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Abstract:

The purpose of this document is to present a summary of the initial activities performed towards analyzing scenarios and specifying Use Cases (UC) as part of WP1, as well as presenting the KPIs defined in order to be monitored by the public authorities.

Keywords:

Use cases, scenarios, Indicators, KPIs, Test site.

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1 Introduction

1.1 Purpose of the Document

The purpose of this document is to present a summary of the initial activities performed towards analyzing scenarios and specifying Use Cases (UC) as part of WP1, as well as presenting the results obtained.

A commonly shared understanding of the goals and scope of the project is required for the success of the project. The first activities triggered the discussion and agreement among all partners regarding the project scope, scenarios and use cases of interest and finally the definition of the requirements for the main components of the SmartKYE. This definition will be done in D1.1.

Finally, the deliverable D1.2 will include the KPIs identified for the assessment of the use cases defined. These KPIs are the ones required by the public authorities in order to assess the smartgrid performance.

The results of these activities, which are presented in this document, are the basis for the design and development work packages of the project that follow up.

1.2 Scope of the Document

The document includes a first section with a basic summary of the project scope and objectives. This section is supposed to be the basic information to be used internally when presenting the project within each organization of the SmartKYE consortium.

The following sections are intended to present a description of the main steps followed during the definition of the project scope, scenario and use-cases of interest.

In Section 6, a first draft description of the pilot sites is presented and a methodology for testing and quality assurance is proposed.

Finally, section 7 contains the indicators identified in order to monitor the system, including a complete description and formulas of these KPIs, mapping the SMARTKYE use cases.

2 Project Summary

2.1 Introduction

SmartKYE strategic goal is to develop a system for the future smart grid neighborhood that will enable better business decisions to be made based on real-time fine-grained data. Key end-users targeted are the public authorities who can monitor and manage key indicators in neighborhoods with the goal of better energy efficiency and CO_2 reduction.

Future Smart Cities will rely upon their districts/neighborhoods to be monitored and managed efficiently in the smart grid era. However the various neighborhoods might significantly differ from each other and follow their own goals. The infrastructure on the districts is expected to be highly heterogeneous e.g., with public lighting system, urban heating system, public buildings, commercial centers, electric vehicles, micro-generation, residential prosumers etc. There is a need for tools to enable the monitoring of Key Performance Indicators at district-wide level, being able to assess the behavior of the Energy Infrastructure deployed in the neighborhoods based on real-time analytics and take the necessary business decisions.

Different Energy Management System (EMS) will be able to share data and services through a new Open Energy Service Platform developed in the project. Stakeholders as and public authorities will be able to access and interface the existing infrastructure in neighborhoods, not only to analyze in real-time the data from such systems but also to implement common strategies enforcing energy efficiency by means of the Business and Monitoring and Control cockpit.

SmartKYE solution aims at gluing the different EMS together via the Open Energy Service Platform. Data will be acquired from all stakeholders, processed in the platform based on business related rules and communicated to the SmartKYE Cockpits. There, real-time analytics will be done and results will be considered by a Decision Support System for business and Monitoring and Control related aspects. Additionally the cockpits will provide visualization of key indicators for the neighborhood assisting further in understanding the key aspects of the city as well as easing the decisions.

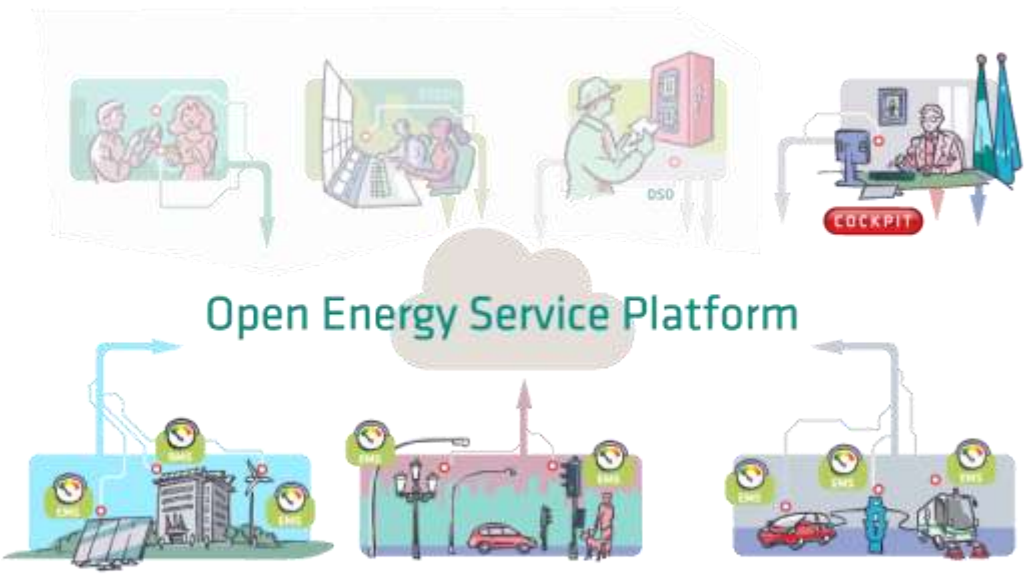


Figure 1 - High level view of the SmartKYE approach

2.2 Objectives of the Project[1]

The SmartKYE project and its consortium are geared towards addressing the previously described challenge and mission in order to provide an innovative integrated energy management system for energy positive neighborhoods.

SmartKYE proposes the development of an advanced, integrated, management system which enables energy efficiency in neighborhoods from a holistic perspective. To that end, the Energy Management Systems deployed in a typical district that are consuming or producing energy, which nowadays normally count with an isolated IT management solution, will be able to share data and services through and open platform among themselves and to external third party applications. This enables the design and development of higher level applications –e.g., SmartKYE Cockpits - that are able to process real-time data and generate valuable analytics to affect the business and Monitoring and Control (M&C) strategies that operate a district - or a subset of the energy services deployed.

The deployment of the open platform proposed by SmartKYE will provide a more **granular and accurate** tool to respond to emergency situations without actually interrupting the service. In this way, to avoid an overload, the grid operator could request to reduce the consumption from public lighting, or EV points of charge; it could request the generation of energy in the case of facilities with their own generators, or the access to previously stored energy, etc. On the other hand, the more granular solution proposed by SmartKYE also enables a finer control of different QoS managed by ESCOs.

