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

DELIVERABLE: D2.3 – eDREAM Standardization Report and Regulatory Roadmap

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Executive Summary

Starting from the preliminary analysis on existing international standards for energy data described in Annex 1 of the Grant Agreement, this document presents information about relevant data standards. The standards govern the way the information is acquired, presented, controlled, communicated and acted upon across heterogeneous near real-time information sources (buildings, active plants, distribution grid, storage systems, etc.) They will be further considered among key architectural elements of the eDREAM framework. This document also defines a multi-purpose vocabulary (conceptual schema) accompanied with corresponding data models, in order to define a framework that will provide interoperability to the developed eDREAM solutions. Moreover, the document reports various regulatory aspects of both Aerial survey techniques for DR potential estimation and the use of both blockchain based smart contracts and blockchain based virtual currencies within the energy domain. Finally, a list of platform Key Performance Indicators (KPIs) and corresponding metrics is collected for the purpose of assessing the efficacy of the eDREAM platform at different levels: prosumers-related metrics, and power network metrics. The identified KPIs take into account the following benefits identified by the EC Smart Grid Task Force: increased sustainability, adequate capacity of distribution grids for 'collecting' and bringing electricity to the consumers, adequate grid connection and access for all kinds of grid users, satisfactory levels of security and quality of supply, enhanced efficiency and better service in electricity supply and grid operation, enhanced consumer awareness and participation in the market by new players, and enabling consumers to make informed decisions related to their energy demand in order to meet the EU Energy Efficiency targets.

Production of this document was a result of a desktop research applied to collect and analyse evidence from various published information sources, including those from ongoing projects and initiatives, such as the Joint Research Centre reports, IEEE, and the respective framework from the European Electricity Grid Initiative (EEGI). Key technical information was also collected from technical partners by means of circulated tables, which are attached in Annex 1.

Table of Contents

List of Figures 5
List of Tables 5
List of Acronyms and Abbreviations 6
1 Introduction 8
1.1 Scope and objectives of the deliverable 8
1.2 Structure of the deliverable 9
1.3 Relation to other Tasks and Deliverables 9
1.4 Methodology 10
2 Definition and collection of data standards 11
2.1 International standards for energy data 11
2.1.1 Main international energy data and communication standards 11
2.1.2 IoT Communication standards 13
2.1.3 Blockchain standards 14
2.2 Multi-purpose vocabulary and project related terminology 15
2.2.1 Power network, demand response and prediction technique terminology 16
2.2.2 Aerial survey terminology 17
2.2.3 Related projects and commercial tools 20
2.2.4 Related external entities 24
2.2.5 Data standards, conventions and communication protocols 27
2.2.6 Ontologies and schemata 31
2.3 Data models 34
2.3.1 DR aerial survey toolkit 35
2.3.2 Electricity Consumption/ Production Forecasting 36
2.3.3 Big data engine tool, Big data Clustering at Multiple Scales 41
2.3.4 HMI Data, eDREAM core platform 43
3 Regulatory requirements 46
3.1 Aerial survey regulations in the UK 46
3.2 Blockchain regulations in energy domain 48
3.2.1 Blockchain- based smart contracts 49
3.2.2 Blockchain-based remuneration platform 49
4 Key Performance Indicators 50
4.1 Prosumers-related metrics 50
4.2 Power network metrics 56
5 Conclusions 65
References 67

ANNEX 1: Data exchange information collection template 70

List of Figures

Figure 1- International harmonized stage codes- ISO 15
Figure 2- Considered eDREAM data models (in callouts) in relation to the envisioned project concept 34
Figure 3- eDREAM Data Model for electricity consumption/production forecasting 39
Figure 4- Structure of data received by Big Data Engine Tool and Load Profiling and Disaggregation components 41
Figure 5- HMI Data Structure 45

List of Tables

Table 1: Main international (IEC) Energy data standards 13
Table 2- Main IoT-communications related standards 14
Table 3- Current development level of IEC/TC 307 blockchain standards in December 2018 15
Table 4- Power network, demand response and prediction technique terminology 17
Table 5- Aerial survey terminology 19
Table 6- Related projects and commercial products 23
Table 7- Related external entities 27
Table 8- Data standards, conventions and communication protocols 30
Table 9- Ontologies and schemata 33
Table 10- DR Aerial survey data model for DR aerial survey toolkit component..............................35
Table 11- ASM Terni Living lab electrical monitoring data model for Electricity Consumption/ Production Forecasting component 36
Table 12- Weather data model for Electricity Consumption/ Production Forecasting component ..37
Table 13- Device information data model for Electricity Consumption/ Production Forecasting component 37
Table 14- Prosumer monitoring data model for Electricity Consumption/ Production Forecasting component 38
Table 15- Micro Grid Monitoring data model for Electricity Consumption/ Production Forecasting component 39
Table 16- Electrical Vehicles and charging stations data 40
Table 17- Chiller data & Air Handling Units (AHU) data 40
Table 18- Data sample: Chiller data & Air Handling Units (AHU) data 41
Table 19- Smart Meters Raw Data from ASM 42
Table 20- ASM Prosumers profiles 42
Table 21- ASM Prosumers clusters 43
Table 22- Data related to HMI 44
Table 23- Prosumers KPI Classification- Demand Response in electricity, power, GHG, economy and social impact 54
Table 24- Prosumers KPI Classification- Renewable Energy Usage Evaluation Metrics....................54
Table 25- Prosumers KPI Classification- Emissions Evaluation Metrics..55
Table 26- Prosumers KPI Classification- Digitalization Evaluation Metrics 55

Table 27- Power Network KPI Classification- Power Supply and Distribution System Evaluation Metrics 59
Table 28- Power Network KPI Classification- Flexibility and Balancing System Evaluation Metrics .. 61
Table 29- Power Network KPI Classification- Transmission System Evaluation Metrics 62
Table 30- Power Network KPI Classification- Renewable Energy Usage Evaluation Metrics 63
Table 31- Power Network KPI Classification- Emissions Evaluation Metrics 64
Table 32- Power Network KPI Classification- Digitalization Evaluation Metrics 64
Table 33- Data exchange information collection template 70

List of Acronyms and Abbreviations

eDREAM	enabling new Demand Response Advanced, Market oriented and secure technologies, solutions and business models
ANO	Air Navigation Order
ANSI	American National Standards Institute
ARRA	American Recovery and Reinvestment Act
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CCHP	Combined Cooling, Heat and Power
CD	Committee Draft
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat and Power
CIM	Common Information Model
COSEM	COmpanion Specification for Energy Metering
DLMS	Device Language Message Specification
DLT	Distributed Ledger Technology
DSO	Distribution Network Operator
EBP	European Blockchain Partnership
EBSI	European Blockchain Services Infrastructure
EC	European Commission
EEP	EnOcean Equipment Profile
ETSI	European Telecommunications Standards Institute
EU	European Union
GFSC	Gibraltar Financial Services Commission
IEC	International Electrotechnical Commission
IMU	Inertial Measurement Unit
INEA	Innovation and Networks Executive Agency
ISO	International Organisation for Standardisation
KPI	Key Performance Indicator

LSVPP	Large Scale Virtual Power Plant
M2M	Machine to Machine
Open ADR	Open Automated Demand Response
OSC	Operating Safety Case
PfAW	Permission for Aerial Work
PfCO	Permission for Commercial Operations
PHEV	Plug-in Hybrid Electric Vehicle
SCL	Substation Configuration description Language
TC	Technical Committee
TSO	Transmission System Operator
UAS	Unmanned Aircraft Systems
XML	Extensible Markup Language

1 Introduction

1.1 Scope and objectives of the deliverable

Deliverable D2.3 aims to provide guidance and reference material for future work and development of solutions within the project. To this end, five main components are presented:

- A list of standards relevant to the eDREAM project has been compiled and presented for the purposes of providing a reference for developing the eDREAM platform.

- A Multi-purpose vocabulary is also presented, which provides an extensive but not exhaustive list of terminology used within the eDREAM platform along with definitions and/or verbose descriptions. Existing data ontologies and demand response standards are also examined and recommendations have been made, based on suitability, in order to aid in the process of choosing the correct data model for eDREAM solutions.

- Preliminary data models for externally-facing eDREAM components are compiled to provide a reference for interfacing with the eDREAM platform, promoting interoperability.

- Regulations regarding aerial surveying techniques, Energy trading using blockchain smart-contract technologies and the integration of blockchain integrated virtual currencies to facilitate smart contracts are examined and reported to provide both reference material and also feasibility recommendations.

- Finally, Key performance Indicators (KPIs) are defined for the purpose of assessing performance, both at the Prosumer level and at the power network level. The metrics collected in this section are based on those collected by ongoing projects such as the joint research centre reports, IEEE, and the respective framework from the European Electricity Grid Initiative (EEGI). The KPIs to be used in this project will also take into account the following benefits identified by the EC smart grid task force: Increased sustainability, adequate capacity and distribution grids for 'collecting' and bringing electricity to the consumers, adequate grid connection and access for all kinds of grid users, satisfactory levels of grid security and quality of supply, enhanced efficiency and better service in electricity supply and grid operation, enhanced consumer awareness and participation in the market by new players, and enable consumers to make informed decisions related to their energy to meet the EU energy efficiency targets.

1.2 Structure of the deliverable

This report is structured into 5 chapters, each with their own corresponding sub-chapters.

Chapter 1 provides an introduction to the deliverable, explaining the scope, objectives and structure of the deliverable.

Chapter 2 looks to define and collect details on available energy data standards relevant to the project. International standards relating to information exchange and system control in smart grids are explored and reported along with existing demand response standards and data ontologies.
A multi-purpose vocabulary is then established to define an extensive list of terms relevant to the project. Finally, a list of preliminary data models for externally-facing eDREAM components are presented.

Chapter 3 explores some of the regulatory requirements and issues facing the project, with particular focus on challenges facing activities related to project pilots. To that end, legislation regarding aerial survey techniques in the UK and also regulations and legal issues concerning blockchain-backed energy trading are explored.

Chapter 4 examines Key performance indicators (KPIs), which are relevant figures and metrics that shall be measured by the platform and can be used to analyse the efficacy and overall performance of the systems involved. Separate lists of KPI metrics are compiled for two groups: Prosumers (consumers with generation capacity, i.e. distributed generation) and Power Networks (DSOs or TSOs).

Chapter 5, the conclusion, summarises and analyses the results of the deliverable, presents outcomes as they relate to other components of the project and presents conclusions based on the deliverable as a whole.

1.3 Relation to other Tasks and Deliverables

The information presented in this deliverable feeds into numerous other work packages within the eDREAM project, predominantly WP3, WP4, WP5, WP6 and WP7. Chapter 2 examines energy data and communications standards as well as defining a set of preliminary data models, which establish useful information preceding the tasks performed in WP4 and WP6. A multi-purpose vocabulary is also established in this subchapter, providing a useful reference for terminology that may be used throughout the project as a whole. Chapter 3 examines regulatory requirements for both aerial survey techniques and also the use of blockchain solutions within the energy domain. This chapter reports important regulatory information that needs to be considered by task 3.4: DR aerial survey techniques for DR potential estimation and all tasks within WP5 to guide development activities and also to ensure adherence to legislative and regulatory restrictions within the locality of eDREAM pilot sites.
Finally, Chapter 4 lists KPI metrics which may be used to assess the efficacy of eDREAM solutions. These KPIs are required for platform assessment and validation efforts, which take place across all tasks within WP7.

1.4 Methodology

Production of this document was a result of a desktop research applied to collect and analyse evidence from various published information sources, including those from ongoing projects and initiatives, such as the Joint Research Centre reports, IEEE, the respective framework from the European Electricity Grid Initiative (EEGI) and national legislative bodies. Preliminary key technical information was also collected from technical project partners by means of tables, which were circulated amongst the consortium and are attached in Annex 1.

2 Definition and collection of data standards

In the fast and continuously changing environment of energy data processing and analytics, the way the information is presented, controlled and communicated among key architectural elements of related systems is a critical issue. Therefore, originates the need to align the prospective development in accordance with standardized practices.

This section initially examines the relevant aspects of current energy data and communication standards, both on the European and the international levels. The purpose is to produce an overview of relevant standards to serve as a reference for development of the eDREAM core platform, predominantly in WP5 and WP6.

Carrying on from the preliminary analysis already conducted during the initial proposal development, relevant standards pertaining to automated demand response and the device automation required to facilitate eDREAM functionality then are examined to provide a reference material for development efforts in WP4.

2.1 International standards for energy data

Developing regional and international standards plays a large role in facilitating interoperability between platforms and services, and can reduce unnecessary repeated development efforts when developing new solutions. In this section energy data and communication standards at the international level are explored to provide a reference for development efforts towards eDREAM components with a high degree of interoperability. Existing demand response tools and standards, and smart device control standards are also examined with the aim of ensuring interoperability of eDREAM solutions. The purpose of this subchapter is to provide a reference of standards to aid in early development activities of eDREAM solutions, where relevant standards will be examined and chosen on a per-case basis.

2.1.1 Main international energy data and communication standards

The general work of international standardization is carried out by the International Organization for Standardization (ISO). It publishes international standards to harmonize national standards. In the field of electricity, the International Electrotechnical Commission (IEC) constitutes the global standardization scale and has dedicated efforts to identify existing standardization and potential gaps relevant for Smart Grid implementation (IEC, 2010), IEC identified a set of core standards valid or essential for nearly all Smart Grid applications, the “core standards”. These core standards, presented below in Table 1, are standards that have an enormous effect on any Smart Grid application and solution representing a backbone of Smart Grid technologies. Besides the core standards, IEC also offers a number of highly important standards for Smart Grid mainly focused on interoperability issues, namely the integration among items constituting a Smart Grid system.

