and the *community-based* VPP targeted by eDREAM pave the way to a new vision of the whole energy ecosystem.

The eDREAM context 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 [5]

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).

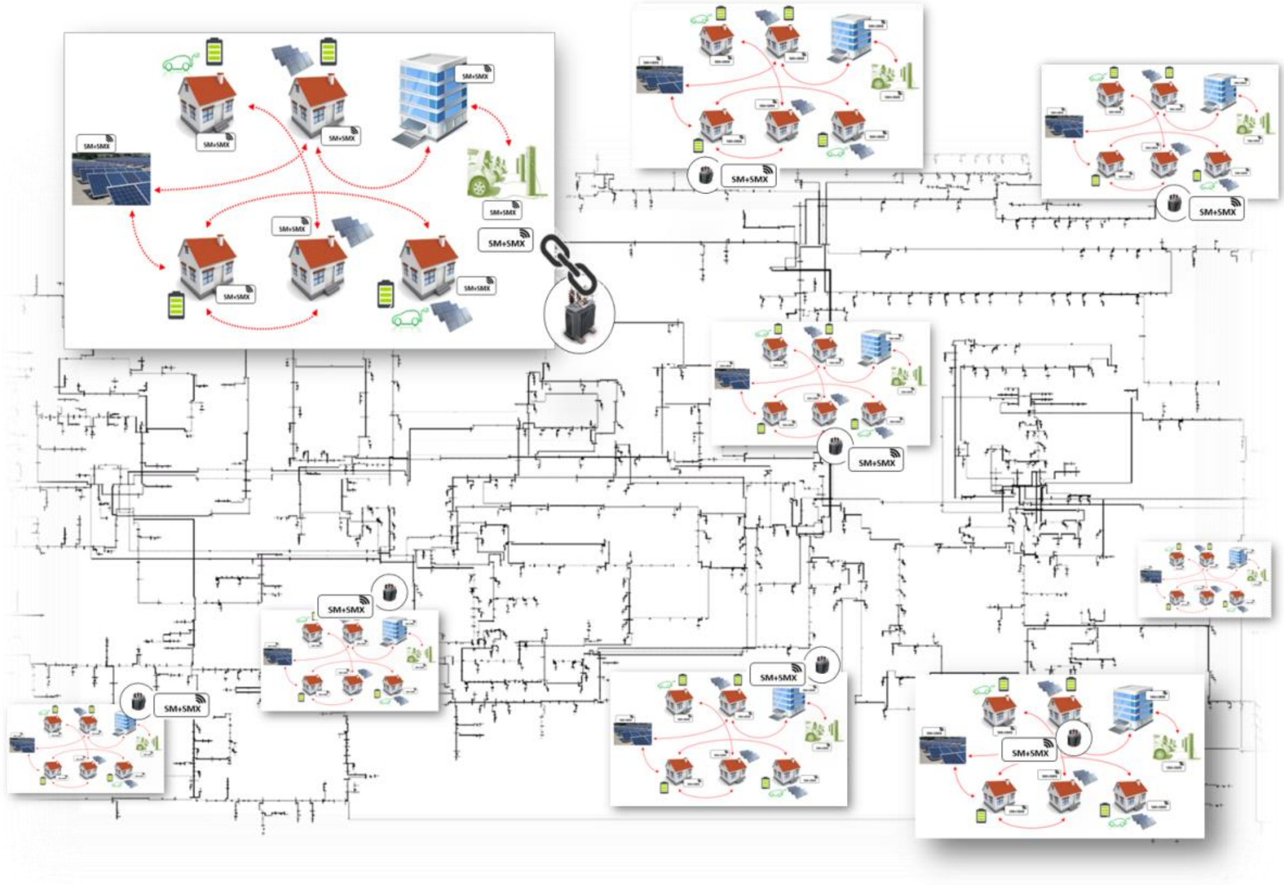

Figure 2 Multiple decentralized active microgrids

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 CMP-like (Cross Modular Platform) these engines, the DSO can access microgrid resources, especially stationary and mobile storage systems and loads, exploiting the 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 distribution ledgers.
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).

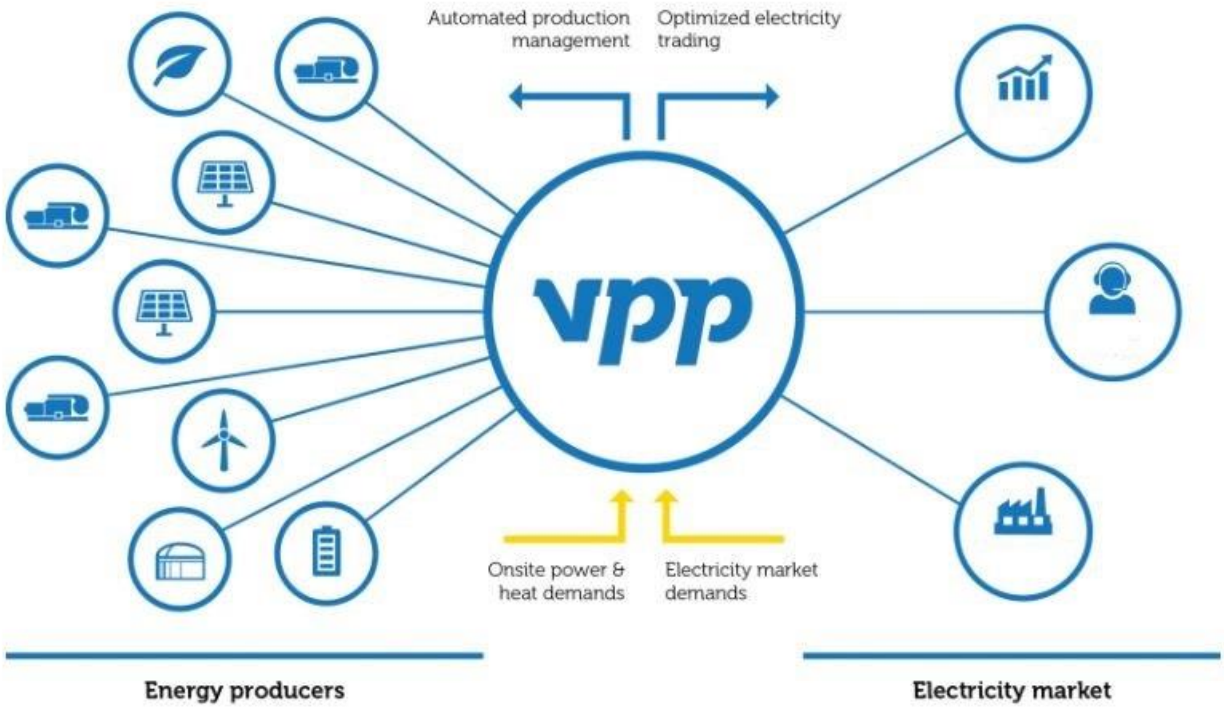

Figure 3 Concept of Virtual Power Plant [6]

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 [7]. 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 the 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 Use Cases defined within eDREAM, a list of actors is defined (Table 1). 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	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.	Organisation
ESCO	*Energy Service COmpany*. Offers auxiliary energy-related services to prosumers.	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 2: 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 are able to offer via smart contracts their flexibility resources, both production and loads modulation. The scenario will be tested in the Italian field pilot, involving the local DSO in Terni (ASM Terni).

Prosumers can be involved via enabling aggregators. Through 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, actually activated in real time by the aggregators at the grid level with the results of i) maintaining the balance of supply and demand in a decentralized environment, ii) achieving the goal of reducing the overloading and iii) reaching power network stability by means of the flexibility provided by active microgrids.

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 has been enabled to offer his flexibility via smart contracts to specific aggregators. The Aggregator creates and sends a forecast of the aggregator energy demand of all its registered prosumers to the DSO and the DSO uses these forecasts to create a forecast of the total load on the congestion points. The DSO identifies a congestion point and grid connections to this congestion point and declares it in the Common Reference Operator (CRO) registry. Aggregators in that region are activated and contract prosumers, connected to this congestion point to offer flexibility. In case congestion is forecast: 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 if so, the DSO sends a flexibility order; Aggregators will adjust the load of its prosumers to fulfil the flexibility need.

These smart contracts will be defined to manage 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 actual delivered (as relived by monitored energy values). If relevant deviations are checked, 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) through which it is requested 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 [8]to monitor the actual adjusted energy demand during the DR event time interval.

In the smart contract the incentives that aggregator recognizes to the prosumer are also included.

The incentives that the aggregator recognizes to the prosumer for its adaptation during a DR event, is calculated for each kW of energy shifted and can be provided as a daily revenue or a discount rate on the regular electricity bill [9].

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 principal objective of the eDREAM project in this scenario is to transform the system into decentralised system when appropriate 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.