SmartKYE targets specifically **public authorities** –e.g., municipalities - responsible of a number of public services demanding energy. These services can be run by ESCOs – as it is the case for most EV sharing systems – or directly by the local authority. In any case, it is the responsibility of the district operator to grant the efficiency – also from the energy point of view – of such public services. Thus, the SmartKYE **cockpits** will offer public authorities with a high level view of the energy and business processes ongoing in a neighborhood.

The project will validate this approach in two high profile pilot sites:

- The 22@ district in Barcelona, Spain.
- The area of Lasithi in Crete, Greece.

The general goals described above can be specified into a set of concrete scientific and technical objectives of the project:

1. Specification of **requirements, use-cases and Key Performance Indicators** associated to scenarios of efficient energy management, including EMSs (e.g., public lighting, Electrical Vehicles, micro-generation, heating/cooling systems, district public facilities), local energy grids, interface to external grids and integration of dedicated services and applications via local and wide area communication networks.
2. **Definition of common Service Oriented Architecture (SOA) for the future smart grid neighborhoods, information models and interfaces** to facilitate industry deployment and adoption by end-user, operators, designers, ESCOs, and system integrators.
3. Development of **Open Energy Services Platform** that will act as a flexible information hub that decouples the energy applications interfacing different EMS in a neighborhood –i.e. in the case of SmartKYE both the business and M&C

district cockpit- from the heterogeneity of the smart grid and communication infrastructure.

4. Integration with the different **Energy Management Systems** (EMS) deployed in a neighborhood to be able to interact with them in a service oriented way.
5. Design and Implementation of **end-user applications** that will help stakeholders' i.e. public authorities to manage and assess the energy positive neighborhoods. This includes cockpits for **business decision** taking as well as visualization of current business data, with special attention to the business models and management strategies that could lead to a better introduction of self-production capability – i.e. making the districts energy positive. Two main applications will be produces:
    a. A Business oriented Cockpit (including analytics, strategies and DSS).
    b. A Monitoring and Control oriented Cockpit (including strategies and DSS).
6. **Validation** and demonstration of the project results in two different pilot sites:
    a. The 22@ district in Barcelona, Spain.
    b. The area of Lasithi in Crete, Greece.
7. **Evaluation** and Assessment by means of a thorough **methodology** of the amount of energy and CO_2 emissions saved through the deployment of SmartKYE technology.

3 SmartKYE domain model

3.1 SmartKYE system scope definition – Initial proposal

Before the definition of scenarios and use-cases, in this section we present a brief description of the scope of SmartKYE project. This vision will be used as reference for the use-cases identification and definition of further sections of this document, such as KPIs and pilot sites.

In this context, use-cases definition can help to further define the system boundaries and in general, generate a clearer and common vision of the project among all the partners involved.

3.2 SmartKYE project architecture

The following Figure illustrates a high level system architecture that could be used as starting point for the discussion and agreement of SmartKYE system scope:

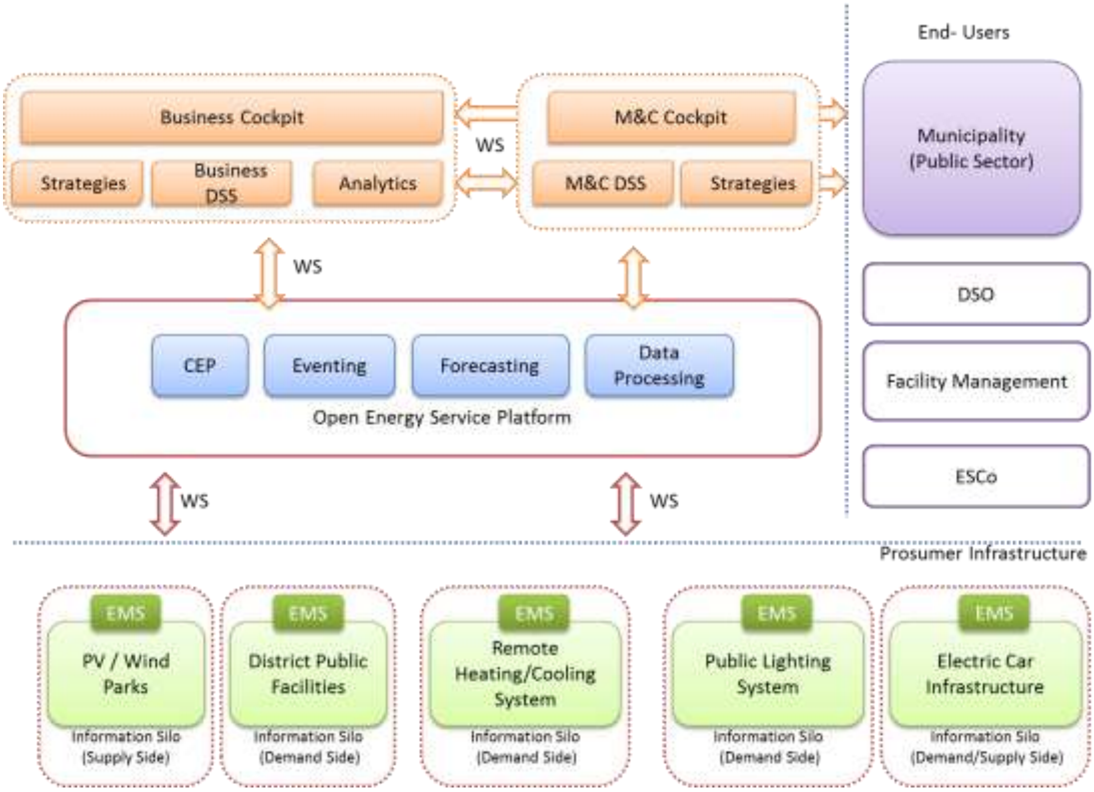


Figure 2 - SmartKYE high level architecture

From this architecture there can be derived several important aspects regarding the scope of the project and SmartKYE system limits. From the point of view of the architecture, requirements should be defined in a first step as independent of the pilot sites, and then try to map the constraints of each site (the configuration proposed is transferable to both pilot sites).

Once presented a clearer vision of SmartKYE architecture, as well as the system scope, along the following sections we present further ideas and guidelines necessary for a clearer and precise use-cases definition.

The SmartKYE project features several systems as depicted in Figure 2. The main systems of the SmartKYE solutions are:

- **Energy Management System (EMS):** these are responsible for data acquisition and provision of energy related information to the energy platform. It is assumed that every system such as Wind farms, EV infrastructure, public lighting system, public buildings, etc. has such an EMS.
- **Open Energy Service Platform (OESP):** This is the platform responsible for interaction among the stakeholders. It serves as a single point of interaction e.g., for data acquisition, data processing etc.
- **Monitoring and Control Cockpit (MCC):** This serves for monitoring and control aspects of the infrastructure. This implies visualization of technical information as well as management of the infrastructure by interaction with the EMS via the OESP.
- **Business Cockpit (BC):** This serves for visualization of business relevant information as well as additional value-added functionalities e.g., via simulation of specific situations.
-

Table 1 provides an overview of the functionalities envisioned in SmartKYE and the mapping to the systems that play the key role. This also helps identifying the differentiating factors between the two cockpits within the SmartKYE.