Beyond the international efforts dedicated by IEC regarding the standardization of Smart Grid Technologies, there are mainly three European Standardization Organizations, CEN, CENELEC and ETSI, responsible for defining and developing voluntary standards at European level, to support the implementation of European legislation, the successful integration of the European energy market and the implementation of the EU's climate and energy targets.

The Members of CEN are the National Standardization Bodies of 34 European countries including all the Member States of the European Union (EU) and other countries that are part of the European Single Market. The European Committee for Standardization, CEN (CEN/CENELEC, 2017), provides a platform for the development of European Standards and other technical documents with regard to various kinds of products, materials, services and processes. CEN works with its Members to develop and define European Standards in response to specific needs that have been identified by businesses and other users of standards. Each National Standardization Body that is part of the CEN system is obliged to adopt each European Standard as a national standard and make it available to customers in their country. They also have to withdraw any existing national standard that conflicts with the new European Standard. Therefore, one European Standard (EN) becomes the national standard in all 34 CEN members' countries (InteGRIDy, 2017). The main standards regulating the different aspects concerning Smart Grid technologies are illustrated in section 2.1.1.

Standard or series	Topic
IEC 60870 -5,-6	Data exchange between utility control centers, utilities, power pools, and regional control centers
IEC 61508	Functional safety specifications for a broad range of electrical and electronic safety applications
IEC 61850	Flexible, future-proofing, open standard, communication between devices in transmission, distribution and substation automation systems (Substation Configuration description Language- SCL) Mapping of COSEM over IEC 61850
IEC 61968 -4, -9	Defines the CIM (common interface model)
IEC 61970	Specifies CIM, focused on transmission domain
IEC 61969	Specifies CIM, focused on distribution domain
IEC 61968 -4, -9	A set of standards related to communications within an electrical distribution system. Section -4 defines interfaces for records and asset management. Section -9 defines an interface standard for meter reading and device control
IEC 62056	Mapping between the Common Information Model CIM (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and message profiles; Sections -5-3, -6-1, -6-2 cover OBIS model Mapping
IEC 62325	CIM based energy marked deregulation standards

IEC 62351	Defines a set of cyber security for power network communication protocols
IEC 62357	Section -1:2012(E) Specifies a reference architecture and framework for the development and application of IEC standards for the exchange of power system information. This technical report provides an overview of these standards as well as guidelines and general principles for their application in distribution, transmission, and generation systems involved in electric utility operations and planning. The future multi-layer reference architecture described in this technical report takes into account new concepts and evolving technologies, such as semantic modelling and canonical data models, in order to build on technology trends of other industries and standards activities to achieve the interoperability goals of the Smart Grid.
IEC 62361	Standard specifying harmonization of data models between CIM and IEC 61850

Table 1: Main international (IEC) Energy data standards

2.1.2 IoT Communication standards

Standard or series	Topic
ETSI/OneM2M	Release 1 of the ETSI OneM2M standards were published in March 2016 with the aim of promoting IoT development across various domains, covering many different categories of smart, connected devices. The standards cover requirements, architecture, Application Programming Interface (API) specifications, security solutions and mapping to common industry protocols such as CoAP, MQTT and HTTP. (ETSI, 2016)
SAREF	“A shared model of consensus that facilitates the matching of existing assets (standards/protocols/data models/etc.) in the smart appliances domain. The SAREF ontology provides building blocks that allow separation and recombination of different parts of the ontology depending on specific needs” (Smart appliances Study SMART 2013, 2013)
SAREF4ENER	An extension of the SAREF ontology consisting of terms specifically for use in the energy domain
ZigBee	Based on the IEEE 802.15.4 personal-area network standard, ZigBee is a specification for low power mesh networking for devices requiring a low data rate robust network. This makes ZigBee ideally suited to domotic applications, i.e. smart devices in the home or office environment

Z-Wave	Z-wave is a robust mesh-networking technology designed for home automation and IoT devices, similar to ZigBee

Table 2- Main IoT-communications related standards

2.1.3 Blockchain standards

So far, due to blockchain technology still being in its infancy, there has been minimal work on standardization in this area. The main application of blockchain to date has been as a component of cryptocurrencies, which are defined as "*A digital currency in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank*" (Oxford Dictionaries, 2018). After being presented by Satoshi Nakamoto as a component of the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" (2008), blockchain has been used as a tool in a number of projects and products including Bitcoin, however solutions so far have largely been developed on an individually customized basis.
Another potential application for blockchain technology could be to facilitate automated, real-time cryptographically signed smart contracts. Ethereum is one platform built to perform such tasks, and is currently being investigated in WP5 as a solution to build eDREAM project solutions upon.

Nevertheless, the EU is paying attention to blockchain from a standardisation. An EU Blockchain roundtable was held on the 20th November 2018, and aimed to gather industry leaders and policy makers to explore the potential of blockchain technology for EU in sectors such as supply chain management, manufacturing, financial services, transport, energy etc. It highlighted the need for a comprehensive EU blockchain strategy and a common approach to blockchain for EU in international arena. The intention was to develop close cooperation between the government and economic sectors, as is required to leverage innovative technologies such as blockchain to transform digital services and increase trust in a wide range of industries and sectors (European Comission, 2018).

A new Australian-lead ISO technical committee, ISO/TC 307 has been established to lay the groundwork for future standardization of blockchain technology at the international level. Table 3 shows the standards currently being developed by this committee, along with their developmental stage, as defined in the International harmonized stage codes (Figure 1). These standards are all still in early stages of development, with the most progress being ISO/CD 22739: *Terminology*.

Standard under development	Name	Stage
ISO/CD 22739	Terminology	30.92
ISO/NP TR 23244	Privacy and personally identifiable information protection considerations	10.99
ISO/NP TR 23245	Security risks, threats and vulnerabilities	10.99
ISO/NP TR 23246	Overview of identity management using blockchain and distributed ledger technologies	10.99
ISO/AWI 23257	Reference architecture	20.00
ISO/AWI TS 23258	Taxonomy and Ontology	20.00
ISO/AWI TS 23259	Legally binding smart contracts	20.00
ISO/CD TR 23455	Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems	30.00
ISO/NP TR 23576	Security management of digital asset custodians	10.99
ISO/NP TR 23578	Discovery issues related to interoperability	10.99
ISO/NP TS 23635	Guidelines for governance	10.99

Table 3- Current development level of IEC/TC 307 blockchain standards in December 2018

Figure 1- International harmonized stage codes- ISO

2.2 Multi-purpose vocabulary and project related terminology

This subchapter defines an extensive, but not exhaustive list of terminology relevant to this project. The purpose of this section is to help to harmonise terminology used in the project, while also providing somewhat of a glossary of terms. The information presented is categorised into the following 6 groups:

Table 4 examines Power network, demand response and prediction techniques

Table 5 examines Aerial survey terminology

Table 6 examines Related projects and commercial products

Table 7 examines Related external entities

Table 8 examines Data standards, conventions and communication protocols

Table 9 examines Ontologies and schemata

2.2.1 Power network, demand response and prediction technique terminology

Table 4 lists some of the commonly used terms related to power networks, demand response and energy consumption/prediction techniques. This is intended to serve as a non-exhaustive glossary of terms. Many additional relevant standardized terms can be found in ISO/IEC 13273-1:2015: Common international terminology - Part 1: Energy efficiency (ISO/IEC, 2016) and ISO/IEC 13273-2:2015: Common international terminology - Part 2: Renewable energy sources (ISO/IEC, 2015).

Term	Acronym Definition	Description
Aggregator		Aggregators are third party intermediaries specializing in coordinating or aggregating demand response from individual consumers to better meet industry parties' technical requirements for specific routes to market. (OFGEM, 2016)
Base load		This is the minimum expected load of a consumer or an electrical network, which is used to determine how much permanent electrical production is required to meet load requirements
DR	Demand response	A technique where an end-user's energy consumption is intentionally altered to augment their load profile to be more favorable to power network conditions, usually to even out peaks and troughs
DSO	Distribution System Operator	Formerly termed DNO in the UK, a DSO is an entity responsible for constructing, maintaining and managing an electrical distribution infrastructure. The distribution network covers medium and low voltage sections of an electrical network, up to the end-user
Flexibility		A measurement of a consumer or prosumer's ability to modify their generation or consumption in response to external received signals, in order to participate in DR strategies
Load profile		A graph of the variation in consumption of an electrical load over time, consisting of either

		projected or measured historical data
Prosumer	Producer-consumer	An electricity consumer with grid-connected generation assets, such as a grid-tied photovoltaic array, energy storage equipment or a combined heat and power (CHP) plant
TSO	Transmission System Operator	A TSO is an entity responsible for constructing, maintaining and managing an electrical transmission infrastructure, which are responsible for transmitting high voltage electricity from large generation sources across large distances
VPP	Virtual power plant	A modelling technique used to cluster multiple heterogeneous Distributed Energy Resources to improve the viability of forecasting the production of such resources

Table 4- Power network, demand response and prediction technique terminology

2.2.2 Aerial survey terminology

Activities within Task 3.4 and related eDREAM pilots require the use of drones to perform aerial surveys on pilot sites. The following table defines key terminology relating to operating drones within the locality of pilot sites, along with terminology relevant to surveying techniques that may be used.

Term	Acronym Definition	Description
AGL	Above Ground Level	Distance of aircraft above Ground Level
AMSL	Above Mean Sea Level	Distance of aircraft above Mean Sea Level
ANO	Air Navigation Order	The ANO 2016 is a document that forms the basis of almost all current legal regulation by the CAA in the United Kingdom
ATC	Air Traffic Control	A service directing aircraft on the ground and through controlled airspace.
ATZ	Aerodrome Traffic Zone	An airspace of defined dimensions established around an aerodrome for the protection of aerodrome traffic.
BVLOS	Beyond Visual Line Of Sight	A situation where a remotely operated aircraft is beyond clear, unobstructed view of the pilot

CAA	Civil Aviation Authority	The statutory organization tasked with overseeing and regulating all aspects of civil aviation in the United Kingdom.
CAP	Civil Aviation Publication	An official publication produced and published by the CAA
DA	Danger Area	Airspace, which has been notified as such within which activities dangerous to the flight of aircraft may take place or exist at such times as may be notified.
EESA	European Aviation Safety Agency	The entity responsible for Aviation safety within Europe
EVLOS	Extended Visual Line Of Sight	EVLOS operations involve utilizing personnel in addition to the aircraft operator to maintain visual sight of the aircraft at all times. Constant radio contact must be maintained with the operator at all times to allow information to be relayed in a timely manner.
ENSF	Enhanced Non-Standard Flight	Procedure to obtain approval for non-standard flights within controlled airspace
FIR	Flight Information Region	Specified region of airspace with a Flight Information Service and Alerting Service are provided.
FPV	First Person View	In the case of unmanned aircraft, FPV flying involves controlling the aircraft within or outside of visual line of sight, using a remote video feed from an on-board video camera for navigation.
Galileo		A GNSS system including its own constellation of satellites, created by the European Union for public and commercial use
GNSS	Global Navigation Satellite System	A globally available satellite navigation system such as GPS, GLONASS, BeiDou and Galileo
GPS	Global Positioning System	A GNSS system including its own constellation of satellites originally created by the United states military, before being opened up for global public and commercial use

ICAO	International Civil Aviation Organization	An Agency of the United Nations with the task of codifying principles and techniques of international air navigation
LiDAR	Light Direction and Ranging	A device that uses lasers to detect objects in space using scanned laser range-finding to measure distances from objects at discrete angle intervals.
NOTAM	Notice To Airmen	NOTAMs inform pilots of changes or restrictions at specific areas
OSC	Operational Safety Case	The OSC is a document produced by any person or organization wishing to conduct commercial work using a drone over 7KG, itemizing all potential risks that may be encountered during the work, and what measures will be taken to negate or counteract risks to persons and property.
PFAW	Permission for Aerial Work	An obsolete term, formerly used in place of PfCO until August 2017
PfCO	Permission for Commercial Operations	Permission required by the CAA for commercial drone use. PfCO is granted by the CAA at the expense of the pilot after suitable evidence is provided of pilot competency and construction of an appropriate flight operations manual.
SUA	Small Un-manned Aircraft	An aerial vehicle under 20KG which is not designed to carry humans and is piloted remotely or by a computer
UAV	Unmanned Aerial Vehicle	An aerial vehicle which is not designed to carry humans and is piloted remotely or by a computer
VFR	Visual Flight Rules	A set of regulations regarding flight in weather conditions clear enough to allow pilots to see where the aircraft is going.
VLOS	Visual Line Of Sight	Flight where the pilot has a clear unobstructed view of the aircraft.

Table 5- Aerial survey terminology

2.2.3 Related projects and commercial tools

This project sits amongst a host of similar past and current projects and development efforts. The following table examines some publicly and privately funded projects and developed solutions related to the eDREAM project, such as other EU-H2020 funded projects and related commercial products.

Term	Acronym Definition	Description
ADRESS	Active Distribution network with full integration of Demand and distributed energy RESourceS	ADDRESS is a large-scale Integrated Project co-founded by the European Commission under the 7th Framework Programme, in the Energy area for the "Development of Interactive Distribution Energy Networks". ADDRESS is framed in the Smart Grids European Technology Platform, whose vision for the electricity networks of the future may be expressed in just 4 words: flexibility, accessibility, reliability, economy.
BEMS	Building Energy Management System	Building Energy Management Systems monitor and control services such as heating, ventilation and air-conditioning, ensuring the building operates at maximum levels of efficiency and removing wasted energy usage and associated costs. The optimal level of efficiency is achieved by continuously maintaining the correct balance between operating requirements, external and internal environmental conditions, and energy usage.
ECOGRID EU		An EU-FP7 funded project aiming to create a new Real-time Market for Small-scale Electricity Consumers.
EDISON		The EDISON project has utilized Danish and international competences to develop optimal system solutions for EV system integration, including network issues, market solutions, and optimal interaction between different energy technologies. Furthermore, the Bornholm electric power system has provided an optimal platform for demonstration of the developed solutions.