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

In this scenario, the eDREAM project aims to define a mechanism for decentralized energy trading, enabling prosumers to buy or sell energy by means of peer-to-peer transactions. This scenario will be validated in the CERTH demo lab in Thessaloniki (GR).

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 the grid balancing because in correspondence to an exceeding production of energy there is a signal of price reduction that could trigger the activation of postponable loads and vice versa.

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 each peer prosumer voluntarily enrolled with the marketplace and will 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. 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 (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.

The scenario will be tested in the UK field pilot, involving a commercial aggregator (KIWI).

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 day 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 use case will have three main subsets of services to deliver:

- Virtual Power Plant generation modelling and forecasting – based on, for example, the type of generation asset, historical data, weather forecast. This tool will allow the VPP to make accurate availability predictions for the outbound services and therefore maximizing availability and utilisation revenues from DSR services.
- Flexibility profiling of VPP and active microgrids - this will include an accurate baseline of the microgrids participants to estimate DR potential for turn-down services, accurate asset baselining for generation assets – e.g. start and sync time for CHP or diesel generator, output baselining for PV and wind in certain weather conditions as well as accurate forecasting. This type of profiling will allow VPP manager to automatically assign new sites/assets to a particular type of outbound service based on the assets particularities such as response time, sync times and maximum dispatch period.
- VPP customer segmentation – this needs to be done both on the sell side, e.g. microgrid customer segmentation (residential, commercial, industrial, by industry vertical etc.) as well as buy side (TSO, DNO, wholesale, P2P). Customer segmentation on the buy side is crucial for the process of maximising revenues as each type of service/markets served by the VPP has specific requirements for the measurement and verification of the power capacity and energy exported to the grid.

The scenario aims 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.

eDREAM 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. As 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 use cases provided in the next section.

4. Use Cases

For each of the three scenarios presented in Section 4, one high-level use case has been developed as well as several low-level use cases (Table 2). Each of the use cases is presented in detail. The use cases 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.

eDREAM USE CASES INVENTORY
HL-UC01: Prosumers DR flexibility aggregation via smart contract
HL-UC01_LL-UC01: Prosumers enrolment with the aggregator
HL-UC01_LL-UC02: Prosumer flexibility availability
HL-UC01_LL-UC03: Prosumer electricity production/consumption forecasting
HL-UC01_LL-UC04: Aggregator – prosumers financial settlement
HL-UC01_LL-UC05: Congestion point detection by DSO
HL-UC01_LL-UC06: DSO request flexibility from aggregators
HL-UC01_LL-UC07: Aggregator delivers flexibility to DSO
HL-UC01_LL-UC08: Stationary and EV fleets load for local balancing services
HL-UC01_LL-UC09: DSO Direct Control of Grid Load
HL-UC01_LL-UC10: DSO-Aggregators financial settlement
HL-UC02: Peer-to-peer local energy trading
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 calculation and bids/offers matching
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
HL-UC03_LL-UC02: VPP capability evaluation
HL-UC03_LL-UC03: VPP for reserve services

HL-UC03_LL-UC04: VPP for frequency services
HL-UC03_LL-UC05: VPP export evaluation
HL-UC03_LL-UC06: VPP for wholesale market – intraday trading
HL-UC03_LL-UC07: VPP for imbalance market

Table 3: Use Cases Inventory

4.1 HL-UC01: Prosumers DR flexibility aggregation via smart contract

In the table below has been reported the High Level description of this Use case:

Description	
Use Case Name	Prosumers' DR flexibility aggregation via smart contracts
Version	V0.4
Last Update	12/07/2018
Authors	TUC, E@W, ASM
Brief Description	Aggregators aggregate individual flexibility of prosumers in response to the DSO flexibility request and they are made aware of individual prosumer deviations from flexibility request. DSO analyses the actual state of the distribution grid and forecast the needs for energy flexibility to deal with potential distribution grid level congestion problems.
Assumptions and Pre-Conditions	Prosumers are enrolled with aggregators and their flexibility availability is known by the aggregators. Current and forecast data from power production and load demands are available.
Target	Establish a mechanism for aggregating flexibility and detecting in near real time the amount of flexibility actually activated by each prosumer. Identify grid issues and actors that can solve them providing flexibility.
Effects/Post Conditions	Aggregators are able to aggregate the flexibility of the prosumer in response to the request of flexibility, managing any individual deviations with respect to the flexibility established. Grid level congestion points are avoided.
Involved Actors	DSO, Aggregator, prosumers

Use Case Initiation	Aggregator receives a flexibility request from DSO. The DSO identifies issues on the grid (e.g. congestion and reverse flow)
Main course	Begin 1. Based on the received flexibility request the aggregator inquires its enrolled prosumers to identify the subset which may deliver the expected flexibility 2. Flexibility request curves are being injected into the prosumers self-enforcing smart contracts by the aggregator 3. The deviation among the prosumer actual energy consumption and the expected profile set by the aggregator through flexibility request curve is being measured (via prosumer self-enforcing smart contract) 4. If a deviation is measured an aggregator level smart contract will try to identify other prosumers (from enrolled ones) to provide missing levels of flexibility; 5. The prosumer deviating is being penalized while the one taking up the missing flexibility is rewarded using DSO provided incentives to the aggregator. For each day (day-ahead trading of flexibility): 6. Aggregators create and send a forecast of the aggregated energy demand of all of their individual clients to the DSO; 7. DSO uses these data to create 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); 8. In case congestion is forecast (intraday: steps are repeated): 8.1 DSO sends a flex request to a Flexibility Marketplace with associated incentives; 8.2 AGGREGATORNAME responds to this flexibility request by placing a flexibility offer in a Flexibility Marketplace; 8.3 DSO can accept one or multiple flexibility offers and, if so, the DSO sends a flexibility order; 8.4 AGGREGATORNAME adjusts the load of its clients to fulfil the flexibility need 8.5 DSO enhances AGGREGATORNAME for flexibility actually provided compared to the forecast plan. 8.6 AGGREGATORNAME pays enrolled prosumers for the flexibility provision based on their flexibility contract (settlement) End
Alternative Courses	No congestion is being forecast by the DSO then no flex request is being issued OR

	No aggregators are able to deliver the expected level of flexibility. DSO contacts a prosumer to manage its assets (direct demand response) Aggregator promise a certain amount of flexibility but fails to deliver.
Relationships with other Use Cases	HL-UC01, HL-UC01_LL-UC02, HL-UC01_LL-UC03, HL-UC01_LL-UC04, HL-UC01_LL-UC05, HL-UC01_LL-UC06, HL-UC01_LL-UC07, HL-UC01_LL-UC08, HL-UC01_LL-UC09, HL-UC01_LL-UC10,
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures;Weather data availability;Multi-Building DR characterization through termal, optical and LIDAR information fusion; Forecast of electricity production / consumption; Baseline load calculations in DR programs;PV/RES Degradation and Trend Analysis;Graph-based analytics;Big Data Clustering at Multiple Scale;VPP & Customer Segmentation and Profiling;Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting;Decision Making and DR Optimization;Interactive Visualization for VPP coalition;Forecast of electricity production/consumption at the grid level;EVSEs and EV fleet monitoring;EVSE remote control;Baseline flexibility estimation;Interactive Multi-purpose Visualization for system flexibility services;Secure data handling;LV grid congestion control through flexibility management;Prosumers flexibility monitoring and DR tracking;Peer to peer local energy trading among prosumers;Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets;Closed loop DR verification and Financial settlement;

Table 4: HL-UC01: Prosumers DR flexibility aggregation via smart contract

The relative Use Case Diagram, in which are represented all the expected interaction between the Actors and eDREAM platform for this scenario, is reported in the figure below:

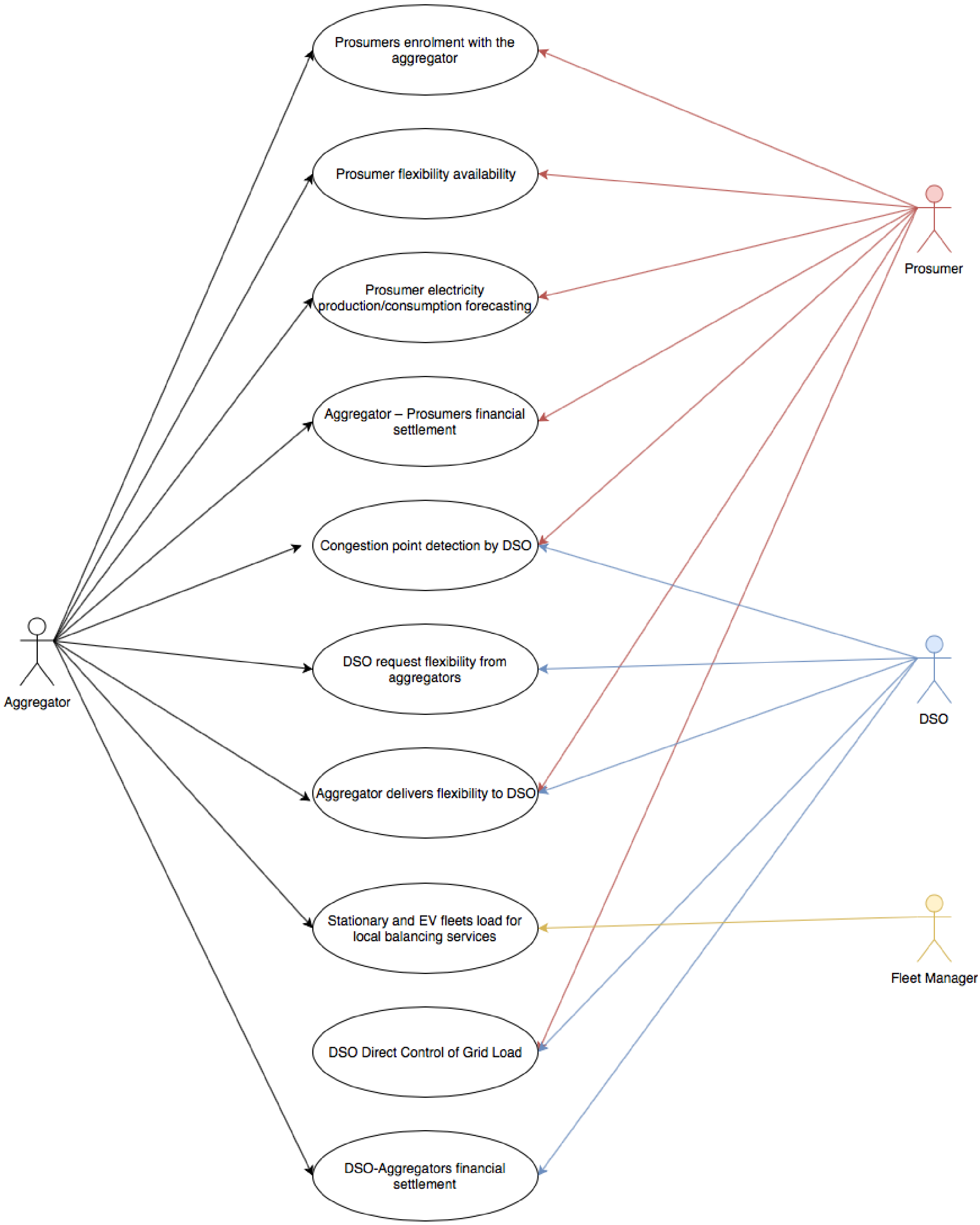

Figure 4 Prosumers DR flexibility aggregation via smart contract General Use Case Diagram

The detailed description of the relative Low Level Use Cases is reported in the following tables:

HL-UC01_LL-UC01: Prosumers enrolment with the aggregator

Description	
Use Case Name	Prosumers' flexibility availability and enrolment with the aggregator
Version	V0.3
Last Update	25/06/2018
Authors	E@W, TUC
Brief Description	Prosumers enrol with aggregators and provide their flexibility availability to aggregators.
Assumptions and Pre-Conditions	Data from load demands, prosumer baseline flexibility
Target	Establish a mechanism for enrolling prosumers and make available their flexibility
Effects/Post Conditions	Prosumer are enrolled with aggregator and agreed on initializing of Smart Contract in which set the conditions for activating its available flexibility
Involved Actors	Aggregators, Prosumers
Use Case Initiation	The aggregator needs to enrol prosumers for flexibility availability
Main course	Begin 1. Aggregator negotiate with its customers (prosumers) showing the benefits through interactive multi-purpose visualization for user interaction 2. Aggregator and prosumers agrees on baseline and incentives for activation of flexibility (initialization of smart contract) 3. Prosumers provide their energy flexibility availability interval End
Alternative Courses	2. Some prosumers do not agree on baseline and incentives for activation of flexibility (initialization of Smart Contract)
Relationships with other Use Cases	HL-UC01, HL-UC01_LL-UC02 and following
Architectural Elements/Services Involved	Baseline flexibility estimation; Interactive Multi-purpose Visualization for system flexibility services; Secure data handling;

	LV grid congestion control through flexibility management; Prosumers flexibility monitoring and DR tracking; Peer to peer local energy trading among prosumers; Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets;

Table 5: HL-UC01_LL-UC01: Prosumers enrolment with the aggregator

HL-UC01_LL-UC02: Prosumer flexibility availability

Description	
Use Case Name	Evaluation of prosumer flexibility
Version	V0.3
Last Update	25/06/2018
Authors	ENG, TUC, E@W
Brief Description	The aggregator periodically evaluates the potential energy flexibility guaranteed by prosumers
Assumptions and Pre-Conditions	The aggregator periodically needs to re-evaluate the energy flexibility potential
Target	Obtain an energy consumption baseline flexibility estimation
Effects/Post Conditions	The estimate on energy demand is derived
Involved Actors	Aggregator, prosumers
Use Case Initiation	The aggregator needs to evaluate the potential application of Demand Response in a specific zone.
Main course	Begin 1. Periodically the operator from the aggregator measure for a limited period the drop in consumption/or the generation forecast vs actual baseline. End
Alternative Courses	1. Aerial survey technology is applied 2. Drones will fly a fixed path to identify peak and minimum energy demand requirement 3. Collected images will be analysed to gather information about the presence of energy intensive plant items of the building (e.g. HVAC, CHP, …) and the heat-loss parameters, the

	Information about the orientation and shading of the building and to detect data for RES micro-generation 4. Estimates of energy demand is derived.
Relationships with other Use Cases	HL-UC01_LL-UC03
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures;Weather data availability;Multi-Building DR characterization through termal, optical and LIDAR information fusion;Forecast of electricity production / consumption;Baseline load calculations in DR programs;PV/RES Degradation and Trend Analysis;Graph-based analytics;

Table 6: HL-UC01_LL-UC02: Prosumer flexibility availability

HL-UC01_LL-UC03: Prosumer electricity production/consumption forecasting

Description	
Use Case Name	Electricity production/consumption forecasting
Version	V0.3
Last Update	25/06/2018
Authors	ENG, TUC, E@W
Brief Description	Prosumers forecast their energy demand/production for day ahead and make this data available for the aggregator
Assumptions and Pre-Conditions	Prosumer is enrolled with the aggregator
Target	Obtain the forecast values for production/consumption at individual prosumer level
Effects/Post Conditions	The aggregator receives from the prosumers the forecast data of their energy demand/production for day ahead
Involved Actors	Prosumers, Aggregator
Use Case Initiation	On daily basis

Main course	Begin 1. Prosumers forecast their energy demand/production values for the next day 2. Prosumers send this info to the aggregators with which they are enrolled 3. Aggregator send this info the DSO which use it to forecast future congestion points End
Alternative Courses	-
Relationships with other Use Cases	HL-UC01_LL-UC04 and following
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures;Weather data availability;Multi-Building DR characterization through termal, optical and LIDAR information fusion;Forecast of electricity production / consumption;Baseline load calculations in DR programs;PV/RES Degradation and Trend Analysis;Graph-based analytics;

Table 7: HL-UC01_LL-UC03: Prosumer electricity production/consumption forecasting

HL-UC01_LL-UC04: Aggregator – Prosumers' financial settlement

Description	
Use Case Name	Aggregator – prosumers' financial settlement
Version	V0.2
Last Update	20/06/2018
Authors	ENG, TUC
Brief Description	Financial settlement between the aggregator and its prosumers
Assumptions and Pre-Conditions	The financial settlement takes place after the agreed delivery time is elapsed and the prosumer behaviour is analysed
Target	To penalize or incentive the prosumer, based on its behaviour
Effects/Post Conditions	The prosumers are paid/penalized based on the amount of flexibility actually delivered

Involved Actors	Aggregator; Prosumers
Use Case Initiation	Aggregator
Main course	Begin 1. Prosumers have addressed a flexibility request from aggregator; 2. Aggregators pays the prosumers according to their smart contract if they have delivered the expected flexibility; 3. Aggregators penalize prosumers according to their smart contract if they have failed to deliver flexibility End
Alternative Courses	-
Relationships with other Use Cases	HL-UC02_LL-UC03
Architectural Elements/Services Involved	Prosumers flexibility monitoring and DR tracking;Peer to peer local energy trading among prosumers;Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets;Closed loop DR verification and Financial settlement