Table 1 – Overview of systems and functionalities

Functionalities	EMS	OESP	MCC	BC
Data Provision	☑	☑		
Data Management		☑		
Control / Management	☑		☑	
Technical Data Visualization			☑	
Business Data Visualization				☑
Decision Support			☑	☑
Business Impact Simulation				☑

3.3 SmartKYE system – Main stakeholders

The next step towards the definition of use-cases is the analysis and presentation of the main actors or stakeholders involved in the interaction with SmartKYE system. The European Technology Platform “SmartGrids Strategic Research Agenda 2035” document[2] classifies the most important involved non-research stakeholders as shown below. The following list assumes certain new roles towards the year 2035. The future role of each stakeholder is, however, subject to research itself.

- **Municipalities**

- **Energy Management Systems (EMS):**
    - Consumers
    - Distributed Generators
    - Prosumers

- **Electric Vehicle users**

- **Other third parties**
    - Energy Retailers
    - Energy Service Companies (ESCOs)
    - Storage Providers
    - Ancillary Service Providers
    - Distribution System Operators (DSOs)
    - Weather information/forecast providers
    - Data processing service providers

A detailed description for each actor is presented in the following tables:

Table 2 - SmartKYE actor – Municipality

Actor	Role, description and goals
Municipalities	This stakeholder comprises the administrative persons responsible for the various technical and business aspects of the municipality. This includes also planning, monitoring and management activities including the operation of all the different systems within a municipality (e.g., public buildings, public lighting, EV infrastructure, etc.). From the point of view of SmartKYE project, this stakeholder is seen as a human operator interacting with SmartKYE system through the two cockpits i.e. the BC as well as the MCC.

Table 3 - SmartKYE actor – Energy management systems

Actor	Role, description and goals
Energy Management Systems (EMS)	These systems, deployed in the municipality or neighborhood, are the actors that can be monitored and controlled by SmartKYE system. There can be many different energy systems that are already in place in a municipality (or would be in place in the short term) e.g., public buildings, public lighting, EV, Wind farms, etc.

- **Consumers:** Consumption of energy products and services. This is the end-user of electricity. In SmartKYE the consumers are public buildings, electric vehicles and public lighting systems.
- **Distributed Generators**: Small- and medium-scale generation of mainly renewable based electricity either for third party consumers or for own consumption.
- **Prosumers**: Consumers with the additional role of self-provided (owned) electricity generation and/or storage, such as electric vehicles.

Table 4 - SmartKYE actor – Electrical Vehicle (EV)

Actor	Role, description and goals
Electric vehicle users	For those scenarios where the integration of EV (hybrid or pure electric vehicle) will be possible, an EV user will be considered as an actor that can interact with SmartKYE system. For example, EV user might interact with SmartKYE system in order to provide particular requirements regarding his EV charging process management (by SmartKYE). The users will be required to interface mobility needs with quality and security of supply needs of the electricity system.

Table 5 - SmartKYE actor – Other third parties

Actor	Role, description and goals
Other third parties (e.g., ESCO, DSO, operators, etc.)	There can be a variety of different external systems besides those already mentioned that can interact with SmartKYE system.

- **Energy Retailers:** Selling energy and other (related) services and products to consumers. Retailers will develop consumer oriented programs and offerings.
- **Energy Service Companies (ESCOs):** Provision of a broad range of comprehensive energy solutions, including designs and implementation of energy savings projects, energy conservation, energy infrastructure outsourcing, power generation and energy supply and risk management.
- **Storage Providers:** Delivery of storage products and services, including their maintenance and operation thereby shifting electricity and energy consumption in time either for third parties or own purposes.
- **Ancillary Service Providers:** Provision of services such as Power Balancing, Voltage Profile Support, Frequency and Time and Blackstart
- **Distribution System Operators (DSOs):** Provision of services for secure, efficient and sustainable operation of electricity distribution systems. Legal obligation of a high quality, secure planning, operation and maintenance of the distribution grid.
- **Weather information/forecast providers:** This actor represents another external system interacting with SmartKYE system in order to provide update weather information and/or weather forecast that can be used internally by SmartKYE to perform energy management.
- **Data processing service providers:** Provision of data processing services respecting consumer privacy.

4 SmartKYE scenarios

The definition of scenarios and use cases are the first steps towards the architecture design of SmartKYE project. Along this section, we present the results of the analysis performed regarding key high-level scenarios and use-cases definition for the project.

Firstly, we present a summary table with the main scenarios identified, and then we provide a detailed description each of these. These scenarios will be later mapped to use-cases proposed by all partners of the consortium.

Table 6 - Summary table – SmartKYE scenarios

SmartKYE scenario ID	Title
SC-01	SC-01: Visualization and Monitoring of system data
SC-02	SC-02: Simulations for decision support
SC-03	SC-03: Management of the municipality energy

4.1 SC-01: Visualization and Monitoring of system data and KPIs

Table 7 - SmartKYE scenario SC-01

SmartKYE scenario	
ID	SC-01
Title	Visualization and Monitoring of system data and KPIs
Description	Being informed is the first step towards understanding the current situation and forms the basis for depending areas such as being able to establish advanced and intelligent control strategies. The availability of historical as well as real time information describing the energy-related characteristics and states of the different systems need to be gathered e.g., energy consumed and/or produced per EMS, per m^2, per person in the EMS; emissions due to the energy in use, data; etc., including some of the KPIs described at the end of this deliverable. The two cockpits (i.e., the BC as well as the MCC) will display the results to the stakeholders i.e., the business relevant data in the BC and the technical data in the MCC.

4.2 SC-02: Simulations for decision support

Table 8 - SmartKYE scenario SC-02

SmartKYE scenario	
ID	SC-02
Title	Simulations for decision support
Description	This scenario describes the situation where SmartKYE system simulates situations or context as a decision support tool for energy control and strategies generation (SC-03). In addition, the simulation scenario can be used to assess the successful impact of the application of a certain energy efficiency measure, viability of the deployment of new energy systems, etc. Historic and forecast data can be taken into consideration in order to asses scheduling possibilities.