EEGI	European Electricity Grid Initiative	The European Electricity Grid Initiative (EEGI) is one of the European Industrial Initiatives (EIIs) under the Strategic Energy Technology Plan (SET-Plan) and proposes a nine-year European research, development and demonstration (RD&D) programme to accelerate innovation and the development of the electricity networks of the future in Europe.
EU DEEP	EUropean Distributed EnErgy Partnership	The EU-deep project's main goal was to design, develop and validate an innovative methodology based on the requirements of future energy markets as well as come up with innovative business solutions for enhanced European DER deployment by 2010.
FENIX	Flexible Electricity Network to Integrate the eXpected 'energy evolution'	The objective of the FENIX project is to boost DER (Distributed Energy Resources) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management.
FIEMSER	Friendly Intelligent Energy Management System for Existing Residential Buildings	FIEMSER is a FP7 project that started in February 2010 with the aim of achieving energy positive buildings through solutions based on a rational consumption of energy, local generation and an increase in the consciousness of the building owners towards their energy consumption habits.
Haystack		Project Haystack is an open source initiative to streamline working with data from the Internet of Things. It standardizes semantic data models and web services with the goal of making it easier to unlock value from the vast quantity of data being generated by the smart devices that permeate our homes, buildings, factories, and cities. Applications include automation, control, energy, HVAC, lighting, and other environmental systems
HOMER	Hybrid Optimization of Multiple Energy Resources	A set of advanced microgrid software modelling tools

MAS2TERING	Multi-Agent Systems and Secured coupling of Telecom and Energy gRIds for Next Generation smartgrid services	MAS2TERING was a three-year technology-driven and business-focused project (2014-2017), aimed at developing an innovative information and communication technology (ICT) platform for the monitoring and optimal management of local communities of prosumers. MAS2TERING combined an original business vision, with goals towards the enablement of local energy aggregation markets, utilizing a set of enabling technologies from the artificial intelligence, communications, and security domains. Last-mile connectivity solutions were combined with a distributed optimization platform, and the security of communications enhanced, to enable effective and secured electricity management at distribution level and create new business opportunities. Doing so, the project enabled new collaboration opportunities between grid operators and telecom and energy companies, both from technology and business perspectives. (MAS2TERING project, 2018)
MEREGIO	Minimum Emission Region	German energy optimization platform including energy trading, DER and load forecasting, energy storage and development of new business models
MIRABEL	Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution	A project funded under the EU FP7 program, MIRABEL aimed to develop a conceptual and infrastructural approach to allow energy distribution entities efficiently manage increasing amounts of renewable energy with effective supply and demand balancing.
MORE MICROGRIDS		This project aims at the increase of penetration of microgeneration in electrical networks through the exploitation and extension of the Microgrids concept, involving the investigation of alternative microgeneration control strategies and alternative network designs, development of new tools for multi-microgrids management operation and standardization of technical and commercial protocols

Open ADR 2.0a	Open Automated Demand Response Profile A	Profile A is designed for resource-constrained, low-end embedded devices that can support basic DR services and markets. Profile A is well suited to support standard DR programs.
Open ADR 2.0b	Open Automated Demand Response Profile B	Profile B is designed for high-end embedded devices that can support most DR services and markets. Profile B includes a flexible reporting (feedback) mechanism for past, current and future data reports. Open Automated Demand Response Profile B has been accepted as the following standard: IEC/PAS 62746-10-1
SAM	System Advisor Model	A tool specifically designed for modelling of Lead-acid and Lithium Ion batteries in PV-battery energy storage applications. The battery modelling is based on detailed capacity, voltage, thermal and lifetime sub-models, which can be parametrized e.g., using battery data sheets.
USEF	Universal Smart Energy Framework	USEF was founded by seven key players, active across the smart energy industry, with a shared goal - one integrated smart energy system which benefits all stakeholders, from energy companies to consumers. USEF's ongoing development is managed by the USEF Foundation, a dedicated core team tasked with coordinating expertise, projects and partners while safeguarding the integrity and objectives of USEF.
VLUX (Verv)		P2P blockchain energy trading functionality developed as an addition to additional Verv's existing automated demand response platform.

Table 6- Related projects and commercial products

2.2.4 Related external entities

There are many different task forces, working groups, standards organizations and other entities that exist at the national, European and worldwide scale who are of importance to the eDREAM project. The following table summarizes many of these entities, who are deemed as important to this project.

Term	Acronym Definition	Description
ANSI	American National Standards Institute	A non-profit organization that oversees the development of standards in the United States of America
CAA	Civil Aviation Authority	The statutory corporation which oversees and regulates all aspects of civil aviation in the United Kingdom.
CEN	European Committee for Standardization	The committee responsible for defining and publishing public standards in the European Union
CENELEC	European Committee for Electrotechnical Standardization	The committee responsible for defining and publishing public standards in the European Union, specifically relating to the area of electrical engineering
DKE	German Commission for Electrical, Electronic & Information Technologies of DIN and VDE	A modern, non-profit service organization which ensures that electricity is generated, distributed and used in a safe and rational manner, thereby serving the good of the community at large.
EAWE	European Academy of Wind Energy	A body of research institutions and universities in Europe working on research and development of wind energy harvesting technology
EERA	European Energy Research Alliance	An alliance of around 250 research centres and universities across 30 European countries, EERA coordinates energy research to achieve more efficient and cheaper low carbon energy technologies. EERA is organized into 17 Joint research programs working towards this goal.

E@H	Energy@Home	A non-profit organization formed in 2012, originally between the Private entities Electrolux, Enel Distribuzione, Indesit company and Telecom Italia that, for the benefit of the environment, aims at developing & promoting technologies and services for energy efficiency in the home based upon device to device communication. Energy@Home has so far worked closely with ZigBee, producing technical specifications used in the ZigBee home automation 1.2 standard.
EPRI	Electric Power Research Institute	The Electric Power Research Institute, or EPRI, conducts research, development, and demonstration projects to benefit the public in the United States and internationally.
ETSI	European Telecommunications Standards Institute	A non-profit European standards organization focused on providing public telecommunication standards
EU	European Union	A political and economic union of 28 member states located mainly in Europe
	European Union Smart Grids Task Force	A Task Force that was set up by the European Commission in 2009 to advise on issues related to smart grid deployment and development. It consists of five Expert Groups which focus on specific areas: Smart grid standards, Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment, Regulatory recommendations for smart grid deployment, Smart grid infrastructure deployment, and Implementation of smart grid industrial policy. Their work helps shape EU smart grid policies.
GFSC	Gibraltar Financial Services Commission	The organization for providing regulation in the financial domain in Gibraltar
IEC	International Electrotechnical Commission	The International Electrotechnical Commission is an international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies – collectively known as "electrotechnology".

ISO	International Organization for Standardization	The International Organization for Standardization is an international standard-setting body composed of representatives from various national standards organizations.
NERC	North American Electric Reliability Corporation	NERC is a non-profit organization for the purpose of ensuring reliability of electrical supply in North America. NERC's major responsibilities include working with all stakeholders to develop standards for power system operation, monitoring and enforcing compliance with those standards, assessing resource adequacy, and providing educational and training resources as part of an accreditation program to ensure power system operators remain qualified and proficient. NERC also investigates and analyses the causes of significant power system disturbances in order to help prevent future events.
OASIS	Organization for the Advancement of Structured Information Systems	a non-profit consortium that drives the development, convergence and adoption of open standards for the global information society
Open ADR Alliance	Open Automated Demand Response Alliance	The Open ADR alliance is a development group consisting of over 130 members including utility suppliers, software suppliers, device manufacturers, national labs, DR aggregators, testing and certification labs, system integrators and consulting firms with the purpose of developing efficient and scalable automated demand response system solutions. The Open ADR alliance have to date developed two products: Open ADR Profile A and Profile B. (OpenADR Alliance, 2018)
Schema		A collaborative group with the aim of developing Schema for many different applications
SEPA	Smart Electric Power Alliance	A USA-based non-profit organization created to promote the transition towards smart grids, facilitating larger adoption of renewable energy resources and also promoting a higher degree of consumer awareness about their energy needs

SGIP	Smart Grid Interoperability Panel	Started by NIST, SGIP is a US-based organization, created to aid smart-grid adoption as per the requirements of the energy independence act of 2007 by coordinating smart-grid related standards
W3C	World Wide Web Consortium	The consortium responsible for developing and publishing standards for the world wide web

Table 7- Related external entities

2.2.5 Data standards, conventions and communication protocols

Numerous useful standards and conventions exist for data and communication. Table 8 below presents a selection of such standards and conventions which are deemed to be relevant to the eDREAM project for the purpose of providing information in addition to standards explored in Chapter 2.1 about the existing landscape in which the eDREAM will be constructed, which is useful for considering how to develop the platform in such a way that ensures optimal interoperability.

Term	Acronym Definition	Description
BACnet	Building Automation and Control network protocol	A Communications protocol for Building Automation and Control (BAC) networks that leverage the ASHRAE, ANSI, and ISO 16484-5 standards
CIM	Common Information Model	An information model developed by the IEC for the power industry for the purpose of unifying and standardizing telemetry, informatics and control signals about an electrical network. IEC standard IEC 16968
COSEM	COmpanion Specification for Energy Metering	A specification of rules, based on existing standards for data exchange with energy meters
DCTerms	Dublin Core terms	An up-to-date specification of all metadata terms maintained by the Dublin Core Metadata Initiative, including properties, vocabulary encoding schemes, syntax encoding schemes, and classes. Conversion and consolidation layer
DLMS	Digital Enhanced Cordless Telecommunications- Ultra-Low Energy	A generalized concept for abstract modelling of communication entities

eMIX	Energy Market Information Exchange semantics	The OASIS eMIX TC works to define standards for exchanging energy characteristics, availability, and schedules to support the free and effective exchange of information. Better communication of actionable energy prices will help enable and expand efficient markets that satisfy the growing demand for lower-carbon, lower-energy buildings, net zero-energy systems, and supply-demand integration that take advantage of dynamic pricing. Businesses, homes, electric vehicles and the power grid will benefit from automated and timely communication of energy price, characteristics, quantities, and related information.
FSGIM	Facility Smart Grid Information Model	An abstract information model for implementing smart grid functionality at the facilities energy management level. This model also facilitates connecting OpenADR 2.0 to various existing protocols
GSE	Generic Substation Events	Generic Substation Events (GSE) is a control model defined as per IEC 61850 which provides a fast and reliable mechanism of transferring event data over entire electrical substation networks. When implemented, this model ensures the same event message is received by multiple physical devices using multicast or broadcast services. The GSE control model is further subdivided into GOOSE (Generic Object-Oriented Substation Events) and GSSE (Generic Substation State Events).
KNX		KNX is an international building automation control standard that enables the integration and programming of a range of products from many manufacturers using a single software tool. Approved as an open standard to:(ISO/IEC 14543-3), (CENELEC EN 50090 and CEN EN 13321-1)

OBIS	OBject Identification System	OBIS provides standard identifiers for all data within the metering equipment, both measurement values and abstract values. OBIS names are used for the identification of COSEM objects and also for identification of the data displayed on the meter and transmitted through the communication line to the data collection system.
OMA Lightweight M2M	Open Mobile Alliance Lightweight machine-to-machine	The OMA LWM2M architecture is based on a client component, which resides in the LWM2M Device, and a server component, which resides within the M2M Service Provider or the Network Service Provider. Each piece of information made available by the client is a resource. A client may have any number of resources and these resources are organized into objects. Each resource supports one or more operations. The Omalwm2m ontology describes the resources, objects and operations supported by the OMA LWM2M architecture
OMS	Open Metering System	The OMS-Group e. V. is a community of interest of associations, presently FIGAWA and KNX, with enterprises in the area of metering relevant to accounting. With the Open Metering System Specification, the OMS-Group has developed an open, vendor independent standard for communication interfaces and basic requirements.
OSGi DAL	Open Services Gateway initiative-Device Abstraction Layer	A set of specifications that define a dynamic component system for Java. These specifications enable a development model where an application is composed of several components which are packaged in bundles. Components communicate locally and across the network through services. The Osgi_dal ontology focuses on the concept of ‘device’ and ‘function’ that are central in the OSGi architecture
OWL	Web Ontology Language	RDF-based languages developed by the W3C for expressing business semantics
QUDT	Quantities, Units, Dimensions and Types	Semantic specifications for units of measure, quantity kind, dimensions and data types

RDF	Resource Description Framework	RDF is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed
SEP (ZigBee)	Smart Energy Profile	Standard and interoperable protocol that connects smart energy devices in the home to the Smart Grid. Designed to operate over TCP/IP
SEP2	ZigBee Smart Energy Profile 2.0	A further development by ZigBee's Smart energy profile, including physical and information level architecture specifications for building automation.
SMB	Server Message Block	Formerly CIFS, SMB is an application-layer network protocol developed by Microsoft, primarily used to share file access, printers, serial ports and other resources between nodes across a network of windows computers.
SPARQL		A standard for querying RDF, with HTML functionality
UML	Unified Modelling Language	The Unified Modelling Language is a general-purpose, developmental, modelling language in the field of software engineering, that is intended to provide a standard way to visualize the design of a system.