Table 8: HL-UC01_LL-UC04: Aggregator – Prosumers financial settlement

HL-UC01_LL-UC05: Congestion points detection by DSO

Description	
Use Case Name	Congestion points detection by DSO
Version	V0.2
Last Update	20/06/2018
Authors	E@W, TUC
Brief Description	DSO use forecasts send by aggregators to detect day-ahead congestion points in the grid.
Assumptions and Pre-Conditions	Forecast data of energy production/consumption of each prosumer
Target	Establish a mechanism to identify future congestion points
Effects/Post Conditions	Congestion point is identified
Involved Actors	DSO, Aggregators, Prosumers

Use Case Initiation	On daily basis, by the aggregators
Main course	Begin 1. Aggregators request the forecast energy demand/production for their enrolled prosumers for the next day; 2. They send the information to the DSO; 3. DSO uses the information to detect congestion points in the next day; 4. If an overloaded branch is detected, DSO declares it in the Common Reference Operator (CRO) registry End
Alternative Courses	-
Relationships with other Use Cases	HL-UC01_LL-UC06
Architectural Elements/Services Involved	Forecast of electricity production/consumption at the grid level;EVSEs and EV fleet monitoring;EVSE remote control;Baseline flexibility estimation;Interactive Multi-purpose Visualization for system flexibility services

Table 9: HL-UC01_LL-UC05: Congestion points detection by DSO

HL-UC01_LL-UC06: DSO request flexibility from aggregators

Description	
Use Case Name	DSO requests flexibility from aggregators
Version	V0.2
Last Update	30/06/2018
Authors	E@W, TUC
Brief Description	DSO request flexibility to avoid a forecast congestion point
Assumptions and Pre-Conditions	Congestion point had been detected
Target	Acquiring the appropriate level flexibility by the DSO from aggregators.
Effects/Post Conditions	DSO is able to request on the marketplace the necessary flexibility to avoid forecast congestion point
Involved Actors	Aggregators, DSO

Use Case Initiation	DSO request for flexibility
Main course	Begin 1. DSO publish a flex request in the flexibility marketplace; 2. Aggregators geographically located in the congestion point area are activated; 3. Aggregators send offers of flexibility in the flexibility marketplace; 4. DSO select flexibility offers from 1 or more aggregators. 5. DSO sends a flexibility order to the selected aggregators to deliver flexibility End
Alternative Courses	-
Relationships with other Use Cases	HL-UC01_LL-UC07
Architectural Elements/Services Involved	Secure data handling;LV grid congestion control through flexibility management;Prosumers flexibility monitoring and DR tracking;Peer to peer local energy trading among prosumers;Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets;

Table 10: HL-UC01_LL-UC06: DSO request flexibility from aggregators

HL-UC01_LL-UC07: Aggregator delivers flexibility to DSO

Description	
Use Case Name	Aggregator delivers flexibility to DSO
Version	V0.2
Last Update	20/06/2018
Authors	E@W, TUC
Brief Description	Aggregator provides flexibility ordered to the DSO
Assumptions and Pre-Conditions	A flexibility order is send by the DSO to the aggregator
Target	Delivering of the appropriate agreed flexibility to the DSO
Effects/Post Conditions	Aggregator provides the appropriate agreed flexibility to the DSO
Involved Actors	DSO, Aggregator, Prosumer
Use Case Initiation	Aggregator receives a flexibility order from DSO

Main course	Begin 1. After receiving the flexibility order from the DSO aggregator send at its turn flexibility orders to its prosumers (injection of demand curve via a smart contract); 2. The prosumers will follow the provided curve by shifting their load accordingly; 3. Deviations from flexibility orders of individual prosumers are monitored via smart contracts; End
Alternative Courses	The prosumers don't deliver the ordered amount of flexibility to the aggregator
Relationships with other Use Cases	HL-UC01_LL-UC08
Architectural Elements/Services Involved	Secure data handling;LV grid congestion control through flexibility management;Prosumers flexibility monitoring and DR tracking;Peer to peer local energy trading among prosumers;Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets;Closed loop DR verification and Financial settlement;

Table 11: HL-UC01_LL-UC07: Aggregator delivers flexibility to DSO

HL-UC01_LL-UC08: Stationary and EV fleets load for local balancing services

Description	
Use Case Name	Stationary and EV fleets load for local balancing services
Version	V0.1
Last Update	12/06/18
Authors	EMOT, ASM
Brief Description	Aggregator offers to DSO its portfolio of EVs and batteries to satisfy DSO flexibility request.
Assumptions and Pre-Conditions	Exceeding power production; Deployed EVs and EVSEs; The EVSE and EV data will be handled considering the EU and national laws regarding privacy and data protection; Data should be reliable and consistent; EVSE unique identifier; EV unique identifier; Security in communications;

	Connectivity and Interoperability between EV and EVSE systems.
Target	Reduce reverse power flow
Effects/Post Conditions	Correct communication between actors. Overview on the status of the EVSE portfolio and the EV fleet. Overview on the local grid status.
Involved Actors	Aggregator/EV Fleet Manager
Use Case Initiation	DSO send a DR campaign to Aggregator
Main course	Begin 1. DSO detects the presence of reverse power flow in the network; this is caused by the inability of the loads adjacent to the PV plant to consume all the energy produced by the PV plant (mainly at lunchtime). 2. To remedy this, the DSO sends a request for flexibility to the aggregator, who, thanks to the continuous real-time monitoring of its loads, has the possibility of giving an immediate response to the DSO, and, if possible, satisfy the DSO's request by charging electric vehicles and batteries. End
Alternative Courses	-
Relationships with other Use Cases	HL-UC01_LL-UC07
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures; Weather data availability; Multi-Building DR characterization through thermal, optical and LIDAR information fusion; Forecast of electricity production / consumption; Baseline load calculations in DR programs; PV/RES Degradation and Trend Analysis; Graph-based analytics; Big Data Clustering at Multiple Scale; VPP & Customer Segmentation and Profiling Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition; Forecast of electricity production/consumption at the grid level; EVSEs and EV fleet monitoring; EVSE remote control; Baseline flexibility estimation; Interactive Multi-purpose Visualization for system flexibility services; Secure data handling; LV grid congestion control through flexibility management; Prosumers flexibility monitoring and DR tracking; Peer to peer local energy trading among prosumers; Interactive Visualization to customize self- enforcing smart contracts for prosumer bidding and scheduling

	in electricity markets; Closed loop DR verification and Financial settlement

Table 12: HL-UC01_LL-UC08: Stationary and EV fleets load for local balancing services

HL-UC01_LL-UC09: DSO Direct Control of Grid Load

Description	
Use Case Name	DSO Direct Control of Grid Load
Version	V0.2
Last Update	20/06/2018
Authors	E@W, TUC
Brief Description	If insufficient flexibility is available to avoid an overload so the regime for that grid part switches to orange. The DSO then directly intervenes by technically limiting connection capacity or using direct control of prosumers assets.
Assumptions and Pre-Conditions	Insufficient flexibility is made available by the aggregators in relation with the forecast congestion point
Target	Establish a mechanism for grid control when flexibility is not available
Effects/Post Conditions	Application of mechanism for grid control when insufficient flexibility is made available by the aggregators in relation with the forecast congestion point
Involved Actors	DSO, Prosumers
Use Case Initiation	The DSO wants to avoid a congestion point
Main course	Begin 1. The flexibility market is overruled by the DSO 2. DSO use the DR optimization toolset to identify the optimal scheduling among prosumers to relax congestions 3. DSO directly controls the prosumers assets 4. After avoiding the congestion point the situation returns to normal End
Alternative Courses	-
Relationships with other Use Cases	-

Architectural Elements/Services Involved	Decision Making and DR Optimization

Table 13: HL-UC01_LL-UC09: DSO Direct Control of Grid Load

HL-UC01_LL-UC10: DSO-Aggregators financial settlement

Description	
Use Case Name	DSO-Aggregator Flexibility request settlement
Version	V0.2
Last Update	20/06/2018
Authors	ENG, TUC
Brief Description	Financial settlement between the DSO and aggregators
Assumptions and Pre-Conditions	The aggregator successfully provided the agreed flexibility to the DSO
Target	To pay the aggregators for the flexibility service
Effects/Post Conditions	The aggregators are paid based on the amount of flexibility delivered
Involved Actors	Aggregator; DSO
Use Case Initiation	DSO
Main course	Begin 1. Aggregators have addressed a flexibility order from DSO leveraging on its enrolled prosumers; 2. DSO pays the aggregators by normalizing the flexibility request associated enumeration with the share of flexibility delivered by each aggregator; End
Alternative Courses	HL-UC01_LL-UC09
Relationships with other Use Cases	HL-UC01_LL-UC07

Architectural Elements/Services Involved	Closed loop DR verification and Financial settlement;

Table 14: HL-UC01_LL-UC10: DSO-Aggregators financial settlement

4.2 HL-UC02: Peer-to-peer local energy trading

In the table below has been reported the High Level description of this Use case:

Description	
Use Case Name	Peer-to-peer local energy trading
Version	V0.2
Last Update	20/07/2018
Authors	TUC
Brief Description	Prosumers trade energy in a peer-to-peer fashion either directly or through an energy aggregator if they are not big enough
Assumptions and Pre-Conditions	Prosumers are willing to buy or sell energy. Prosumers are registered with the energy trading platform or with the energy aggregator.
Target	Establish a mechanism for decentralized price driven energy trading.
Effects/Post Conditions	Prosumers are enabled to the energy trading in a decentralized market.
Involved Actors	Prosumers, Aggregator
Use Case Initiation	Market session is launched
Main course	Begin 1. Prosumers either directly or indirectly via energy aggregators submit energy bids and offers using their predefined self-enforcing smart contracts;

	2. The bids and offers are validated to ensure that the energy trading market session rules are not violated; 3. Session clearing price is being determined and the bid and offers are optimally matched; 4. Prosumers accept the matched offers/bids representing their commitment to inject/withdraw the quantity of energy specified; 5. Energy transactions are generated, replicated in all the nodes and validated 6. Energy transactions are fully confirmed when the new block containing them will added to the blockchain. End
Alternative Courses	-
Relationships with other Use Cases	HL-UC02_LL-UC01 and following
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures; Weather data availability; Multi-Building DR characterization through thermal, optical and LIDAR information fusion; Forecast of electricity production / consumption; Baseline load calculations in DR programs; PV/RES Degradation and Trend Analysis; Graph-based analytics; Big Data Clustering at Multiple Scale; VPP & Customer Segmentation and Profiling; Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition; Forecast of electricity production/consumption at the grid level; EVSEs and EV fleet monitoring; EVSE remote control; Baseline flexibility estimation ;Interactive Multi-purpose Visualization for system flexibility services; Secure data handling; LV grid congestion control through flexibility management; Prosumers flexibility monitoring and DR tracking; Peer to peer local energy trading among prosumers; Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets; Closed loop DR verification and Financial settlement

Table 15: HL-UC02: Peer-to-peer local energy trading

The relative Use Case Diagram, in which are represented all the expected interaction between the Actors and eDREAM platform for this scenario, is reported in the figure below:

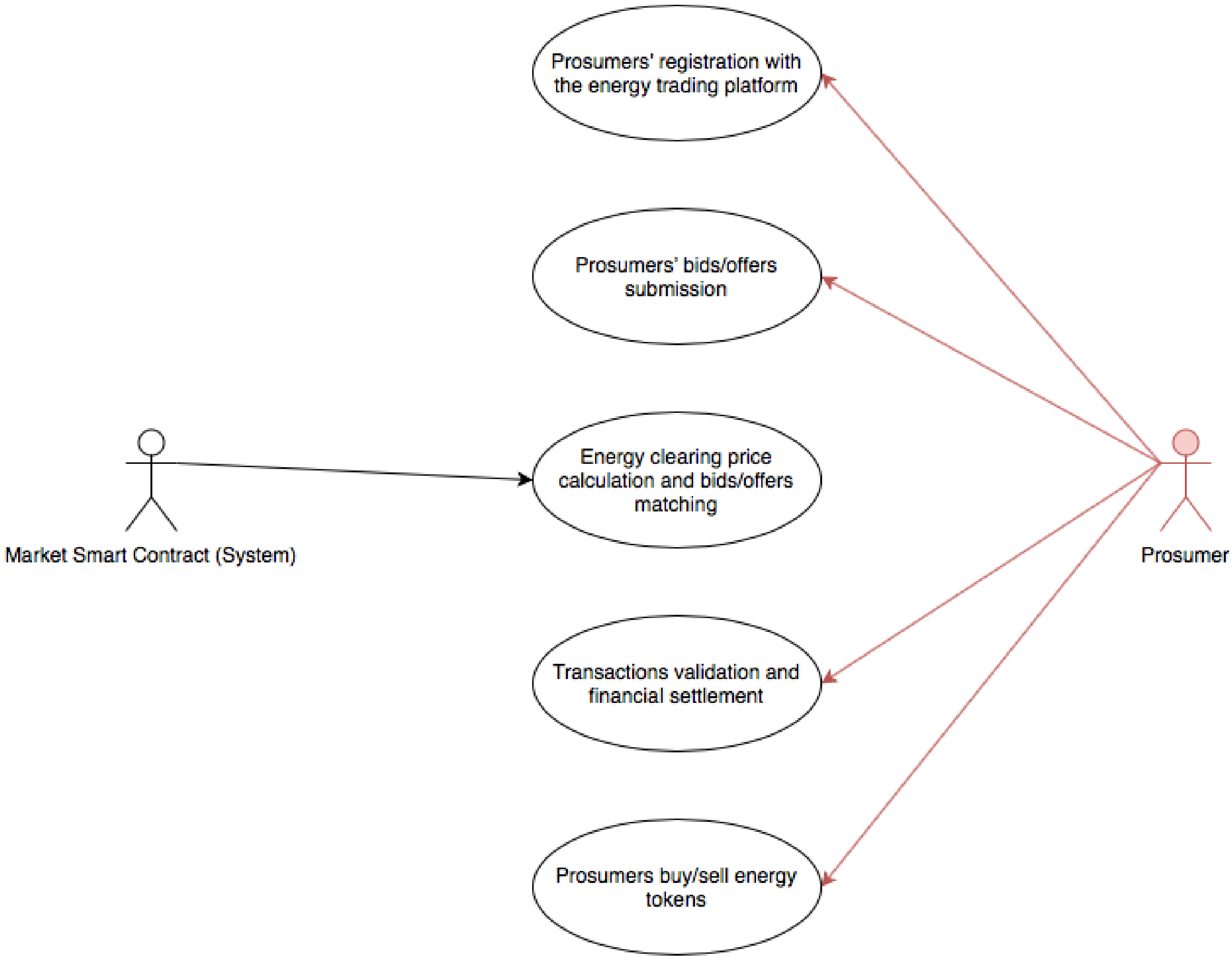

Figure 5 Peer-to-peer local energy trading General Use Case Diagram

The detailed description of the relative Low Level Use Cases is reported in the following tables:

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

Description	
Use Case Name	Prosumers registration with the energy trading platform
Version	V0.1
Last Update	21/06/2018
Authors	TUC
Brief Description	Prosumers register with the blockchain trading platform to have permission to trade energy.
Assumptions and Pre-Conditions	Data about the prosumer identification and energy production/demand is available. The energy trading platform is operational
Target	Establish a mechanism for enrolling prosumers with the energy trading market
Effects/Post Conditions	The prosumer is registered with the energy trading market
Involved Actors	Prosumers
Use Case Initiation	Prosumer would like to trade energy with the blockchain based energy market
Main course	Begin 1. Prosumers use the energy market interface to provide information required for their registration; 2. A self-enforcing smart contract will validate their registration; 3. Prosumers will buy energy token needed to transacting energy which will be deposit in their wallets; 4. Prosumers will use market smart contracts definition front end to customize the smart contracts defining their energy trading rules End
Alternative Courses	-
Relationships with other Use Cases	HL-UC02_LL-UC02
Architectural Elements/Services Involved	Peer to peer local energy trading among prosumers; Interactive Visualization to customize self-enforcing smart

	contracts for prosumer bidding and scheduling in electricity markets;

Table 16: HL-UC02_LL-UC01: Prosumers registration with the energy trading platform

HL-UC02_LL-UC02: Prosumers bids/offers submission

Description	
Use Case Name	Prosumers bids/offers submission
Version	V0.1
Last Update	21/06/2018
Authors	TUC
Brief Description	Prosumers submit bids/offers of energy with the energy market
Assumptions and Pre-Conditions	The prosumer is registered with the energy trading market
Target	Establish a mechanism for prosumers to submit their bids/offers of energy
Effects/Post Conditions	The bids/offers are submitted
Involved Actors	Prosumers
Use Case Initiation	Prosumer would like to submit energy bids/offers with the blockchain based energy market
Main course	Begin 1. Prosumers use the energy market interface to provide information required to submit bids/offers (e.g. amount of energy) 2. Prosumers must associate with the bid/offer a number of tokens equivalent with the amount of energy in bid/offer (e.g. 1 token = 1 Kw) 3. Market smart contract validates the bid/offers against the session rules; End
Alternative Courses	-
Relationships with other Use Cases	HL-UC02_LL-UC03
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures; Weather data availability;

	Multi-Building DR characterization through thermal, optical and LIDAR information fusion; Forecast of electricity production / consumption; DR optimal design; PV/RES Degradation and Trend Analysis; Graph-based analytics; Big Data Clustering at Multiple Scale; VPP & Customer Segmentation and Profiling; Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition; Forecast of electricity production/consumption at the grid level; EVSEs and EV fleet monitoring; EVSE remote control; Baseline flexibility estimation; Interactive Multi-purpose Visualization for system flexibility services; Secure data handling; LV grid congestion control through flexibility management; Prosumers flexibility monitoring and DR tracking; Peer to peer local energy trading among prosumers; Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets.