4.3 SC-03: Management of the municipality energy

Table 9 - SmartKYE scenario SC-03

SmartKYE scenario	
ID	SC-03
Title	Management of the municipality energy
Description	This scenario describes the situation where SmartKYE system performs energy monitoring and management. Particularly, it will be performed energy monitoring and management, based on the different EMS under their control. For example, this scenario can describe the situation for DER generation forecasting and demand forecasting (e.g., atmospheric conditions, buildings occupancy, etc.), and how it can influence energy management.

5 SmartKYE use-cases

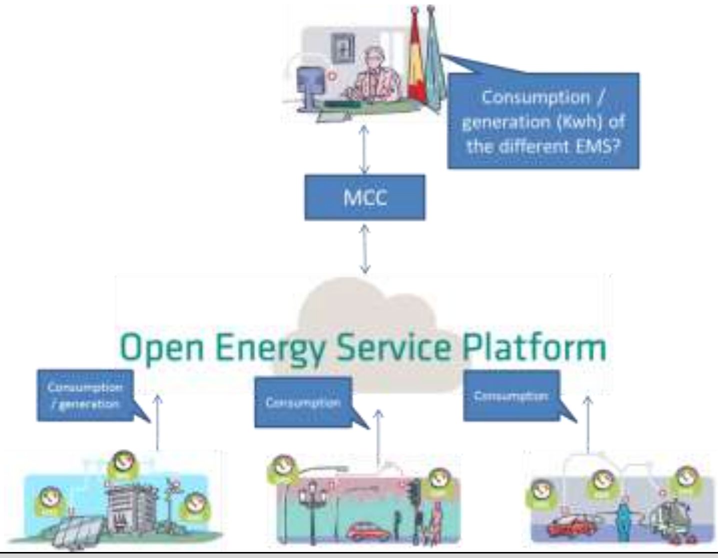
Along this section different use-cases of interest for the project are presented. At the same time all use-cases presented will be mapped to any of the scenarios identified and presented in previous sections.

5.1 SC-01 use-cases Visualization and Monitoring of system data and KPIs

5.1.1 UC-01: Visualization and Monitoring of EMS data focus on the technical side

Table 10 - SmartKYE use-case UC-01

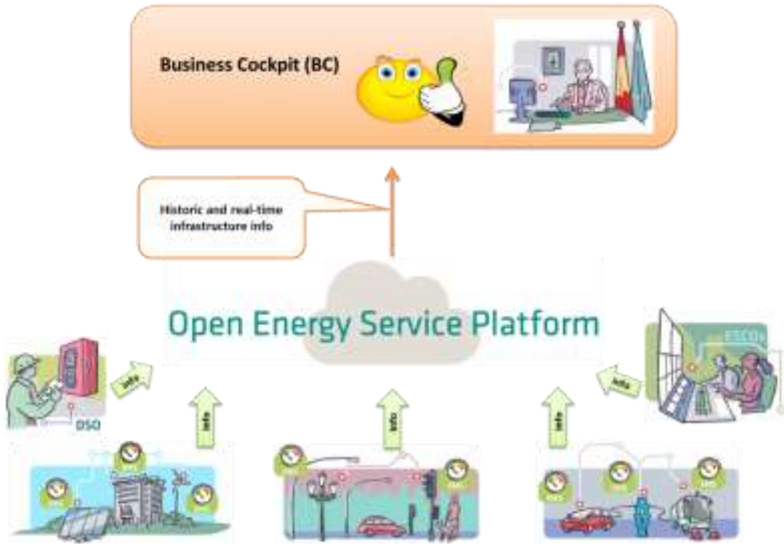
Use Case	
ID	UC-01
Title	**Visualization and Monitoring of EMS data focus on the technical side**
Relevant scenario	SC-01
Description (narrative)	The objective is to obtain real time and historical data from the different EMS, and provide added-value processed reports on technical metrics and KPIs with different granularities for the local municipalities e.g., KWh consumed and produced, per m2, per person; etc. It depends strongly on the equipment and monitoring and control systems currently installed in an EMS. This includes the visualization on the map of the facilities of the State of functioning of the different elements and monitoring of the evolution of some of the energy indicators, the visualization of the scheduling and strategies available in the system and the systems situations or incidents.
Pre-condition	• The system has the capability to retrieve information (historic and in real time). • The EMSs has a database with historic and real-time data, or at least the capability to deploy one. • The OESP provides access to data of several different EMS.
Actors (stakeholders)	• Municipalities • Other third parties: ESCOs, DSOs, etc.
SmartKYE systems involved	• MCC • OESP • EMS
Trigger	Municipality queries (through corresponding UI) to know the operational data.
Basic Path	• The MCC expresses information needs to the OESP • The OESP will interface with the different EMS to extract the data and provides it to the MCC.
Post-condition	EMS report presented to the user through the UI.
Exception Paths	Information not available due to: 1. Lack of connectivity

	2. Lack of information stored • Error message to be presented to the Municipalities
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, BDIGITAL, ICCS, TECHNOFLEX
Priority	High

5.1.2 UC-02: Visualization of Smart City KPIs

Table 11 - SmartKYE use-case UC-02

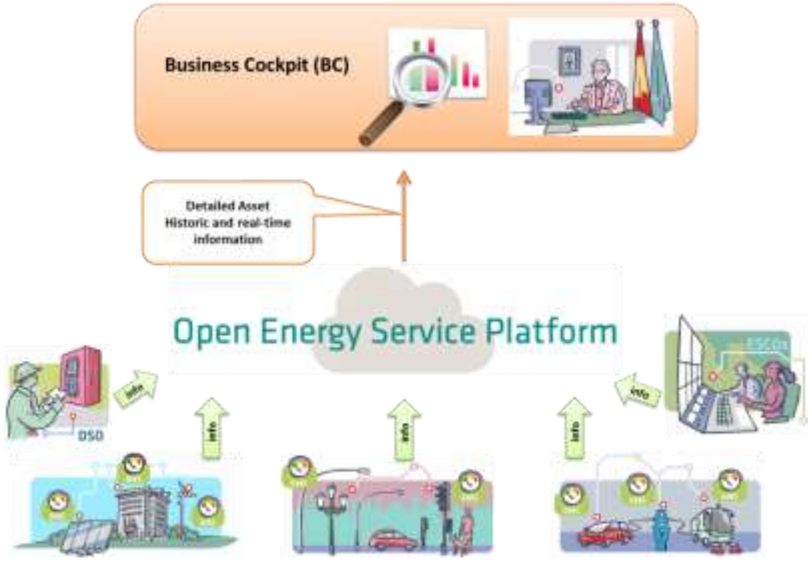
Use Case	
ID	UC-02
Title	**Visualization of Smart City KPIs**
Relevant scenario	SC-01
Description (narrative)	The objective is to provide an overview on the smart city state with focus on the business (and not on the technical) side. This will be the result of abstracted information coming from the available systems and meshed up to provide a high level view (e.g., traffic-light style assessment). The information depicted in the application will be based on selected KPIs that take information from multiple sources (online and offline). Analytics considering historic and recent data will be available. Potential visualizations include: • Overall Energy Consumption • Financial Costs related to energy • City Indicators e.g., CO_2 levels, weather, etc. The aim is not to depict technical info which will be done in MCC, but to present some business relevant KPIs for a quick overview of the city.