Table 8- Data standards, conventions and communication protocols

2.2.6 Ontologies and schemata

Many Ontologies and schemata have been developed to date, often for either commercial products of as part of funded projects to facilitate IoT control, domotics, energy management and more. A selection of relevant Ontologies and Schemata are presented in Table 9 to serve as a reference for ongoing development in the eDREAM project, including T2.4, WP4, WP5 and WP6.

Term	Acronym Definition	Description
Brick		Brick is a uniform schema for representing metadata in buildings. Our schema defines a concrete ontology for sensors, subsystems and relationships among them, which enables portable applications. We demonstrate the completeness and effectiveness of Brick by using it to represent the entire vendor-specific sensor metadata of diverse buildings across different campuses, each comprising thousands of data points, and running complex unmodified applications on these buildings.
DogOnt	Ontology Modelling for Intelligent Domotic Environments	An ontology developed for facilitating smart home automation (domotic) using smart appliances
eDIANA		The eDIANA ontology defines the universe of concepts and their relations in the domain of eDIANA Platform Architecture, related to device awareness. The ontology defines three main classes, namely the Information, Service and Device classes. The Information class contains the different categories of information that will be referenced by the elements defined in the Service and Device classes.
EnOcean		The EnOcean ontology specifies the user data embedded in the structure of a radio telegram as defined by the EnOcean Equipment Profile (EEP) for their own proprietary energy harvesting, building automation and IoT devices

FAN		The Fanfpai ontology describes the resources (appliances) used in the Flexible Power Application Infrastructure (FPAI). These resources are defined in the Resource Abstraction Interface (RAI class), which is used to express the energetic flexibility that appliances can offer and how this flexibility should be exploited
FIPA	Foundation for Intelligent Physical Agents	The FIPA ontology describes a device ontology that aims at enabling interoperability between software agents, as defined by the FIPA Device Ontology Specification. This ontology can be used by agents when communicating about devices: when agents pass profiles of devices to each other, these profiles can be validated using the information contained in this ontology
OEMA Ontology Network	Ontology for Energy Management Applications Ontology Network	The OEMA Ontology Network is a group of ontologies for several different energy domains, which share a common representation of concepts. The OEMA ontology network is made up of eight interconnected domain ontologies. Each ontology represents one or various energy domains.
PowerOnt	Power Ontology	An ontology produced as part of the Smart Appliances project that provides energy consumption data for smart home appliances using the underlying DogOnt Ontology
SAREF	The Smart Appliances REFerence	SAREF is an ontology for the purpose of providing a standardized platform for controlling smart, connected appliances in a domestic environment, allowing data collection, remote control and remand response functionality.
SAREF4ENER	The Smart Appliances REFerence for Energy	An extension of SAREF created in collaboration with Energy@Home, EEBus and several Italy and Germany based industry associations to facilitate the interconnection of their several different data models for demand response scenarios. SAREF4ENER is published as an ETSI technical specification (ETSI TS 103 410-1)

W3C SSN	W3C (World Wide Web consortium) Semantic Sensor Network Incubator Group	An ontology that describes sensors and observations, and related concepts. It does not describe domain concepts, time, locations, etc. These are intended to be included from other ontologies via OWL imports. This ontology is developed by the W3C Semantic Sensor Networks Incubator Group (SSN-XG).

Table 9- Ontologies and schemata

2.3 Data models

The purpose of a data model is to provide specifications and a logical structure on all of the data within an information-based system. This document specifies the initially planned logical data models for the eDREAM platform, specifically the data flow exterior to the platform. The purpose of which is to provide guidelines for interfacing with eDREAM platforms with the aim of facilitating a high degree of interoperability. It is important to note however that some of the information presented in this subchapter is subject to change as many related components are in initial stages of development and details have yet to be finalised. Further development and specification of data models will be carried out within T2.4 - System requirements, functional and technical specifications. The data models presented in this subchapter are grouped according to the system architectural component from which they send information to, or retrieve information from. The data model tables collected in this section were populated by circulating the table template included in Appendix 1 with the consortium, collecting input from each technical partner responsible for developing new or existing tools which utilize any data transactions into, or out of the platform with the view of providing a specification for promoting interoperability. The structure of the data models presented are reported below in Figure 2.

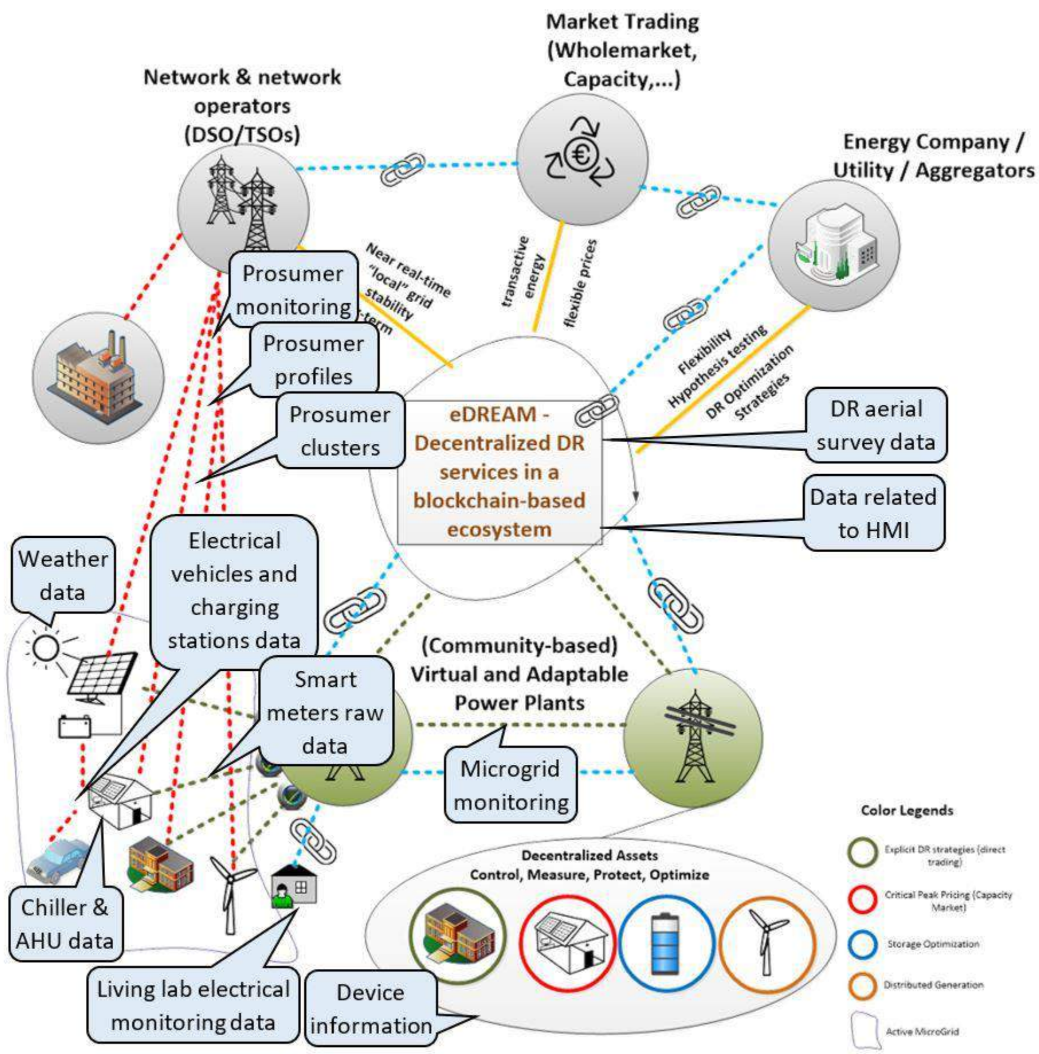

Figure 2- Considered eDREAM data models (in callouts) in relation to the envisioned project concept

2.3.1 DR aerial survey toolkit

Data Category	**DR Aerial survey data**
Data Type	Visual photogrammetry data Infra-red thermography data LiDAR data Timestamped IMU data
Description/Attributes	*This data set comprises of the information collected during the drone survey. Images taken from cameras are stored on-board on removable flash memory, LiDAR data is logged and stored locally on-board the drone and exported as a pcap point cloud file with NMEA $GPRMC sentence time and location stamps included. Separate IMU data may also be included to ensure accuracy of spatial measurement process.*
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	***Sender:*** *Drone survey* ***Receiver:*** *DR aerial survey toolkit*
Variable Type/Modelling Format	N/A N/A Point Cloud CSV
Data Standard	N/A
Acronym	N/A
Unit	N/A
Data Exchange Format	*JPEG* *JPEG* *PCAP* *CSV*
Data Availability	*Confidential*

Table 10- DR Aerial survey data model for DR aerial survey toolkit component

2.3.2 Electricity Consumption/ Production Forecasting

Data Category	**ASM Terni Living lab electrical monitoring data**
Data Type	Electrical Storage EV Charging point Building PV Plant
Description/Attributes	*Sample asset monitoring data provided by ASM for use in training/assessing the energy forecasting system component* *10 minute average instantaneous active power values*
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	***Source****: ASM Terni/* Field Data Aggregation ***Receiver****:* Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	*N/A*
Data Standard	*N/A*
Acronym	*P*
Unit	Watts
Data Exchange Format	*CSV*
Data Availability	*Confidential*

Table 11- ASM Terni Living lab electrical monitoring data model for Electricity Consumption/ Production Forecasting component

Data Category	**Weather Data**
Data Type	• Temperature • Radiation Short Wave • Wind Speed • Air density
Description/Attributes	Real time and historical data used for Production forecasts
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	**Source**: Weather API **Receiver**: Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	Figure 3
Data Standard	*N/A*
Acronym	*N/A*

Unit	- Celsius - W/m2 - m/s - mBar
Data Exchange Format	*JSON*
Data Availability	Consortium

Table 12- Weather data model for Electricity Consumption/ Production Forecasting component

Data Category	**Device Information**
Data Type	• Total solar PV Panel Area • PV Solar Panel Yield • Blade Lengths • uCHP installed power • Maximum power consumption • Maximum power generation • Power modulation capacity
Description/Attributes	Static information regarding the devices installed on prosumer site
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	**Source**: Field Data Aggregation **Receiver**: Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	Figure 3
Data Standard	N/A
Acronym	N/A
Unit	- m2 - % - M - Watt - KWatt
Data Exchange Format	*JSON*
Data Availability	Confidential

Table 13- Device information data model for Electricity Consumption/ Production Forecasting component

Data Category	**Prosumer Monitoring**
Data Type	• power consumption • power generation
Description/Attributes	Monitoring information from the power meters installed at prosumer site
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	**Source**: Field Data Aggregation **Receiver**: Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	Figure 3
Data Standard	N/A
Acronym	N/A
Unit	- Watt - Watt
Data Exchange Format	*JSON*
Data Availability	Confidential

Table 14- Prosumer monitoring data model for Electricity Consumption/ Production Forecasting component

Data Category	**Micro Grid Monitoring**
Data Type	• power consumption • power generation
Description/Attributes	Monitoring information from the power meters installed at microgrid site
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	**Source**: Field Data Aggregation **Receiver**: Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	Figure 3
Data Standard	N/A
Acronym	N/A
Unit	- Watt - Watt

Data Exchange Format	*JSON*
Data Availability	Confidential

Table 15- Micro Grid Monitoring data model for Electricity Consumption/ Production Forecasting component

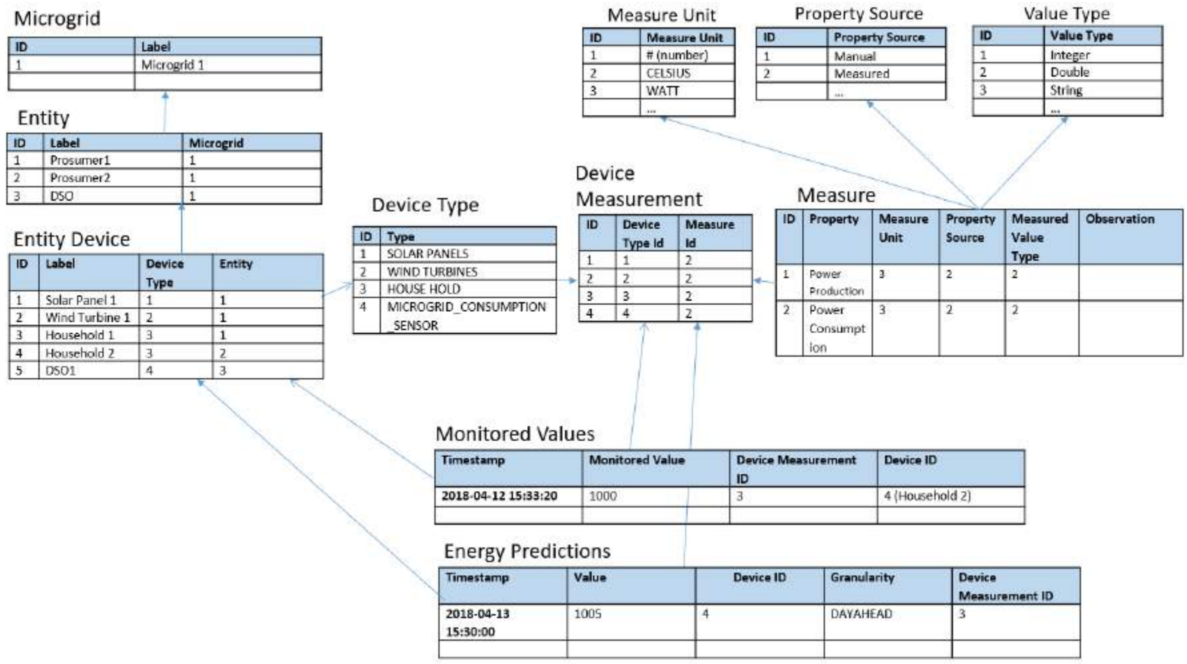

Figure 3- eDREAM Data Model for electricity consumption/production forecasting

Data Category	**Electrical Vehicles and charging stations data**
Data Type	Electrical Vehicles (EVs): - Battery State-of-Charge (%); - Residual Autonomy (Km); - Needed time to Full Charge (m); - Geolocation (geographic coordinates); - Doors Car State (Opened/Closed); - Engine Car State (On/Off). Charging Stations: - Energy data (power, voltage, current, frequency); - Number of plugs in use (0/1/2); - Alarms (electrical problems, connection problems).
Description/Attributes	*Monitoring information from the EV on-board diagnostic devices (OBD) and from the charging station single-board computer*
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	*Source: Field Data Aggregation* *Receiver: Electricity Consumption Forecasting*