Table 17: HL-UC02_LL-UC02: Prosumers bids/offers submission

HL-UC02_LL-UC03: Energy clearing price determination

Description	
Use Case Name	Energy clearing price determination
Version	V0.1
Last Update	21/06/2018
Authors	TUC
Brief Description	Establish the energy price per market session
Assumptions and Pre-Conditions	Market session is opened, bids/offers had been submitted
Target	Determine the energy trading price

Effects/Post Conditions	The bids/offers are submitted
Involved Actors	-
Use Case Initiation	End of market session
Main course	Begin 1. market level smart contract aggregates and sort the energy supply offers in ascending order 2. market level smart contract aggregates and sort the energy demand bids in descending order 3. the intersection point between the two curves gives the market-clearing price; 4. bids/offers matching market actions: 4.1. the offers (supply) with the price lower than the clearing price 4.2. the bids (demand) with the price higher than the clearing price End
Alternative Courses	-
Relationships with other Use Cases	HL-UC02_LL-UC04
Architectural Elements/Services Involved	Peer to peer local energy trading among prosumers; Closed loop DR verification and Financial settlement.

Table 18: HL-UC02_LL-UC03: Energy clearing price determination

HL-UC02_LL-UC04: Transactions validation and financial settlement

Description	
Use Case Name	Transactions validation and financial settlement
Version	V0.1
Last Update	21/06/2018
Authors	TUC
Brief Description	Validate energy transactions and settle prosumers accounts
Assumptions and Pre-Conditions	Market session is ended

Target	Allocate tokens to the prosumers accounts/wallets
Effects/Post Conditions	Tokens are allocated to prosumers
Involved Actors	Prosumers
Use Case Initiation	End of market session
Main course	Begin 1. Based on the stake (i.e. number of tokens) committed per market session 1 prosumer is selected as block miner 2. It aggregates transactions in a block which is then replicated to all the prosumers 3. The block is validated and added to the chain End
Alternative Courses	-
Relationships with other Use Cases	-
Architectural Elements/Services Involved	Peer to peer local energy trading among prosumers; Closed loop DR verification and Financial settlement.

Table 19: HL-UC02_LL-UC04: Transactions validation and financial settlement

HL-UC02_LL-UC05: Prosumers buy/sell energy tokens

Description	
Use Case Name	Prosumers buy/sell energy tokens
Version	V0.1
Last Update	21/06/2018
Authors	TUC
Brief Description	Validate energy transactions and settle prosumers accounts
Assumptions and Pre-Conditions	Market session is ended
Target	Implement a mechanism to allow prosumers to buy tokens and deposit them in their account/wallets
Effects/Post Conditions	Tokens are allocated to prosumers
Involved Actors	Prosumer
Use Case Initiation	End of market session

Main course	Begin 1. A fixed number of tokens are generated initially having an equivalent energy amount and price; 2. upon prosumers registration or on demand they may be bought/sold 3. prosumers deposit money in their accounts which are then used to by energy tokens which are feed to their wallets End
Alternative Courses	-
Relationships with other Use Cases	-
Architectural Elements/Services Involved	Peer to peer local energy trading among prosumers; Interactive Visualization to customize self-enforcing smart contracts for prosumer bidding and scheduling in electricity markets

Table 20: HL-UC02_LL-UC05 Prosumers buy/sell energy tokens

4.3 HL-UC03: VPP in Energy Community

In the table below has been reported the High Level description of this Use case:

Description:	
Use Case Name	Virtual Power Plant in Energy Community
Version	V0.2
Last Update	13rd August 2018
Authors	ATOS, ENG, E@W, ASM
Brief Description	A large set of customers, prosumers and producers are virtually gathered and connected in an Energy Community in order to achieve self-sufficiency and eventually export power surplus or ancillaries to the grid. An aggregator coordinates the active and passive users participating in this community. In such scenario an internal under-generation from RES – due to sudden weather changes – will force controllable community's generators to overproduce in order to cover RES drop. On the other hand, passive users may reduce their loads if necessary. In particular, the aggregator or VPP energy manager assess the potential of the managed resources, analysing prosumers'

	profiles, enabling the participation to reserve- or frequency services. After the assignment of the different prosumers in VPP to a specific profile pattern, the export capacity forecast is applied to a trading strategy which maintains a day-ahead schedule, as well as offers capacity to the imbalance market.
Assumptions and Pre-Conditions	Aggregator achieves to gather a large number of prosumers in a given grid section, participating in the Energy Community programmes.
Target	Ensuring balance between production and consumption in the Energy Community through the control of dispatchable generators and the curtailment of loads. Aggregator is able to run analysis in order to identify setpoints of dispatchable generators and load profiles of users, in order to balance energy demand. Maximise utilisation and revenues from RES and classic generation sources through different ancillary services such as reserve markets, frequency services, intra-day trading and imbalance market.
Effects/Post Conditions	Aggregator is able to perform big data analysis in order to profile loads to be shed and to identify setpoints of dispatchable generators. Thanks to this, the aggregator is able to enable the prosumers participation to reserve or frequency services and to apply trading strategy which maintains a day-ahead schedule, as well as offers capacity to the imbalance market.
Involved Actors	Aggregators, VPP Energy Managers, Prosumers/Producers, System Operators and/or Distribution Network Operators, Suppliers
Use Case Initiation	Aggregator detects a short-term RES decrease in a part of its customers' portfolio arranged in energy community. This drop may originate a mismatch between power generation and consumption in the community.
Main course	Begin 1. Aggregator receives data of short term generation forecasting, customers' behaviour, and power demand and supply in community's nodes;

	2. Aggregator needs to perform clusterization of data received and sets initial parameters in order to categorize active and passive users' curves to assign each prosumer to a specific profile pattern; IF the aggregator has to provide Reserve or Frequency services 3. Prosumers' profiles are analysed in order to extract their capability; If Reserve Services a. Loads and generators profiles together with VPP capability assessment and forecasting data are used to obtain optimal setpoints for generators and load curtailment according to the RES drop Energy Community scenario. If Frequency Services b. The portfolio is rebalanced excluding assets which do not meet the requested response time and the qualified assets are assigned to specific services (Dynamic, Static, Enhanced) based on their generation profile. ELSE have to implement Market Services 4. Aggregator or VPP energy manager evaluate 30 minutes export capacity through forecasting tools if Wholesale Market – Intraday trading a. VPP launched an offer on the wholesale market for the next 30 minutes slot if Imbalance market b. 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. End
Alternative Courses	1. Prosumers realize imminent DR request and intentionally change consumptions in order to alter their own baseline; 3. Aggregators are not able to achieve the capability internally required by community; 3. (a), (b) Generation assets are aggregated into fix size portfolio and do not serve local community; 4. (a) The variable part of the generation portfolio which cannot be committed the week or the day ahead in other markets is wasted; 4. (b) The variable part of the generation portfolio is monetised through the wholesale market and price peaks are missed (opportunity cost).

Relationships with other Use Cases	HL-UC03_LL-UC01, HL-UC03_LL-UC02, HL-UC03_LL-UC03, HL-UC03_LL-UC04, HL-UC03_LL-UC05, HL-UC03_LL-UC06, HL-UC03_LL-UC07
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures; Weather data availability; Multi-Building DR characterization through termal, optical and LIDAR information fusion; Forecast of electricity production / consumption; PV/RES Degradation and Trend Analysis; Graph-based analytics; Big Data Clustering at Multiple Scale; VPP & Customer Segmentation and Profiling; Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition.