Pre-condition	• Historic data availability of the last years from each EMS and from the municipality • Assessment of the relevant KPIs based on data (online & offline) and current situations (live data) is possible • OESP and EMS can provide the necessary processed data
Actors (stakeholders)	• Municipalities
SmartKYE systems involved	• BC • OESP • EMS
Trigger	Municipality administrative employees e.g., mayor interact via a UI and get a high level view of the overall city status.
Basic Path	All information is acquired by the OESP. Offline electronic data may be preloaded to BC.
Post-condition	Data is visualized in the BC
Exception Paths	Inadequate data, visualization capabilities or connection problems may lead to not being able to realize the visualization.
Diagram (optional)	
Realization	
Main responsible partners (Author)	SAP
Contributing partners	Indirectly for data acquisition via OESP: Bdigital, ETRA, ICCS, UDE
Priority	high

5.1.3 UC-03: Asset Overview and Analytics

Table 12 - SmartKYE use-case UC-03

Use Case	
ID	UC-03
Title	**Asset Overview and Analytics**
Relevant scenario	SC-01
Description (narrative)	The objective is to provide more detailed analytics based on selection criteria (e.g., a GIS-constrained polygon or other area preselection) within a smart city. Areas would be selected and information related to KPIs will be depicted for the assets included in that area. For instance a selection of a neighborhood would result in visualization of the assets selected e.g., number of buildings, EV charging points, etc. and analytics on these would be presented. Depending on the KPIs, potential timely information may also be included. Potential information to be depicted include: • Assets (in numbers), their state and their energy impact • KPI calculation for the specific selected area
Pre-condition	• Accurate positioning (GPS) for all assets • Historic data availability of the last years • Recent Historic data availability up to some hours before • Assessment of the relevant KPIs based on data (online & offline) and current situations (live data) • OESP can provide the necessary filtered/computed data
Actors (stakeholders)	• Municipalities
SmartKYE systems involved	• BC • OESP • EMS
Trigger	Municipality administrative employees interact via a UI and select e.g., based on GIS criteria the city areas and get the visualization of the assets.
Basic Path	All information is acquired by the OESP. Offline electronic data may be preloaded to BC.
Post-condition	Data is visualized in the BC
Exception Paths	Inadequate data, visualization capabilities or connection problems may lead to not being able to realize the visualization.
Diagram (optional)	

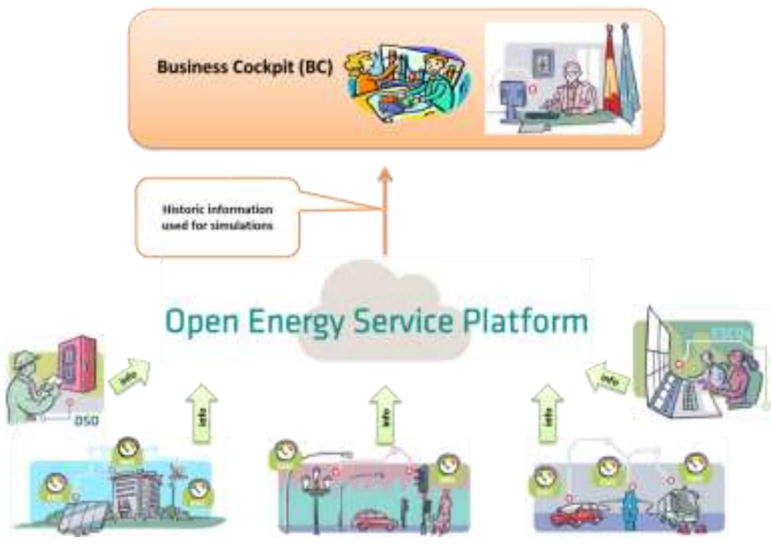
	
Realization	
Main responsible partners (Author)	SAP
Contributing partners	Indirectly for data acquisition via OESP: Bdigital, ETRA, ICCS, UDE
Priority	medium

5.2 SC-02 use-cases Simulations for decision support

5.2.1 UC-04: City planning and Business Impact

Table 13 - SmartKYE use-case UC-04

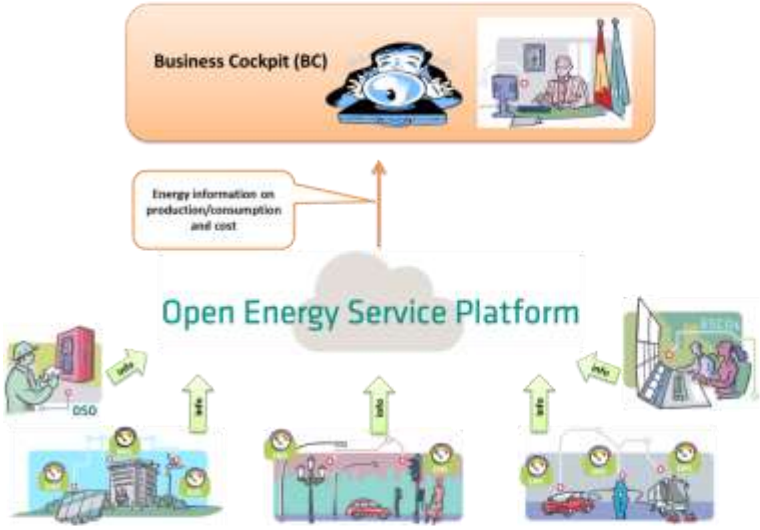
Use Case	
ID	UC-04
Title	**City planning and Business Impact**
Relevant scenario	SC-02
Description (narrative)	A simulation will be done for "what-if" scenarios and an assessment of the business impact will be measured by adjusting its characteristics e.g., municipality increases their number of EVs, wind mills generation increases, adjusting buildings efficiency levels etc. The municipality administrative employee will be able to add/remove assets and tweak aspects of the simulation and realize the impact in (i) energy signature, (ii) financial aspects. This tool is expected to assist with understanding the energy aspects of the city and how modifying some of its assets can result in different behaviors.
Pre-condition	• Historic data availability of the last years on specific municipality assets e.g., car costs, energy costs, etc.