Variable Type/Modelling Format	N/A
Data Standard	N/A
Acronym	N/A
Unit	- Percentage; - Kilometres; - Minutes; - Geographic coordinates; - Opened/Closed; - On/Off; - Watt; - Watt*hour; - Volt; - Ampere; - Hertz.
Data Exchange Format	*JSON*
Data Availability	*Confidential unless anonymized*

Table 16- Electrical Vehicles and charging stations data

Data Category	**Chiller data & Air Handling Units (AHU) data**
Data Type	Energy consumption and Power data for Chillers and Air handling units. Can be either average Power for the time interval or energy consumption for the time interval.
Description/Attributes	12-month historical energy consumption data for 6 chillers working as a cooling factory for a commercial building sourced by KiWi, usable as training set
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	**Source**: KiWi Power proprietary edge equipment PiP (Power Information Pod) and Fruit **Receiver**: Electricity Consumption/ Production Forecasting
Variable Type/Modelling Format	*For one project we produced a data broker that fits data into a reduced schema derived from CIM*
Data Standard	*Float*
Acronym	*N/A*
Unit	Timestamp: dd/mm/yyyy hh:mm Power: kW Energy: KWh
Data Exchange Format	*Csv, JSON (on request)*
Data Availability	Access to partners: allowed for the purpose of fulfilling the project objectives; access to the public may be granted on a fully anonymized data set, e.g. aggregated data or anonymization through introduction of noise

Table 17- Chiller data & Air Handling Units (AHU) data

Data sample

Site	Meter"	"Time"	"Value (kW)"
Site identifier	Chiller 2	01/01/2018 00:00	60
Site identifier	Chiller 2	01/01/2018 00:01	58

Table 18- Data sample: Chiller data & Air Handling Units (AHU) data

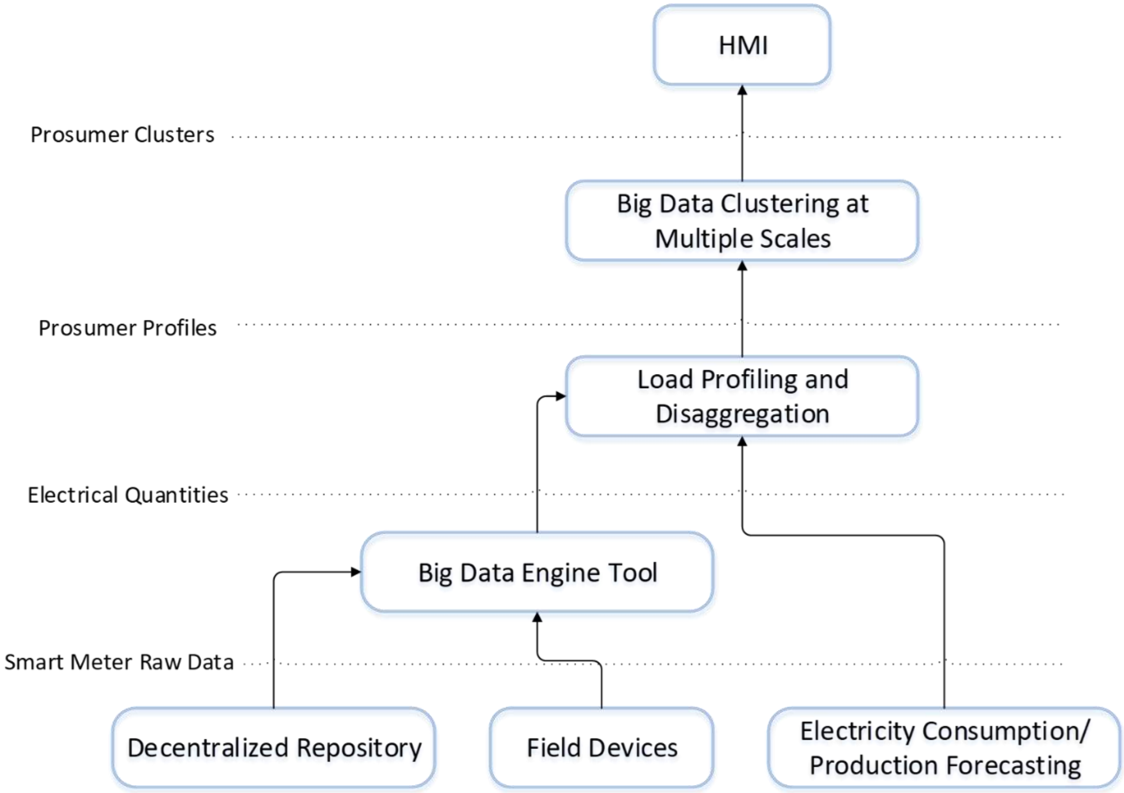

Figure 4- Structure of data received by Big Data Engine Tool and Load Profiling and Disaggregation components

2.3.3 Big data engine tool, Big data Clustering at Multiple Scales

Data Category	**Smart Meters Raw Data from ASM**
Data Type	Id smart meter; Date; Time interval between measurements; Net absorbed energy; Net injected energy; Reactive Energy Q1; Reactive Energy Q2; Reactive Energy Q3; Reactive Energy Q4;
Description/Attributes	Raw data of 1 year measures from 137 smart meters of LV prosumers, 15 minutes frequency sampling (actually received from ASM)

Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	Data received from: • Field Devices • Decentralized Repository Data sent to: Big Data Engine Tool
Variable Type/Modelling Format	*No standard Ontology at the moment*
Data Standard	String (time and smart meters id) and float (the rest)
Acronym	N/A
Unit	Time date (dd-mm-yyyy); Active energy (Wh) Reactive Energy (VArh)
Data Exchange Format	CSV
Data Availability	Confidential

Table 19- Smart Meters Raw Data from ASM

Data Category	**Prosumers profiles**
Data Type	Id smart meter; Date; Time interval between measurements; Net absorbed energy; Net injected energy;
Description/Attributes	Load and Generation Profiles of prosumers ready to be clustered
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	Data received from: Load Profiling and Disaggregation Data sent to: Big Data Clustering at Multiple Scale;
Variable Type/Modelling Format	*No standard Ontology at the moment*
Data Standard	String (time and smart meters id and cluster id) and float (the rest)
Acronym	N/A
Unit	• dd-mm-yyyy; • Wh • VAh
Data Exchange Format	CSV
Data Availability	Confidential

Table 20- ASM Prosumers profiles

2.3.4 HMI Data, eDREAM core platform

Data Category	**Prosumers clusters**
Data Type	Cluster Id; Silhouette Index; Elbow variance; Id smart meter; Date; (attribute of the clusterization derived from energy consumption/generation);
Description/Attributes	Clusters of prosumers ready to be visualized
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	Data received from Big Data Clustering at Multiple Scales; Data sent to: HMI
Variable Type/Modelling Format	*No standard Ontology at the moment*
Data Standard	String (time and smart meters id and cluster id) and float (the rest)
Acronym	N/A
Unit	• dd-mm-yyyy; • Wh • % • 1 : 1 (adimensional)
Data Exchange Format	CSV
Data Availability	Confidential

Table 21- ASM Prosumers clusters

Data Category	**Data related to HMI**
Data Type	DR Schema - DR mode (On and Off); DR Signal: - Timestamp, time interval Energy product; - DR action ID (RES curtailment, load shifting, load shedding); - Prosumer ID; - Device ID; DR Strategy Optimization: - Remuneration for DR participation; - Triggering event; - Economic KPIs; - DR participation; Optimal DR Performance; - Energy consumption; - Energy production; - Peak load demand;

	- Peak generation; Data from field devices (measurements – real-time data); Historical data;
Description/Attributes	Data related to stakeholder’s portfolio management; Monitoring data; Data from interaction between DSO, Aggregator and Prosumers; Monitoring data;
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	*Source:* - *End-users remote HMIs (via web interfaces);* - *Smart meters;* - *Recentralized Repository;* *Receiver:* - *End-users remote HMIs (via web interfaces);* - *Components of Core platform;*
Variable Type/Modelling Format	- *DR Schema: Boolean;* - *DR Signal: String <timestamp, time interval, DR action ID, prosumer ID, device ID>;* - *DR Strategy: String <timestamp, prosumers ID, asset ID, DR remuneration, trigger start/stop, KPI>;* - *DR performance: String <timestamp, power values>* - *The rest: float;*
Data Standard	N/A
Acronym	N/A
Unit	- Minutes; - Geographic coordinates; - On/Off; - Start/Stop; - Watt; - KWatt; - Watt*h; - KWatt*h; - Volt; - Ampere; - Hertz; - Monetary value;
Data Exchange Format	*XML*
Data Availability	*Confidential unless anonymized*

Table 22- Data related to HMI

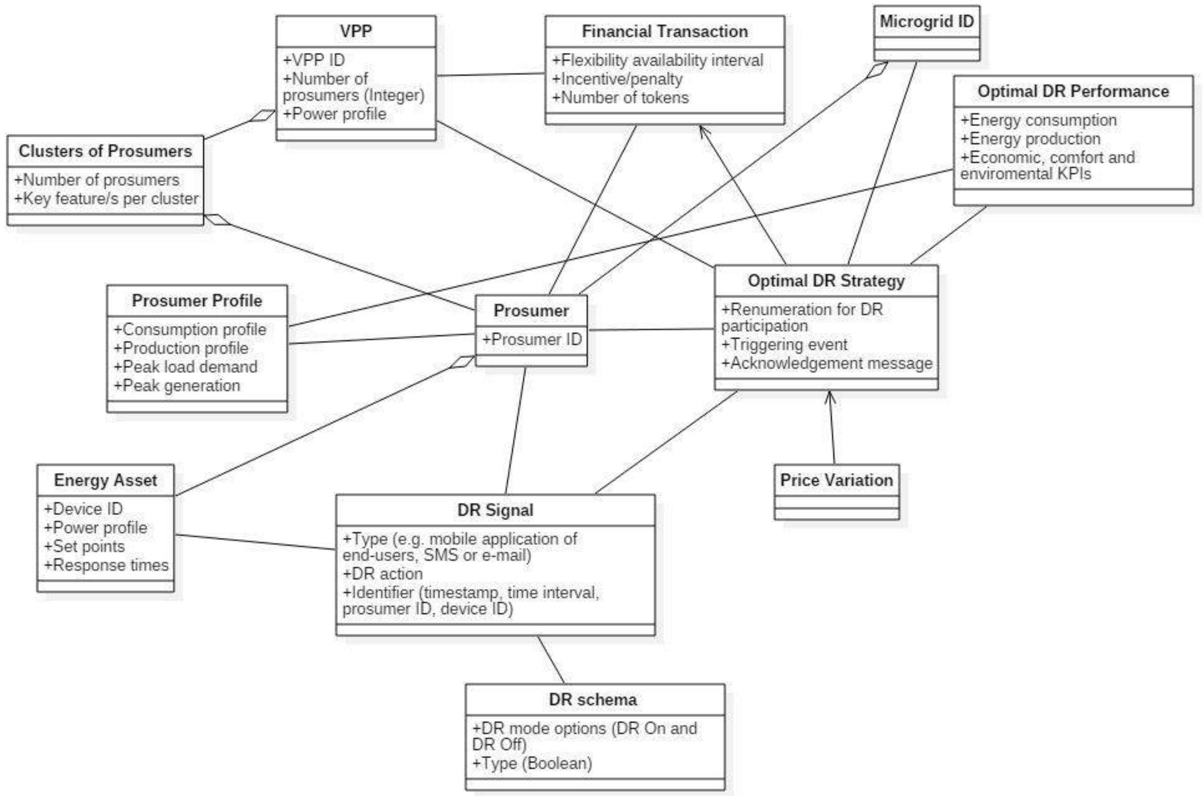

Figure 5- HMI Data Structure

3 Regulatory requirements

This chapter examines regulatory barriers and requirements in relevant localities for the purpose of constructing a regulatory roadmap, which is intended to serve as a guide for key areas of the development of eDREAM solutions. Specifically, the areas examined are Aerial survey regulations in the UK, to prepare for the UK-based pilot activities in T3.2- Aerial survey techniques for DR potential estimation, then legislation and regulations are examined relating to utilising blockchain based solutions within the eDREAM platform from both the Smart contract negotiation and the financial perspective in preparation for tasks in WP5. Regulations within Italy, the locality of the pilot site utilising blockchain technology are the main focus of this investigation, however efforts on the European level are also explored.