Table 21: HL-UC03: VPP in Energy Community

The relative Use Case Diagram, in which are represented all the expected interaction between the Actors and eDREAM platform for this scenario, is reported in the figure below:

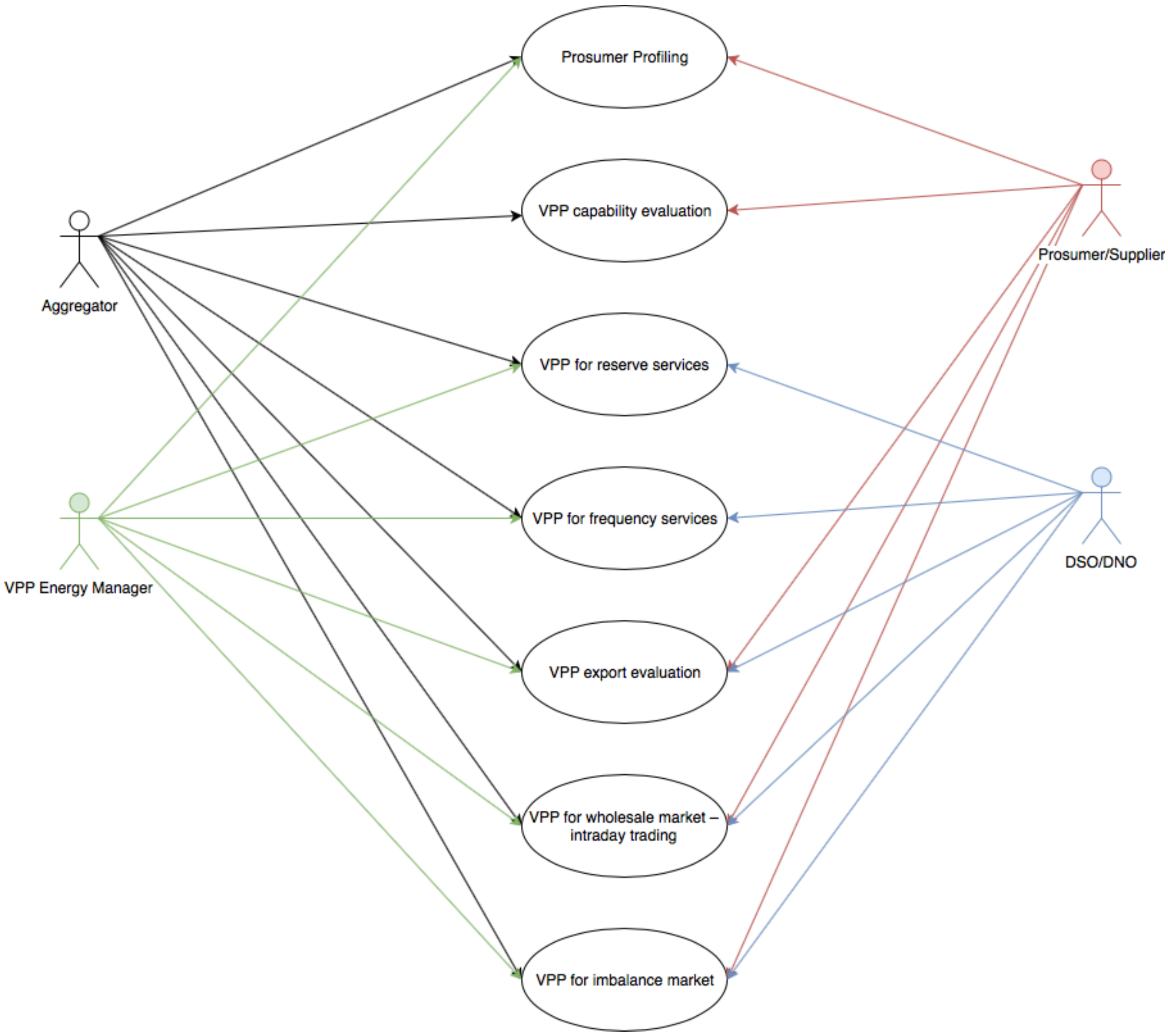

Figure 6 VPP in Energy Community General Use Case Diagram

The detailed description of the relative Low Level Use Cases is reported in the following tables:

HL-UC03_LL-UC01: Prosumers profiling

Description:	
Use Case Name	Prosumers profiling
Version	V0.2
Last Update	13rd August 2018
Authors	ATOS, ENG, E@W, ASM
Brief Description	Aggregator receives data of short term generation forecasting, customers' behaviour, and power demand and supply in community's nodes, from the "field data aggregation" layer and the "techniques for DR flexibility assessment" layer of eDREAM

	platform to categorize and assign each prosumer to a specific profile pattern
Assumptions and Pre-Conditions	Aggregator achieves to gather a large number of prosumers in a given grid section
Target	Aggregator is able to run analysis to identify setpoints of dispatchable generators and new load profiles of users, in order to balance energy demand.
Effects/Post Conditions	Aggregator is able to perform big data analysis in order to profile loads to be shed and to identify setpoints of dispatchable generators.
Involved Actors	Aggregators, VPP Energy Managers, Prosumer
Use Case Initiation	Aggregator detects a short-term RES decrease in a part of its customers portfolio arranged in energy community.
Main course	Begin 1. Aggregator receives data of short term generation forecasting, customers' behaviour, and power demand and supply in community's nodes, from the "field data aggregation" layer and the "techniques for DR flexibility assessment" layer of eDREAM platform. 2.Data from customers are disaggregated in order to separate uninterruptible loads from curtailable ones; 3.Data pre-processing: data from loads and generation are prepared to be sent to the clusterization algorithm; 4.Big Data Clustering: data already pre-processed are clusterized through data analytics techniques. Aggregator sets initial parameters in order to perform clusterization; 5.VPP Segmentation: active and passive users' curves are categorized in order to assign each prosumer to a specific profile pattern; End
Alternative Courses	Prosumers realize imminent DR request and intentionally change consumptions in order to alter their own baseline.
Relationships with other Use Cases	HL-UC03_LL-UC01, HL-UC03_LL-UC02, HL-UC03_LL-UC03, HL-UC03_LL-UC04, HL-UC03_LL-UC05, HL-UC03_LL-UC06, HL-UC03_LL-UC07
Architectural Elements/Services Involved	Electric meters, edge and field device electric measures; Weather data availability; Multi-Building DR characterization through thermal, optical and LIDAR information fusion; Forecast of electricity production / consumption;

	PV/RES Degradation and Trend Analysis; Graph-based analytics; Big Data Clustering at Multiple Scale; VPP & Customer Segmentation and Profiling; Interactive Visualization for VPP coalition;

Table 22: HL-UC03_LL-UC01: Prosumers Profiling

HL-UC03_LL-UC02: VPP capability evaluation

Description:	
Use Case Name	Virtual Power Plant capability evaluation
Version	V0.2
Last Update	13/08/2018
Authors	ATOS, ENG, E@W, ASM, KIWI
Brief Description	The aggregator or VPP energy manager, needs to assess the potential of the managed resources, analysing prosumers' profiles, enabling the participation to reserve or frequency services.
Assumptions and Pre-Conditions	Prosumers data is already analysed, prosumers are categorized and profiled.
Target	To assess the aggregated potential of the different RES and classic generation sources managed by the aggregator.
Effects/Post Conditions	The aggregator knows the capability of its portfolio.
Involved Actors	Aggregator, Prosumers
Use Case Initiation	The aggregator needs to know the capability in order to provide ancillary services such as reserve services or frequency services.
Main course	Begin 1. After the categorization of available loads and generators, 2. prosumers' profiles are analysed in order to extract their available capability; End
Alternative Courses	Aggregators are not able to achieve the capability required for implementation of ancillary services;

Relationships with other Use Cases	HL-UC03_LL-UC03, HL-UC03_LL-UC04
Architectural Elements/Services Involved	Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Interactive Visualization for VPP coalition;

Table 23: HL-UC03_LL-UC02: VPP capability evaluation

HL-UC03_LL-UC03: VPP for Reserve Services

Description:	
Use Case Name	VPP for Reserve services
Version	V0.2
Last Update	13/08/ 2018
Authors	ENG, E@W, ASM, KIWI
Brief Description	A number of different RES and classic generation sources such as CHPs, Diesel and gas generators are aggregated into a generation portfolio for bidding into Reserve market (STOR, DSBR, Fast Reserve).
Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers in a given grid section, participating in an Energy Community programmes with different RES and classic generation sources accessing to reserve markets as an aggregated portfolio.
Target	Maximise utilisation and revenues from RES and classic generation sources through accessing Reserve markets as an aggregated portfolio.
Effects/Post Conditions	Aggregator is able to perform big data analysis in order to profile loads to be shed and to identify set points of dispatchable generators. From the aggregation perspective, this creates the premises of maximizing the revenue from the capability available by always using the aggregated portfolio in the reserve service.
Involved Actors	Aggregators, VPP Energy Managers, System Operators and/or Distribution Network Operators, Prosumer.
Use Case Initiation	Reserve services dispatch from System Operator
Main course	Begin

	1. The VPP optimization engine uses as input loads and generators profiles together with VPP capability assessment and consumption/generation forecast 2. Optimal setpoints for generators and load curtailment are determined according to the RES drop Energy Community scenario. 3. Profiles are aggregated to obtain curve with different profile from that of any of its individual components End
Alternative Courses	• Prosumers realize imminent DR request and intentionally change consumptions in order to alter their own baseline; • Aggregators are not able to achieve the capability required for implementation of ancillary services;
Relationships with other Use Cases	HL-UC03_LL-UC02
Architectural Elements/Services Involved	Decision Making and DR Optimization; Interactive Visualization for VPP coalition;