	• KPIs are clearly defined and can be assessed and mapped to financial data • EMS is able to historical behavior for its all assets individually • Analytics of the impact is done using the static data provided from EMS
Actors (stakeholders)	• Municipalities
SmartKYE systems involved	• BC • OESP • EMS
Trigger	Municipality administrative employees interact via a UI by selecting among available assets from EMSs, and get the results of the simulation online.
Basic Path	Data is processed in order to simulate KPI impact under certain assumptions. Real-time data is optional.
Post-condition	Data is visualized in the BC; some parameters enable modification of results.
Exception Paths	Inadequate data, visualization capabilities or connection problems may lead to not being able to realize the visualization.
Diagram (optional)	
Realization	
Main responsible partners (Author)	SAP
Contributing partners	Indirectly for data acquisition via OESP and available EMS
Priority	low

5.2.2 UC-05: Enhanced energy signature predictability for new business opportunities

Table 14 - SmartKYE use-case UC-05

Use Case	
ID	UC-05
Title	**Enhanced energy predictability for new business opportunities**
Relevant scenario	SC-02
Description (narrative)	Predictability of stakeholder's energy load within a municipality will offer new business opportunities to the municipality stakeholders. For instance, stakeholder's predictability may offer participation in DR schemes as an additional source of income, or the participation in a local energy marketplace, or even help in better energy production planning and congestion preventing. To do so, highly accurate forecasting needs to be possible. This UC will investigate how enhanced forecast can be realized by various methods in order to increase the predictability of individual stakeholders (e.g., a building) or a group of them (e.g., as part of a cluster).
Pre-condition	• Historic data availability of the last years on specific municipality assets e.g., buildings production/consumption, costs etc. • Availability of DR incentives to participate e.g., price paid to participants, penalty reduction etc. • Highly accurate forecasting
Actors (stakeholders)	• Municipalities
SmartKYE systems involved	• BC • (OESP)
Trigger	Municipality administrative employees get the result of such analysis via the business cockpit. Some aspects may be dynamically configured via the UI and some others will be run offline.
Basic Path	Based on given data, predictability of groups is calculated and provided.
Post-condition	Prediction for the specified group is available (e.g. via OESP)
Exception Paths	Inadequate data may result to not being able to provide (correct) prediction of groups.
Diagram (optional)	

	
Realization	
Main responsible partners (Author)	SAP
Contributing partners	Indirectly for data acquisition via OESP: Bdigital, ETRA, ICCS, UDE
Priority	low

5.3 SC-03 use-cases Management of the municipality energy

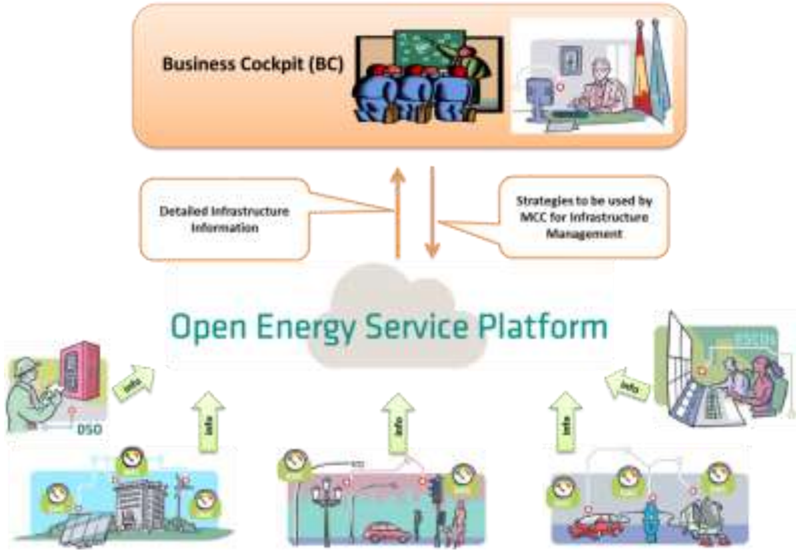
5.3.1 UC-06: Cost Assessment based on the Energy Flexibility

Table 15 - SmartKYE use-case UC-06

Use Case	
ID	UC-06
Title	**Cost Assessment based on the Energy Flexibility**
Relevant scenario	SC-03
Description (narrative)	The aim of this UC is to enable assessment of various energy scheduling scenarios based on business relevance. The result is potential strategies that can be followed in order to achieve cost-based goals. To do so the high level objectives of the Municipality are translated to measurable indicators that together with the OESP provided energy nature and flexibility will generate some strategies that could be followed and their cost impact. These strategies are then passed to the MCC who can take further decisions on how to apply them to the specific infrastructure e.g., the EMSs available.

	Input:
	• Municipality objectives as measurable indicators
	• Forecast Data (online or offline) per EMS
	  ○ Energy Production/Consumption (TS data)
	  ○ Costs associated with the energy (TS data)
	  ○ Context info: e.g., portions that are shiftable (TS data), and potentially priorities on the loads
	Output:
	• A list of prioritized strategies (with potential addition of aggregated TS data on energy and prices) based on costs, or potentially other indicators e.g., energy significance of EMS(s).
	
	Workflow:
	
	• The high level objectives of the municipality are expressed as constraints e.g., budget available, that the BC will try to achieve.
	• Based on these, a process for the cost assessment and estimated benefit of their reduction can be calculated by using EMS information acquired via the OESP. As an example, an EMS (or their aggregation) can offer the load prediction of asset(s) (e.g., EVs), its cost and the predicted flexibility potential within an interval (e.g., a PLS can turn of 50% of the lights within a street). Further aggregation of such assets will produce total load and its approximated potential to be flexible (reduced/increased) within an interval.
	• The outcome of the process is described in a form of high level strategies where types of energy (e.g., buildings, street lights, PV, etc.) or even EMSs are prioritized by their load relevance (expressed as TS data) including the potential flexibility and the associated cost (TS data).
	• These results will be provided as a service on BC (or on OESP), and therefore can be consumed by the MCC for its further processing, deployment and control. Once the MCC acquires the proposed strategies from the BC, it enhances them further according to its internal intelligence (algorithms), goals, current situation (live data) and technical knowledge of the underlying systems i.e., EMSs. MCC then selects the control actions that are negotiated with EMSs that are within the limits of the strategies that the BC has provided.
	