3.1 Aerial survey regulations in the UK

As a component of eDREAM D3.4: *Aerial 3D models and simulation procedures for DR estimation*, aerial surveys will be performed at the chosen UK pilot site(s) to gather the relevant data to exploit the technology and demonstrate the platform. It is therefore necessary to first gather and analyze the relevant local regulatory legislation before conducting the associated survey activities.

The UK Civil Aviation Authority (CAA) has a comprehensive set of rules, regulations and guidance for all commercial use of Unmanned Aircraft Systems (UAS), including multi-rotor aircraft known as drones. During eDREAM pilot operations It is of vital importance to ensure full compliance with all such rules, regulations and guidance to avoid causing damage to persons or property, and to ensure the operator is not liable to legal action being taken against them.

Under article 252 of the Air Navigation Order 2016, all SUAs (Small unmanned aircraft) operated in public places must have a valid permit. Regulation (EC) 785/2014 requires that all drones operated in public places used for commercial purpose and the CAA also require that all drone operators conducting commercial work have permission to do so under the Permission for Commercial Operations (PfCO).

Prior to July 2018, CAA permissions (PfCO) were grouped into two categories: Standard and non-standard. Standard PfCO allowed a user to operate a drone of a mass of up to 7Kg in a congested area for commercial purposes, given that they have they have appropriate insurance, and completed an operations manual and pilot competency training and assessment process. Non-standard PfCO allowed a drone of more than 7Kg to be operated with the additional requirement of submission of operating safety cases (OSC) for each flight (CAA, 2015).

Effective July 2018 the Air Navigation Order 2016 has been adjusted, reducing the number of SUA classes from 4 to 2: 0-20KG Multirotor and 0-20KG Fixed wing, eliminating the need for non-standard permissions to operate SUAs with a mass of 7-20KG. Existing permissions granted before the end of July 2018 will also be partially backdated, granting existing standard PfCO holders' permission to operate equipment up to 20KG within 150m of a congested area.

New PfCO applicants may now also operate SUAs up to 20KG within 50m of people and buildings in congested areas. Permission to perform night operations is now automatically generated provided that appropriate procedures are detailed in the applicant's operations manual. These should include performing a daylight reconnaissance prior to the flight, identifying the entire aircraft flight path and recording details of all hazards, restrictions and obstacles. During flight, Visual Line of Sight (VLoS) should be maintained at all times and the takeoff and landing site(s) should have adequate lighting.

UK Airspace has both Controlled and Uncontrolled zone areas. Controlled airspace is split in Class A,C,D and E and requires an Air Traffic Control clearance if flying any UAS with a mass greater than 7kg. In addition, there are also Flight Restriction Zones, defined around aerodromes for the protection of manned aviation. The zone is separated into inner and outer zones. The inner zone consists of the area over the aerodrome and up to the aerodrome's boundary. The outer zone is a ring of airspace outside of the aerodrome between the Inner Zone and a line that is 1km form the aerodrome boundary. Such zones are well defined in Air Navigation Charts. When Air Traffic Control facilities are available in the area, no part of the zone should be accessed without prior clearance. Class G is uncontrolled airspace so any aircraft can use it without Air Traffic Control clearance.

For all flight planning, the National Air Traffic Services (NATS) Aeronautical Information Service (AIS) should be checked for special conditions on the day and time of the planned flight, known as Notice to Airmen (NOTAM). There are also prohibited areas where any air traffic activity above them is forbidden. Those are market on charts and online sources as EGP with a numerical code.

The details regarding the pilot competence and operating safety case (OSC) and can be found in the CAA guidance document CAP 722 (CAA, 2015). It should be noted that even with non-standard PfCO from the CAA, the operator still has to comply with other safety standards stipulated by local authorities, emergency services, highways agency etc. and it may be necessary to inform such bodies or request permission based on the situation.

Current charges for PfCO range from £173-£1211 depending on the mass of the aircraft, and can be found in the 'General aviation scheme of charges', P.3.11 (CAA, 2018). Turn-around time for permissions applications are quoted at 28 days. Several companies in the North east of England have been found to offer training, certification and application for PfCO as a complete package. These will be discussed in D3.4: Aerial 3D models simulation procedures for DR estimation.

For reference, a DJI Matrice 210 drone, equipped with a Zenmuse XT thermal camera and 2 high capacity batteries (TB55), which should be capable of performing the thermal surveying tasks planned for the eDREAM pilots, has a total mass of 4.84Kg and a maximum take-off weight of 6.14Kg (DJI, 2018). Standard permission would therefore have been adequate for the equipment required by the scope of this project.

Additional relevant (ANO) 2016 articles include:

- Article 94- Small unmanned aircraft (SUA)
- Article 95- Small unmanned surveillance aircraft
- Article 241- Endangering safety of any person or property

3.2 Blockchain regulations in energy domain

The European Community has not currently defined a specific legislative framework regulating the application of blockchain technologies in the energy domain. The current efforts have been mainly focused on regulating the use of this technology in the financial sector. Nonetheless, as reported by (Miseviciute, 2018) the position taken by the European Community on blockchain and DLT (Distributed Ledger Technology) indicates a keen interest in understanding the real potential and the impacts that such technologies may have in the different sectors. Moreover, many European Institutions are concerned about the possibility that a premature regulatory framework outlined during these stages of development might limit the innovative potential of such technologies or even incur in the case of creating inefficient or inadequate legislative instruments. In light of these considerations, the European Community intends to explore the various applications of blockchain technology and its possible benefits both for public and private sectors through the implementation of several proof-of-concepts and pilots in different contexts (Blockchain Live, 2017).

In April 2018, 22 European countries signed a declaration for the creation of the European Blockchain Partnership (EBP), which will confront the progress among member states in this field and Co-operate in the establishment of the European Blockchain Services Infrastructure (EBSI). Since then, 5 more Member States have joined the Partnership, bringing the total number of signatories to 27 (European Comission, 2018). The agreement consists of the study on the technology at European scale in the digital single market, giving evidence of benefits for the public and private sectors. In February 2018, the European Commission had already launched the EU observatory and forum on blockchain, investing over 80 million euros in projects, with implications in the technical and social fields that work with this technology. By 2020, about €300 million more should be allocated to blockchain, according to the Commission's statement. For the commissioner of the digital economy Mariya Gabriel: "soon all the utilities will integrate the blockchain". The Commission had already expressed itself in favor of technology, underlining that "the decentralized and collaborative nature of the blockchain and its applications makes it possible to exploit the entire digital market" (Liberatore, 2018). From a regulatory point of view, the case of cryptocurrencies appears to be the most technologically and functionally advanced and therefore the one that requires imminent regulation. The EU is now currently starting to take steps to develop an environment for blockchain technology powered solutions, along with legislator support for the technology. On the 20th November 2018 an EU Blockchain Industry Roundtable was held in Brussels, in which several industry leaders innovative start-ups agreed to work with governments and the European commission to support further developmental efforts blockchain technology, and the legislative landscape around it (European Comission, 2018).

At an international level, the International Organization for Standardization (ISO) has already formed a technical committee on Blockchain and distributed ledger technologies, ISO/TC 307 to begin laying the groundwork for future standardization, which also facilitates future legislative efforts. Of the 11 standards currently under development, Standard ISO/NP TS 23635 lays out "Guidelines for governance”. This committee also establishes standard documentation defining standard terminology, Privacy and personally identifiable information protection considerations, Security risks, threats and vulnerabilities, Overview of identity management using blockchain and distributed ledger technologies, legally binding smart contracts and Security management of digital asset custodians. (ISO, 2018) The publication of these standards should greatly aid in development of appropriate regulatory legislation, therefore increased legislative efforts should be expected as these standards develop.

3.2.1 Blockchain- based smart contracts

At the moment, a regulatory framework has not yet been defined in Italy nor is there a legislative initiative under discussion that regulates the application of blockchain or DLT technologies in the energy context. However, as for the European case, pilot activities are being carried out supported by private entities, in order to understand the effective potential of these instruments for this sector and regulating it properly. Among the most promising initiatives, the one conducted by Enel and E.ON is rather interesting (Enel, 2017). It features a novel approach including an energy exchange through a new platform that uses blockchain technology. Blockchain allowed the counterparts to perform the transaction within a few seconds. Thanks to the direct trading which does not include the involvement of third parties, the costs of electricity purchases were also reduced.
The decentralized wholesale energy trading was tested in 2016 at the E.ON Future Lab. The system is based on a peer-to-peer network developed by the company specialized in IT Ponton. In May 2017, the partners started the Enerchain project together with other European energy companies. The goal of the 33 companies that have joined the initiative is to develop a decentralized European market for energy trading. In Italy, blockchain technologies have a defined regulation only for the purposes of limiting money laundering through the use of cryptocurrencies. The Legislative Decree n. 231/2007 defines from a legal point of view what is the virtual currency, the Virtual Currency Exchange who are the service providers in relation to the use of virtual currency, extending to such subjects the obligations for clients' verification and reporting towards authorities.

3.2.2 Blockchain-based remuneration platform

Real-time omnidirectional energy trading between prosumers and aggregators requires a unified transaction platform with the ability to make quick, efficient and secure transactions. The eDREAM framework proposes using blockchain-backed smart contracts to fulfil this need, however before looking to implement solutions legislation and regulation in this domain must be examined and understood.

Currently, the *Central banks of the EU Member States do not consider virtual currencies as equivalent to money, and they are not treated as legal tender. The European Central Bank typifies virtual currency as a digital representation of value, not issued by a central bank, credit institution or e-money institution, which in some circumstances can be used as an alternative to money* (Miseviciute, 2018). However, the recent events associated with the financial fluctuations of cryptocurrencies with the consequent risks of financial speculation led the Vice President of the EC, Valdis Dombrovskis, in December 2017 to urge the European supervisory authorities to take measures aimed at preserving financial stability and preserving investors against these fluctuations. In addition, in his recent speech of January 2018, Vice-President Dombrovskis said that the EC wants "*Europe to embrace the opportunities of blockchain, the technology underlying cryptocurrencies. But to do so, we the EU must be vigilant and prevent cryptocurrencies from becoming a token for unlawful behaviour*" (Dombrovskis, 2018). During the speech, he also stressed out the necessity to discuss as soon as possible together with key authorities and the private sector in order to outline the longer-term significance of cryptocurrencies beyond the current market trends. Cryptocurrencies and the related regulatory questions are clearly a focus of the EU's attention, and may be subject to regulatory action in the year to come. Apart from the EU context, a first concrete attempt to establish a regulatory framework for the application of DLT technologies has recently been carried out by the Government of Gibraltar with the elaboration of a regulatory draft in 2017, subsequently approved and then entered into force in 2018. Mainly the regulation states that firms in Gibraltar, that use DLT to store or transmit value belonging to others, have to apply for a license from the Gibraltar Financial Services Commission (GFSC) (Gibraltar Financial Services Comission, 2018).

4 Key Performance Indicators

This chapter defines a comprehensive list of KPIs which may be used to assess the efficacy of the platform to perform its many different objectives. These KPIs/metrics are proposed for consideration in WP7: eDREAM validation and reliability analysis, where they will be selected as appropriate on a case-by-case basis to evaluate the performance of implemented solutions. The KPIs to be used in the project will take into account the following benefits identified by the EC Smart Grid Task Force: Increased sustainability, adequate capacity and distribution grids for 'collecting' and bringing electricity to the consumers, adequate grid connection and access for all kinds of grid users, satisfactory levels of security and quality of supply, enhanced efficiency and better service in electricity supply and grid operation, enhanced consumer awareness and participation in the market by new players, and enable consumers to make informed decisions related to their energy to meet the EU Energy Efficiency targets. KPIs defined in this document will be used as input of WP7 for the evaluation assessment.

4.1 Prosumers-related metrics

In terms of prosumer related metrics, there are several indicators proposed to evaluate the solutions implemented by different projects across the Smart Grid end users. Having a strong connection with the already implemented Horizon 2020 project – Demand Response in Blocks of Buildings – there have been considered the KPI used and evaluated in DR BoB project, along with the eDREAM project requirements, from DoA in Chapter 1.1.3- Measures and indictors (DoA Pg. 144) and chapter 2- Impact of the eDREAM proposal (DoA pg. 167). In the existing power grid systems, the traditional DSO or the energy retailers are responsible to compute KPIs related to the electricity delivery and power quality, with a very low level of data sent to the end users, especially consumers. The DSO and energy retailers are thus directly responsible for any operational problems. It is in their best interest to evaluate the performance of the grid and minimize the risks, as already mentioned, especially with the integration of local distributed (renewable) energy sources, having a significant impact in the network operation. Thus, prosumers and DSO / retailers cooperation are important in order to increase the grid performance and minimize the risk of power outage on the one side and to allow prosumers active involvement in the energy market on the other side. In this section, the aim is to provide a classification and an overview of the most relevant metrics and indicators that are used for the prosumers.