Table 24: HL-UC03_LL-UC03: VPP for Reserve Services

HL-UC03_LL-UC04: VPP for Frequency Services

Description:	
Use Case Name	Virtual Power Plant for Frequency Services
Version	V0.2
Last Update	13/08/ 2018
Authors	ENG, E@W, ASM, KIWI
Brief Description	A number of different RES and classic generation sources such as CHPs, Diesel and gas generators are aggregated into a generation portfolio for bidding into Frequency services markets (Dynamic, Static)
Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers in a given grid section, participating in an Energy Community programmes with a variety of RES and classic generation assets
Target	Maximise utilisation and revenues from RES and classic generation sources through accessing Frequency response markets

Effects/Post Conditions	Aggregator is able 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
Involved Actors	Aggregators, VPP Energy Managers, System Operators and/or Distribution Network Operators.
Use Case Initiation	Frequency trips below or above specified set points
Main course	Begin 1. Assets profiles and VPP capability assessment are used to identify set points and response times 2. 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. 3. Availability declarations are updated with the System operator End
Alternative Courses	1. Generation assets are aggregated into fix size portfolio and do not serve local community 2. Aggregators are not able to achieve the capability required for implementation of ancillary services;
Relationships with other Use Cases	HL-UC03_LL-UC05
Architectural Elements/Services Involved	Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition;

Table 25: HL-UC03_LL-UC04: VPP for Frequency Services

HL-UC03_LL-UC05: VPP export evaluation

Description:	
Use Case Name	Virtual Power Plant export evaluation
Version	V0.2
Last Update	13/08/2018
Authors	E@W, ENG, KIWI, ASM

Brief Description	After the assignment of the different prosumers in VPP to a specific profile pattern, the export capacity forecast is applied to a trading strategy which maintains a day-ahead schedule, as well as offers capacity to the imbalance market.
Assumptions and Pre-Conditions	Prosumers are categorized and profiled
Target	To forecast VPP export capacity in order to apply it to a trading strategy
Effects/Post Conditions	Estimation of accurate 30 minutes generation and load forecasts to allow to the aggregator to perform big data analysis 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
Involved Actors	Aggregators, VPP Energy Managers, System Operators and/or Distribution Network Operators, Prosumer
Use Case Initiation	Aggregator need to know the VPP export capacity to implement trading services such as intraday trading and imbalance market
Main course	Begin 1. Categorization of available generators and local consumption 2. 30 minutes export capacity is forecast. End
Alternative Courses	Trading services could be applied with no capacity forecasting having lower performance
Relationships with other Use Cases	HL-UC03_LL-UC06 HL-UC03_LL-UC07
Architectural Elements/Services Involved	Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Interactive Visualization for VPP coalition;

Table 26: HL-UC03_LL-UC05: VPP export evaluation

HL-UC03_LL-UC06: VPP for Wholesale Market – Intraday trading

Description:	
Use Case Name	Virtual Power Plant for Wholesale Market – Intraday trading
Version	V0.2
Last Update	13/08/2018
Authors	E@W, ENG, KIWI, ASM
Brief Description	A number of different RES and classic generation sources such as CHPs, Diesel and gas generators are aggregated into a generation portfolio for optimised support of local demand as well as bidding into the Wholesale Market – Intraday trading

Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers in a given grid section, participating in an Energy Community programmes with a variety of RES and classic generation assets; Aggregator also has a supply licenses or an agreement with a supplier to be allowed to bid in the Wholesale market.
Target	Maximise utilisation and revenues from RES and classic generation sources through accessing the Wholesale Market via intra-day trading services
Effects/Post Conditions	Aggregator is able to perform big data analysis in order to profile loads to be shed and to identify set points of dispatch able generators as well as response times from each type of generation asset; Accurate 30 minutes generation and load forecasts needed.
Involved Actors	Aggregators, VPP Energy Managers, System Operators and/or Distribution Network Operators, Supplier
Use Case Initiation	Prices on the Wholesale reach a certain threshold.
Main course	Begin 1. Estimation of accurate 30 minutes generation and load forecasts to forecast the VPP export capacity; 2. VPP launched an offer on the wholesale market for the next 30 minutes slot; 3. 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. 4. 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. End
Alternative Courses	Generation assets are aggregated into fix size portfolio and do not serve local community The variable part of the generation portfolio which cannot be committed the week or the day ahead in other markets is wasted.
Relationships with other Use Cases	HL-UC03_LL-UC05

Architectural Elements/Services Involved	Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition;

Table 27: HL-UC03_LL-UC06: VPP for Wholesale Market – Intraday trading

HL-UC03_LL-UC07: VPP for Imbalance market

Description:	
Use Case Name	Virtual Power Plant for Imbalance market
Version	V0.2
Last Update	13 August 2018
Authors	E@W, ENG, KIWI, ASM
Brief Description	A number of different RES and classic generation sources such as CHPs, Diesel and gas generators are aggregated into a generation portfolio for optimised support of local demand as well as bidding into Imbalance market
Assumptions and Pre-Conditions	Aggregator has access to a large number of prosumers in a given grid section, participating in an Energy Community programmes with a variety of RES and classic generation assets; Aggregator also has a supply licenses or an agreement with a supplier to be allowed to bid in the Wholesale market.
Target	Maximise utilisation and revenues from RES and classic generation sources through accessing the Imbalance markets
Effects/Post Conditions	Aggregator is able to perform big data analysis in order to profile loads to be shed and to identify set points of dispatch able generators as well as response times from each type of generation asset; Accurate 30 minutes generation and load forecasts needed.
Involved Actors	Aggregators, VPP Energy Managers, System Operators and/or Distribution Network Operators, Bilateral agreements with Suppliers
Use Case Initiation	Prices on the Imbalance reach a certain threshold.
Main course	Begin 1. Estimation of accurate 30 minutes generation and load forecasts to forecast the VPP export capacity;

	2. 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 3. 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. 4. 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. End
Alternative Courses	Generation assets are aggregated into fix size portfolio and do not serve local community The variable part of the generation portfolio is monetised through the wholesale market and price peaks are missed (opportunity cost)
Relationships with other Use Cases	HL-UC03_LL-UC05
Architectural Elements/Services Involved	Virtual Power Plant Generation Modelling and Optimal Coalition Forecasting; Decision Making and DR Optimization; Interactive Visualization for VPP coalition;

Table 28: HL-UC03_LL-UC07: VPP for Imbalance market

5. Conclusions

The purpose of this document was to identify the preliminary set of use cases (presented in section five) and relative scenarios (section four). The emerging neighbourhood market of energy and energy services, provides the context of this work, in the setting of active microgrids which aim to maximize local self-consumption reducing the energy exchange to the higher-level grid. Use cases and scenarios will be used to define the system technical and functional requirements, driving the components design. In an iterative approach, this set of use cases and scenarios will be presented to the stakeholders for further refinement. This is the first version of the document, a consolidated version and the final version of the use cases and scenarios will be presented in due course. Specifically, work on the preliminary use cases and related scenarios collected will be reported in the second version, including a deployment guideline (D2.7, M20). Moreover, the third and final version will report on work to clearly collect the user requirements as well as the eDREAM framework deployment guidelines (D.2.9, M30).

References

[1]. IEC 62559-2:2015: Use case methodology – Part 2: Definition of the Templates for Use Cases, Actor List, and Requirements List, 2015.

[2]. CEN-CENELEC-ETSI Smart Grid Coordination Group, Version 2.0, "SG-CG/ M490/F_ Overview of SG-CG Methodologies," 08/2014.

[3]. Alistair Cockburn, Basic Use Case Template, http://cis.bentley.edu/lwaguespack/CS360_Site/Downloads_files/Use%20Case%20Template%20%28Cockburn%29.pdf

[4]. Dan T. Ton and Merrill A. Smith, The U.S. Department of Energy's Microgrid Initiative, The Electricity Journal, (2012), 84-94 .

[5]. R. Buhler, Integration of Renewable Energy Sources Using Microgrids, Virtual Power Plants and the Energy Hub Approach, EEH Power System Laboratory - Swiss Federal Institute of Technology (ETH) Zurich, (2012), 1-32.

[6]. VPP Intelligent Energy, Sales & production management, https://vpp.hu/eng/53/sales_production_management

[7]. M.M. Othman, Y. G. Hegazy, A. Y. Abdelaziz, A review of Virtual power plant Definitions, Components, Framework and Optimization, International Electrical Engineering Journal (IEEJ), (2015), 2010-2024. http://www.ieejournal.com/

[8]. Smart City Cluster FP7 Collaboration, Task 4. Measurement and Verification Methodology for Energy, Environmental and Economic Efficiency Metrics, https://www.slideshare.net/DC4Cities/smart-city-cluster-collaboration-task-4-measurement-and-verification-methodology-for-energy-environmental-and-economic-efficiency-metrics

[9]. C. Pop, T. Cioara, M. Antal, I. Anghel, I. Salomie, M. Bertoncini, Blockchain Based Decentralized Management of Demand Response Programs in Smart Energy Grids, sensors (2018) 1–21.