	The overall view is:
	• Business Goal assessment by BC and generation of high-level strategies
	• Technical assessment of BC high-level strategies, and generation of technical EMS-specific strategies by the MCC that are applied to the infrastructure.

	Please note that: • The strategies produced from the BC service are high level and may be EMS-specific agnostic; For instance the “total PLS load” adjustment could be communicated to MCC, but then it is up to the MCC to map the “PLS” reduction to the specific EMSs in the system and manage their behavior. Even if some PLS is mentioned by BC (e.g., PLS EMS should reduce load by 40%), the MCC operator/service is the one who decides how to do this at EMS level e.g., turn 50% of lights off, or reduce luminosity by 30% or combinations of them etc. • The goal of this UC is the strategy generation and potential input by the MCC. The actual control and monitoring parts which can then be derived are tackled in other UCs e.g., UC-07, UC-08, UC-09 etc.
Pre-condition	• The individual load relevance for each of the EMSs involved, with the predicted potential of their load variability (e.g., load reduction) per interval, and associated cost within a timeframe of the interest (all TS data). • Data and constrains are provided to the BC service. • Strategic goals are defined and constitute the boundaries of the solutions to be sought.
Actors (stakeholders)	• Municipalities • MCC
SmartKYE systems involved	• BC • MCC • OESP • (EMS)
Trigger	Business functionality is offered by the BC that enables the processing under specific boundary conditions and results to a set of one or more strategies that are passed to the MCC.
Basic Path	The BC service once invoked may provide a result to the MCC e.g. via OESP.
Post-condition	Results are made available in an electronically form.
Exception Paths	Missing data or not being able to find a solution, may result to incapability of creating strategies. Communication problems may hinder the dissemination of strategies to MCC.
Diagram (optional)	

	
Realization	
Main responsible partners (Author)	SAP
Contributing partners	Indirectly via OESP: Bdigital, ETRA, ICCS, UDE
Priority	Low

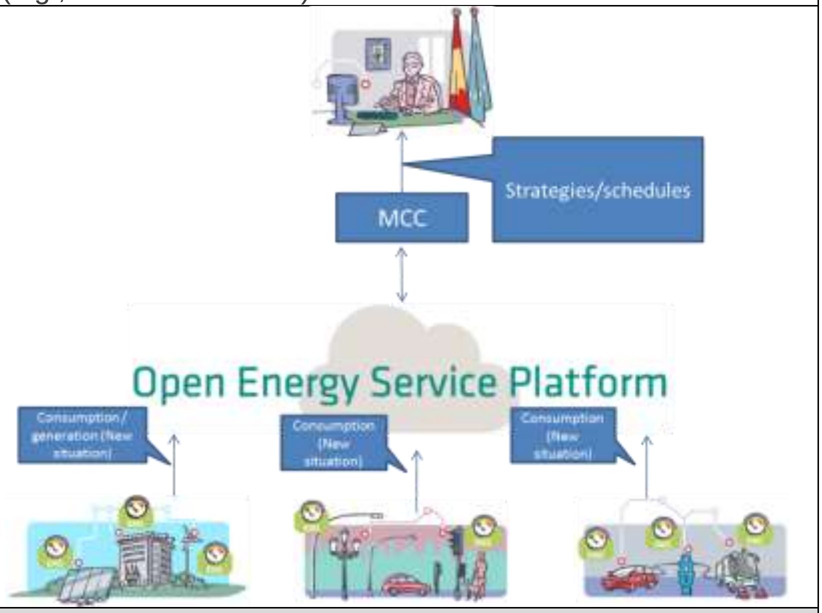
5.3.2 UC-07: Scheduling energy demand curve

Table 16 - SmartKYE use-case UC-07

Use Case	
ID	UC-07
Title	**Scheduling energy demand curve**
Relevant scenario	SC-03

Description (narrative)	This use-case describes the situation where each EMS performs energy strategies according to the rest of EMS controlled (e.g., energy generating and consuming systems and different types of loads), defined in the MCC cockpit.
	This Use case may use functionalities offered by UC-06.
	Input:
	• Municipality objectives as measurable indicators
	• Real time data per EMS
	    ○ Energy Production/Consumption
	    ○ Weather information,
	    ○ Context info: e.g., portions that are movable, and potentially priorities on the loads
	• Historical Data (online or offline) per EMS
	    ○ Energy Production/Consumption (TS data)
	    ○ Weather information
	    ○ Context info: e.g., portions that are movable (TS

<table>
<tr><td></td><td>data), and potentially priorities on the loads
Output:
A list of prioritized strategies based on costs, or potentially other indicators e.g., energy significance of EMS(s).
Workflow:
The objectives of the municipality are expressed as constraints e.g., total consumption and production, consumption by EMS, etc.
Based on these, scheduling energy demand curve can be calculated by using EMS information acquired via the OESP. As an example, an EMS (or their aggregation) can offer the load prediction of asset(s) (e.g., EVs), and percentage of potential reduction within an interval (e.g., a PLS can turn of 50% of the lights within a street). Further aggregation of such assets will produce total load and its approximated percentage of potential reduction within an interval.
The outcome of the process is the information concerning strategies</td></tr>
<tr><td>Pre-condition</td><td>The system has the capability to retrieve information (historic and in real time).
The EMSs has a database with historic and real-time data, or at least the capability to deploy one.
The OESP provides access to data of several different EMS.
The EMSs offer services for their control</td></tr>
<tr><td>Actors (stakeholders)</td><td>Municipalities
EMS
Other third parties</td></tr>
<tr><td>SmartKYE systems involved</td><td>OESP
MCC
EMS</td></tr>
<tr><td>Trigger</td><td>There can be different triggers for the optimization of the demand curve of a EMS
System starts
New loads or EMS are detected by the OESP, so that local optimization mechanisms are triggered to adapt to the new situation/context</td></tr>
<tr><td>Basic Path</td><td>Based on data received from different EMS (either energy generating or consuming), the MCC generates “control schedule plans”. Optimization operations are performed continuously according to data received.
When generators EMS are available, energy generation forecast applications can provide “artificial” generation forecasts to energy optimization applications, so this information can influence the control schedule plan generation process.
“Control schedule plans” generated for each of the EMS for a specific period of time is assigned a priority and stored</td></tr>
</table>