These metrics are categorized into the following 4 tables:

- **Table 23** examines Demand Response in electricity, power, GHG, economy and social impact,
- **Table 24** examines Renewable Energy Usage Evaluation Metrics
- **Table 25** examines Emissions Evaluation Metrics
- **Table 26** examines Digitalization Evaluation Metrics

Demand Response in electricity, power, GHG, economy and social impact				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Electricity savings	Reduction of electricity consumption due to DR (including both shedding and shift periods).	$E_{savings,elec}(\Delta t) \approx \Sigma(\bar{P}_{baseline,elec}(t) - \bar{P}_{DR,elec}(t)) \cdot \delta_{shed+shift}(t)$ $E_{savings}[\%] = 100 * E_{savings}[kWh_p] / E_{consumption,baseline}[kWh_p]$ The data required for the calculation: • δRshed+shift R: DR event trigger ($\delta_{shed+shift}$= 1 during shedding and shift periods, and 0 elsewhere). • $PD(t)$: asset real energy consumptions (for each energy vector) during DR event, in kW. • $Pbaselin(t)$: asset baseline energy consumptions (for each energy vector) without DR event, in kW. The calculated data will be: • $E_{savings}$: Energy savings (negative in case or overconsumption). • In kWh of primary energy. • In % for all considered time and space perimeters (see Section 3.3) • $E_{savings,elec}$: Electricity savings (negative in case or overconsumption). • in kWh of final energy. • in % for all considered time and space perimeters.	[kWh/DR event]	Energy savings
Peak power reduction	This indicator corresponds to the reduction of the maximum electricity power demand.	$D_{elec,peakreduction}(\Delta t) = max_{t\in\Delta t}(D_{elec,baseline}) - max_{t\in\Delta t}(D_{elec,DR})$ $D_{elec,peakreduction}[\%] = 100 * D_{elec,peakreduction}[kW] / max_{t\in\Delta t}(D_{elec,baseline}[kW])$ The needed measures are: • $D_{elec,R}(t)$: asset real electricity demand during DR event, in kW. • $D_{elec,aseline}(t)$: asset baseline electricity demand without DR event, in kW. The calculated data will be: • $D_{elec,eakreduction}(\Delta t)$: average peak power reduction. • In kW of final energy. • In % for all considered time and space perimeters.	[kW/Dr event]	Power and demand flexibility

Peak power gap reduction	This indicator corresponds to the reduction between peak power and minimum night time demand.	$\Delta D_{elec,peakreduction}(\Delta t)=$ $=\Delta D_{elec,baseline}(\Delta t)-\Delta D_{elec,DR}(\Delta t)$ With: $\Delta D_{elec,baseline}(\Delta t)=$ $=max_{t\in\Delta t}(D_{elec,baseline})-min_{t\in\Delta t}(D_{elec,baseline})$ $\Delta D_{elec,DR}(\Delta t)=max_{t\in\Delta t}(D_{elec,DR})-min_{t\in\Delta t}(D_{elec,DR})$ $\Delta D_{elec,peakreduction}[\%]=$ $=100*\Delta D_{elec,peakreduction}[kW]/\Delta D_{elec,baseline}[kW]$ The needed measures are: • $D_{elec,R}(t)$: asset real electricity demand during DR event, in kW. • $D_{elec,aseline}(t)$: asset baseline electricity demand without DR event, in kW. The calculated data will be: • $\Delta D_{elec,eakreduction}(\Delta t)$: average peak power reduction. • In kW of final energy. • In % for all considered time and space perimeters.		Power and demand flexibility
Avoided electricity import	The avoided electricity import corresponds to the reduction of electricity demand to the grid in kWh during a fixed amount of time (shedding, DR event, etc.). This indicator reflects the global flexibility obtained from avoided consumptions and local use of electricity increase, including renewables.	$E_{savings,elec}(\Delta t)\approx\Sigma(P_{baseline,elec}(t)-$ $P_{DR,elec}(t))\cdot\delta_{shed+shift}(t)_{t\in\Delta t}$ $E_{gen,autoconsumed,increase}(\Delta t)\approx\Sigma(G_{DR,autoconsumed}(t)-$ $G_{baseline,autoconsumed}(t))\cdot\delta_{shed+shift}(t)$ $E_{import,avoided,elec}[\%]=$ $=100*E_{import,avoided,elec}[kWh]/E_{import,baseline}[kWh]$ With: $E_{import,baseline}(\Delta t)=\int D_{elec,baseline}(t).dt$ $_{\Delta t}\approx\Sigma D_{elec,baseline}(t)$ The data required for the calculation: • δRshed+shift R: DR event trigger ($\delta_{shed+shift}$= 1 during shedding and shift periods, and 0, elsewhere) • $P_{DR,lec}(t)$: asset real electricity consumption during DR event, in kW. • $P_{baseline,lec}(t)$: asset baseline electricity consumptions without DR event, in kW. • $G_{DR,utoconsumed}(t)$: auto-consumed electricity generation during DR event, in kW. • $G_{baseline,utoconsumed}(t)$: auto-consumed electricity generation without DR event, in kW. • $D_{elec,aseline}(t)$: whole site baseline electricity import (or demand). The calculated data will be: • $E_{import,avoided,elec}$: Avoided electricity import (or demand). • In kWh of primary energy. • In % for all considered time and space perimeters.		Electricity saving

Economic gain	The economic gain corresponds to the overall benefit in national currency (£, €, RON) due to the DR implementation .	$EG(\Delta t)=\Delta FR(\Delta t)+\Sigma \Delta Ex(t)_{t\in\Delta t}$ ΔEx corresponds to the energy expenses variations (electricity, fuels and district heating): $\Delta Ex(t)=(D_{baseline,distr\ heating}(t)-D_{DR,distr\ heating}(t))*Pr_{distr\ heating}+(D_{baseline,elec}(t)-D_{DR,elec}(t))*Pr_{elec}(t)$ The needed measures and information are: • $DD(t)$: asset real energy demand during DR event, in kW. • $Dbaselin(t)$: asset baseline energy demand without DR event, in kW. • $S_{DR,lec}(t)$: electricity selling during DR event, in kW. • $S_{baseline,lec}(t)$: electricity selling baseline without DR event, in kW. • $Pr_{ele}(t)$: electricity sales tariff (bought from the grid), in national currency per kWh. • $Pr_{elec,eedin}(t)$: electricity feed-in tariff (sold to the grid), in national currency per kWh. • $FR_{DR,til}$: Utilization payment of related DR program, in national currency or national currency per kWh. • $FR_{DR,vail}$: Availability payment of related DR program. The only output data will be: • $E(\Delta t)$: Economic gain from DR scenario, in national currency.	[euro/DR event]	Economic

Table 23- Prosumers KPI Classification- Demand Response in electricity, power, GHG, economy and social impact

Renewable Energy Usage Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Share of electrical energy produced by RES/local generation/ CHP	Evaluate the shared energy produced by RES	Percentage of RES energy shared with respect to total energy used/generated	%	Envir onme ntal

Table 24- Prosumers KPI Classification- Renewable Energy Usage Evaluation Metrics

Emissions Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Reduction of green-house gases emissions	This indicator corresponds to the reduction of equivalent CO_{R2R} emissions in kgCO_{R2eqR} due to the DR implementation.	$I_{CO2,reduction}(\Delta t) = \Sigma \Delta I_{CO2}(t)_{\ t\in\Delta t}$ With: $\Delta I_{CO2}(t) = \Sigma(D_{DR,elec}(t) - D_{baseline,elec}(t))_{source\in\{sources\}} * MIX_{source}(t) EF_{source}$ The needed measures and information: • $DD(t)$: asset real energy demand during DR event, in kW. • $Dbaselin(t)$: asset baseline energy demand without DR event, in kW. • $MIX_{source}(t)$: proportions of the national electricity mix (index source corresponding to the production sources, as diesel, gas, coal, nuclear, hydropower, wind, solar, etc.) • EF_{source}: emission factors of national production sources and district heating supplier, in kgCO2ReqR/kWh. The only output data will be: $I_{CO2,eduction}(\Delta t)$: Reduction of greenhouse gases emission (negative in case of emission increase), $kgCO_2$.	$[kgCO_{2eq}/DR\ event]$	Environmental GHG reduction

Table 25- Prosumers KPI Classification- Emissions Evaluation Metrics

Digitalization Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Automation and control	Evaluate the automation and control capabilities	Number of human interactions The reduction cost of manual control avoidances	Euro	Economic, Prosumer capability to perform DR
Meter Measuring Costs	Evaluate the costs reduction of meter measuring.	Average of the metering and aggregation costs per year	Euro	Economic
Demand Response service costs	Evaluate the cost of Demand Response service per prosumer	Total cost of service per prosumer	Euro	Economic

Table 26- Prosumers KPI Classification- Digitalization Evaluation Metrics

Baseline, in the context of this section of the document, is relevant to any data that is measured by quantitative methods. It aims at establishing both the framework for the evaluation of the system and action success and performance, referring to the KPIs. It is also required an overview of the measuring methodologies as a standard for Demand Response in Europe.

According to an industry white paper by EnerNoc (2011), baseline calculation methodologies differ in regards to baseline shape, type of data used timeframe of historical data, and program objective and design; hence, a properly designed baseline methodology is perhaps the most important determinant of the success of any DR program involving prosumers.

- **Baseline Type I** – baseline is generated using historical interval meter data and may also use weather and/or historical load data to generate a profile baseline that usually changes hour-by-hour;
- **Maximum Base Load (also known as Firm Service Level in PJM)** – uses system load and individual meter data from the past DR season to generate a flat, constant level of electricity demand for the baseline that the customer must remain at or below;
- **Meter Before – Meter After** – baseline is generated using only actual load data from a time period immediately preceding an event;
- **Baseline Type II** – statistical sampling generates a baseline for a portfolio of customers in the instances where interval meter for all individual sites is not available;
- **Generation** – baseline is set as zero and measured against usage readings from behind-the-meter emergency back-up generators. This type of baseline is only applicable for facilities with on-site generation (ENERNOC, 2011).

4.2 Power network metrics

In terms of power network, there are several metrics proposed to evaluate the solutions implemented by different projects across the Smart Grid. Most notable we find the guidebook presenting the Smart Grid Program Metrics regarding the ARRA (American Recovery and Reinvestment Act) (United States of America Department of Energy, 2018). Regarding the smart grid project evaluation in Europe, there are several surveys (Personal, et al., 2014), (SUNSEED, 2016), (Harder, 2017), (UPGRID, 2017), (SGEM project, 2012) which tackle this issue and provide a broad spectrum of metrics and KPIs used for reporting and evaluation. In the classical grid systems, the traditional DSO was responsible to compute KPIs related to the power reliability and quality (Pacific Power Association, 2012), (World Bank, 2009). The DSO is directly responsible for any operational problem; thus, it is in its best interest to evaluate the performance of the grid and minimize the risks. With the integration of the renewable energy in the smart grids, the network operation can be influenced by the prosumers in terms of demand response capabilities, energy storage, microgrids, etc. Their cooperation is utterly important in order to increase the grid performance and minimize the risk of power outage.

In this context, the current chapter aims to provide a classification and an overview of the most relevant metrics and indicators that are used in the Power Networks. We identified the impact of the metrics to influence four main aspects of the grid:

- economics
- Power Network Reliability

- environmental
- security

Furthermore, the Metrics identified are divided up into the following six categories, and are presented in the following tables:

- Power Supply and Distribution System Evaluation Metrics (Table 27)
- Transmission System Evaluation Metrics (Table 29)
- Flexibility and Balancing System Evaluation Metrics (Table 28)
- Renewable Energy Usage Evaluation Metrics (Table 30)
- Emissions Evaluation Metrics (Table 31)
- Digitalization Evaluation Metrics (Table 32)

Power Supply and Distribution System Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Distribution Feeder or Equipment Overload Incidents	Report the periods when equipment load exceeded the manufacturer specified limits.	The total number of hours of overload operation The percentage of time of overload operation	N %	Power Network Reliability
Distribution Feeder Load	Real and reactive power loads on the components	Hourly readings of the load	MW	Power Network Reliability
Equipment Failure Incidents	Failure incidents and reason for failure	Number of occurrences due to: • Line transformer deterioration • Circuit breaker failure • Cable failure	N	Power Network Reliability
Distribution Equipment Maintenance Cost	The cost of the activities related to equipment maintenance	The cost for a reporting period	$	Economic
Distribution Operations Cost	The cost of the activities related to distribution operation	The cost for a reporting period	$	Economic
Distribution Feeder Switching Operations Cost	The cost of switching the feeder lines in case of failures or other signals	The cost for a reporting period	$	Economic
Distribution Capacitor Switching Operations Cost	The cost of switching capacitor banks for regulating the voltage.	The cost for a reporting period	$	Economic
Distribution Restoration Cost	The restoration cost of the distribution system after incidents	The cost for a reporting period	$	Economic

Distribution Restoration Average Time	The average restoration time in case of system incidents.	The average restoration time for a reporting period	Second /Minutes	
Distribution Losses	Losses on a portion or the entire system	Modeled or computed loss percentage	%	Power Network Reliability, Economic
Distribution Power Factor	The power factor of a portion or of the entire system	Modeled or computed power factor	pf	Power Network Reliability
Truck Rolls Avoided	The cases when a specialized crew dispatch was avoided due to intelligent analysis of the process.	Estimated number of times the crew dispatch was avoided	$\mathbb{N}$	Power Network Reliability
SAIFI	System Average Interruption Frequency Index	$\frac{total\ no.of\ customer\ interruptions}{total\ no.of\ customers\ served}$	$\mathbb{N}$	Power Network Reliability
SAIDI	System Average Interruption Duration Index for each year	$\frac{sum\ of\ all\ customer\ interruption\ durations}{total\ number\ of\ customers\ served}$	Minutes	Power Network Reliability
MAIFI	Momentary Average Interruption Frequency Index (consider only interruptions of less than 5 minutes)	$\frac{total\ no\ of\ customer\ interruptions\ less\ than\ the\ defined\ time}{total\ no\ of\ customers\ served}$	$\mathbb{N}$	Power Network Reliability
CTAIDI	Customer Total Average Interruption Duration Index	$\frac{sum\ of\ durations\ of\ customer\ interruptions}{no\ of\ distinct\ customers\ interrupte}$	Minutes	Power Network Reliability
ASUI	Average Service Unavailability Index	$1 - ASAI$	$\mathbb{N}$	Power Network Reliability
ASAI	Average Service Availability Index	$1 - \frac{SAIDI}{8760}$ • Annual SAIDI given in hours	$\mathbb{N}$	Power Network Reliability
CEMIn	Customers Experiencing Multiple Interruptions	Fraction or percentage of the customers experiencing more than N interruptions	%	Power Network Reliability
Outage Response Time	The elapsed time between the outage event and the first initiated action	Monitored value by the meters used to detect and report.	minutes	Power Network Reliability
Number of High Impedance Faults Cleared	Evaluates the cleared impedance faults	Estimated number of times when the impedance faults were cleared	$\mathbb{N}$	

DER interconnection	Evaluate the grid operators that have standard interconnection policies	The percentage of the grid operators with interconnection policies	%	Power Network Reliability

Table 27- Power Network KPI Classification- Power Supply and Distribution System Evaluation Metrics

Flexibility and Balancing System Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Demand flexibility	The ability of the sub system to respond and shift their demand to periods when the electricity is cheap and abundant	$P_{DSM}(\%) = \frac{(P_{DSM})_{R\&I} - (P_{DSM})_{BAU}}{P_{peak}}$ P_{DSM} – represents the sum of the amount of load capacity that can be shifted thanks to DSM in the BAU (business as usual) and R&I (research and innovation) scenarios P_{peak} – represents the max. electricity demand in the area under evaluation		Environmental. Power Network Reliability, Economical
Distributed Generation Capacity	The total installed units implicated in demand management programs and the energy delivered	The total capacity of the units	N	Environmental
Forecasting reliability of demand/generation	Evaluate the accuracy of the forecasting techniques used with regard to electricity demand and generation	Predicted Capacity with respect to the actual capacity on a reporting period	%	Power Network Reliability
Fulfilment of voltage limits	Evaluate the power quality in distribution networks	$V(\%) = \frac{V_{BAU} - V_{R\&I}}{V_{BAU}}$ V_{BAU} – the 95% percentage voltage value during monitoring period, the value for which 95% of all voltage line measurements fall below in BAU scenario $V_{R\&I}$ – the 95% percentage voltage during monitoring period, the value for which 95% of all voltage line measurements fall below in R&I scenario	%	Power Network Reliability

Generation flexibility	Evaluated through generation response capabilities	$P_{DER}(\%) = \frac{(P_{DER})_{R\&I}}{\sum(P_R)_{R\&I}} - \frac{(P_{DER})_{BAU}}{\sum(P_R)_{BAU}}$ • P_{DER} - Represents the sum of the amount of flexible generation capabilities that the distribution network operator can shift in the BAU and R&I scenarios • P_R – Represents the sum of the generation installed capacity on the system in the BAU and R&I scenarios	%	Power Network Reliability, Economic
Hosting Capacity of Electric Vehicles	Evaluates the capability of the network to host EVs	$HC_{EV}(\%) = \frac{(HC_{EV})_{R\&I} - (HC_{EV})_{BAU}}{P_{EV}}$ HC_{EV} – represents the sum of the power consumed by the characterized EV charging points in the BAU and R&I scenarios P_{EV} – represents the sum of the installed charging points power	%	Power Network Reliability
Increased Distribution Capacity	Investigating the grid infrastructure and upgrading it	The added amount of distribution capacity		Power Network Reliability
Load Factor	Estimates whether the grid utilization is at a constant level during the day.	$LF_{day} = \frac{P_{average}}{P_{max}}$	N	Power Network Reliability
Peak Shaving Valley Filling	Evaluates the Reduction of the peak distribution or load factor according to the DSO order.	The capacity of the peak distributed.	N	Power Network Reliability
Price Volatility	Evaluate the volatility of the prices applied for the consumers	Price standard deviation	%	
Production Curtailment	Evaluates the reduction of produced energy	Production curtailed	MWh	Power Network Reliability
Ancillary Services Price	Evaluate the Ancillary Service Price	The price per hour	$/MWh	Economic

Peak Generation and Mix	Evaluate the generated energy by type	The amount of energy generated	MW	Power Network Reliability
Peak Load and Mix	Evaluate the controllable load by type	The amount of energy load	MW	Power Network Reliability
PHEVs	Evaluate the charging capacity of the vehicles	• Percentage of the vehicle's capacity versus the total capacity of the grid • Number of charging points	% N	Power Network Reliability
Flexibility	The flexibility that aggregators can offer to other market players	• The quantity available • The hour when a given quantity is available	MWh h	Power Network Reliability

Table 28- Power Network KPI Classification- Flexibility and Balancing System Evaluation Metrics

Transmission System Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Congestion	Evaluate the congestion occurred in the grid	The total congestion on a reporting period	MW	Power Network Reliability
Congestion Cost	Evaluate the cost of the congestions occurred in the grid	The cost of the congestions on a reporting period	MW	Economic
Transmission Line or Equipment Overload Incidents	Evaluate the overloads incidents on the transmission lines	The number of overloads incidents on a reporting period	N	Power Network Reliability
Transmission Line Load	Real and Reactive power evaluation on the transmission lines	Hourly Monitored Values	MW	Power Network Reliability
Transmission Equipment Failure Incidents	Evaluate the failure incidents on the transmission equipment	Number of failure incidents	N	Power Network Reliability
Transmission Equipment Maintenance Cost	The cost of the activities related to transmission equipment maintenance	The cost for a reporting period	$	Economic

Transmission Operations Cost	The cost of the activities related to transmission operations	The cost for a reporting period	$	Economic
Transmission Restoration Cost	The restoration cost of the transmission lines after incidents	The cost for a reporting period	$	Economic
Transmission Losses	Losses on a portion or the entire system	Modeled or computed loss percentage	%	Power Network Reliability
Transmission Power Factor	The power factor of a portion or of the entire system	Modeled or computed power factor	pf	Power Network Reliability
Bulk Power System Transmission Related Events **(NERC, 2017)**	Evaluate the transmission events that result in loss of load	Number of events in a year that result in load loss for more than 15 minutes	N	Power Network Reliability
Dynamic Line Rating Percentage	Evaluate the transmission circuits operated under dynamic line ratings	Percentage of kilometers of dynamic line ratings from the total lines	%	Power Network Reliability
Dynamic Line Rating Capacity Expansion	Evaluate the transmission transfer capacity expansion due to the use of dynamic (versus fixed) line ratings	The average of transmission capacity extension per kilometer for a reporting period	MW-km	Power Network Reliability
PMU Data Completeness	Evaluate the Phasor Measurement Unit Operations	Percentage of PMUs that are successfully providing data	%	Power Network Reliability
Network Completeness	Evaluate the Power Distribution Center Operations	Percentage of PMUs integrated into regional PDC	%	Power Network Reliability

Table 29- Power Network KPI Classification- Transmission System Evaluation Metrics

Renewable Energy Usage Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Amount of load capacity participating in DR	Evaluate the load capacity contracted	Amount of load capacity	MW	Environmental
Hosting Capacity RES	Evaluate the ability of the network to absorb more renewable power generation units	The portion of the RES sources	MW	Environmental
Increased hosting capacity for RES and other new loads	Evaluate the methods of increasing the hosting capacity in the Grid	The added amount of hosting capacity	MW	Environmental
Share of electrical energy produced by RES	Evaluate the shared energy produced by RES	Percentage of RES energy shared with respect to total energy distributed	%	Environmental
Improvement in Renewable Medium Voltage Generation	Evaluate the renewable generation injected at the primary distribution network	The added amount of renewable energy injected	MW	Environmental
Improvement in Renewable Low Voltage Generation	Evaluate the renewable generation injected at the primary distribution network	The added amount of renewable energy injected	MW	Environmental
Residential power sales	Residential sales with respect to total sales	Percentage of residential power sales	%	Environmental, Economic

Table 30- Power Network KPI Classification- Renewable Energy Usage Evaluation Metrics

Emissions Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
CO2 Emissions	The total CO2 emissions in the system	Modeled or estimated	Tons	Environmental
Pollutant Emissions (SOx, NOx, PM-10)	The total Pollutant emissions in the system	Modeled or estimated	Tons	Environmental

Greenhouse gas (GHG) emissions intensity	The emission rate of the pollutant with respect to the industrial production process	Pollutant emission per unit of electricity generated	g/KWh	Environmental
Emissions of ozone-depleting substances	Evaluate the emissions of ozone-depleting substances	Modeled or estimated	Tons	Environmental

Table 31- Power Network KPI Classification- Emissions Evaluation Metrics

Digitalization Evaluation Metrics				
KPI	**Description**	**Calculation Method or Identification**	**Metric Unit**	**Impact**
Automated Remote Event reading	Evaluate the reliability of the event readings	Percentage of events successfully read	%	Economic, Power Network Reliability
Automation and control	Evaluate the automation and control capabilities	• Number of human interactions • The reduction cost of manual control avoidances	N $	Economic, Power Network Reliability
Consumers being metered automatically	Evaluate the automatic metering capabilities	Number of consumers metered automatically	$	Economic
Meter Measuring Costs	Evaluate the costs reduction of meter measuring.	Average of the metering costs per year	$	Economic
Success index in meter reading	Evaluate the meter reading performance	• Percentage of meters successfully reading • Number of meters that failed	% N	Economic, Power Network Reliability
Success index in event reading	Evaluate the event reading performance	• Percentage of meters successfully reading • Number of meters that failed	% N	Economic, Power Network Reliability

Table 32- Power Network KPI Classification- Digitalization Evaluation Metrics

5 Conclusions

This document presents information about relevant data standards that govern the way the information is acquired, presented, controlled, communicated and acted upon across heterogeneous near real-time information sources. It also defines a conceptual schema for a multi-purpose vocabulary including a non-exhaustive list of terms relevant for the project. Overview of the relevant data models in existing demand response standards is included together with the specific eDREAM component data requirements. Moreover, the document reports various regulatory aspects of both Aerial survey techniques for DR potential estimation and the use of blockchain based smart contracts within the energy domain. Finally, a list of platform Key Performance Indicators (KPIs) and corresponding metrics is collected for the purpose of assessing the efficacy of the eDREAM platform. The presented KPIs are relevant figures and metrics that shall be measured by the platform and can be used to analyze the efficacy and overall performance of the systems involved. Separate lists of KPI metrics are compiled for two groups: Prosumers (consumers with generation capacity, i.e. distributed generation) and Power Networks (DSOs or TSOs).

A selection of standards relevant to the project, with particular attention to the activities involved in pilot activities were examined, with the intention of providing useful reference material for current and future development efforts across the eDREAM project, particularly T2.4, WP3, WP4, WP5, WP6 and WP7.

The outcome of the multi-purpose vocabulary is a comprehensive reference for aiding development across several different work packages and tasks, as well as providing a useful reference as a glossary of terms for parties reviewing other eDREAM reports

The result of the collection of data models for components of eDREAM solutions is to facilitate interoperability by providing a basic technical reference of data entering and exiting the platform. It should be noted however, that as both the project and the relevant architectural components are still in the early stages of development the information presented may not be entirely complete or accurate. As development continues on these components, more up to date specifications will be provided in D2.4: Requirement-driven system development.

In addition to informing personnel working on T3.4 about the procedure that must be followed to gain appropriate certification to fly a drone for commercial purposes in the UK, this research also highlighted an issue which had an effect on the location of the UK pilot site. The pilot activities planned to take place as part of T3.4 involve flying a drone of approximately 5Kg over and around a pilot site in London, United Kingdom. The criteria for an appealing pilot site include the building being of a reasonable size, having comprehensive HVAC equipment to serve as DR assets, having DG assets such as a backup generator or a CHP/CCHP plant or a PV array, and having as much accessible sensor data as possible including building temperature, energy consumption and gas consumption. As a result of the research on the regulations in the locality of the initially intended pilot site, it was discovered that the personnel working on T3.4 would be unlikely to be able to receive permission to fly within that area, as it was within controlled airspace. The result was that that potential alternative pilot sites were examined, and a new suitable site was selected.

The result of the brief investigation into regulations pertaining to blockchain backed smart contracts and token-based remuneration methods concluded that the legislative and regulatory efforts are currently still in their infancy, however there is currently a great deal of concurrent effort being put towards developing standards, regulations and legislation. Minor developments have been made so far including Gibraltar, but it does not seem that there is much a firm legal precedent for eDREAM solutions in the locality of the pilot sites. As the technology develops it should be expected that progress will speed up dramatically, and therefore entities like ISO, the European union and national governance bodies should be closely monitored for ongoing development.

All information is presented in a structured way including the summary, introduction, scope, objectives, literature overview, main results and outcomes as they relate to other elements of the project development. As such, it represents a main reference source of information about available energy data standards relevant to the project, and provides a technical reference on data that will be sent and received by the prospective project platform. This is to provide a comprehensive reference for development of new tools and services around the eDREAM platform, as well as adapting existing products.

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ANNEX 1: Data exchange information collection template

Data Category	**<e.g. DR strategies, Customers' clustering, IoT Smart meters, Weather data etc.>**
Data Type	<please mention the names of each parameter>
Description/Attributes	*<please provide a short description of the data set>*
Related Architectural Component/Tool/Method (Data Received from/Data Sent to)	*<please mention the source module or the receiver module e.g. Electricity consumption/production forecasting etc.>*
Variable Type/Modelling Format	*<Does this data conform to a standard ontology e.g. SAREF>*
Data Standard	*<e.g. string, float etc.>*
Acronym	*<Is there an acronym associated with this data?>*
Unit	<e.g. Volts RMS>
Data Exchange Format	*<e.g. XML, JSON etc.>*
Data Availability	*<e.g. Confidential, confidential unless anonymized or public>*

Table 33- Data exchange information collection template