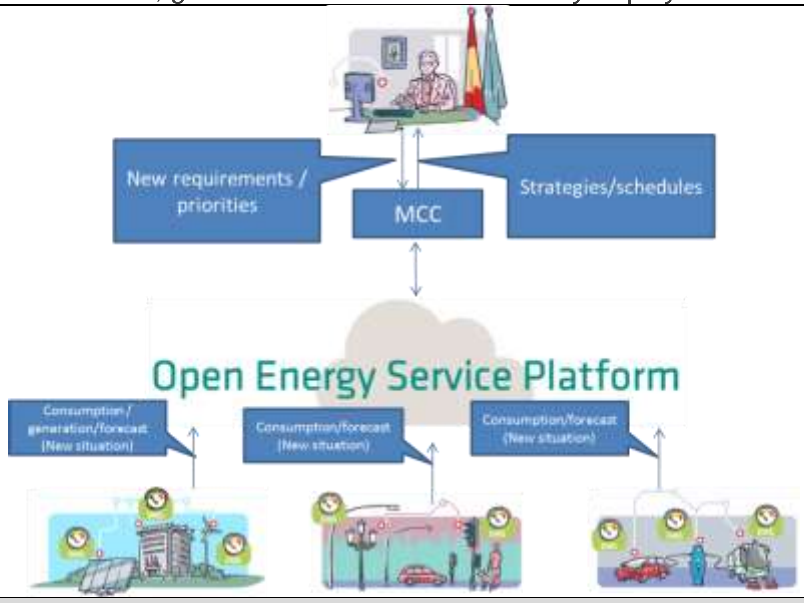
	locally. • While executing a specific operation strategies, the MCC monitors the situation and may adjust how the strategies should be further executed (potentially optimized at MCC level).
Exception Paths	• If required, energy loads operation can be adapted or modified despite of generators availability or forecast, in order to accomplish a certain Service Level Agreement (SLA) or operation condition required. Operation schedule should be updated immediately due to the reception of new operation requirements with a high priority. For example, in case of reception of a mandatory demand response (DR) request from a new operation requirements are set by the municipalities, OESP should generate a new control schedule plan so that main loads operation should be adapted (e.g., reduced or shifted).
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, ICCS, TECHNOFLEX, BDIGITAL
Priority	High

5.3.3 UC-08: Optimization of a EMS energy demand curve based on a situation/context information

Table 17 - SmartKYE use-case UC-08

Use Case	
ID	UC-08
Title	**Optimization of a EMS demand curve based on a new planned situation/context**

Relevant scenario	SC-03
Description (narrative)	This use-case describes the process where new situations or context within a municipality (e.g., buildings occupancy, organized events, traffic, etc.) are planned and consequently used for the generation of new control schedule plans and strategies. An optimization action should be generated for certain situations. Once an optimization strategy is already applied, previous control plans could be delayed or simply changed according to new local data or by an external actor. However, it may be necessary to generate new control schedule plans and strategies based on a new situation within the municipality. Data from the EMS are analyzed and detect/derive a new planned situation/context. New situation/context detected are presented for validation to the municipality so that **new operation requirements would be sent in order to trigger the generation of new control schedule plans** (local to each EMS). The new context can be properly identified and stored.
Pre-condition	• Pre-defined types of situation/contexts (e.g., buildings occupancy, organized events, traffic) Identified and stored well known situation/contexts • Pre-defined load priorities or **control schedule plan** prioritization mechanisms.
Actors (stakeholders)	• EMS • Municipalities • Other third parties
SmartKYE systems involved	• MCC • OESP • EMS
Trigger	New planned situation/context event detected within a EMS (or alternatively a new situation/context defined)
Basic Path	• Based on the new situation/context, the municipality can define manually new operation requirements for certain (or all) EMS. Additionally, the municipality can assign priorities to each load or EMS to be controlled within the situation/context and, once defined the whole scenario, it can receive also a priority. • The new context (including the new operation requirements) may benefit from other UC. Finally, if decided by the municipality, the new situation/context is properly identified and stored. • New optimization actions and strategies will be properly defined e.g., the load with low priorities or with high potential storage could be shifted.
Post-condition	Different load EMS are adapted and controlled according to a new context.
Exception Paths	• Current energy demand of an EMS cannot be adapted to required situation/context due to problems in the grid (e.g., previous reception of mandatory demand consumption).

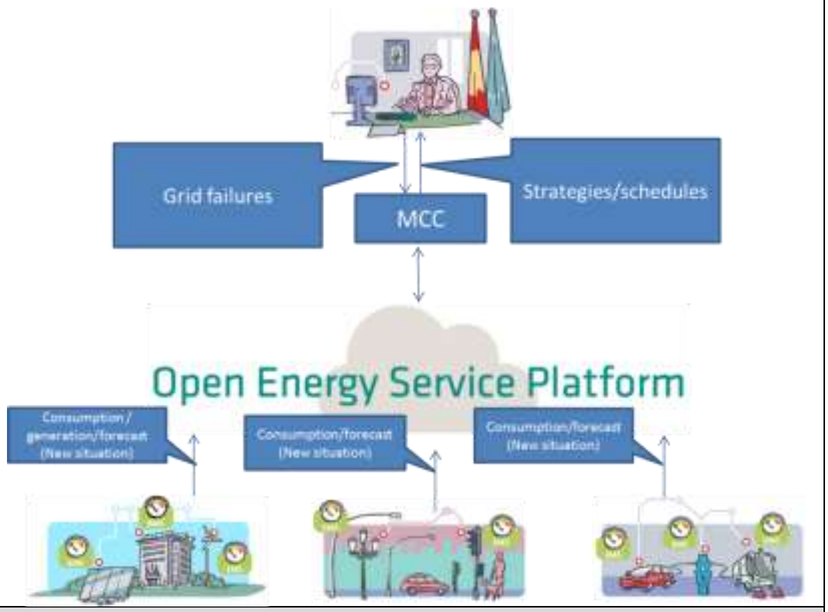
	• Municipality is notified that the time schedule proposed cannot be deployed, so that further considerations should be taken into account. • Municipality can decide not to change current time schedules, or perform new strategies in the scenario to evaluate, get a successful result and finally deploy it.
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, ICCS, TECHNOFLEX, BDIGITAL
Priority	High

5.3.4 UC-09: Optimization in case of foreseen congestions

Table 18 - SmartKYE use-case UC-09

Use Case	
ID	UC-09
Title	**Optimization in case of foreseen congestions**
Relevant scenario	SC-03
Description (narrative)	This use-case describes the situation where the overall EMS demand/supply should be adapted due to foreseen congestions. Under this scenario, it should perform local optimizations and strategies (e.g., load shifting/shedding actions), in order to assure energy supply for critical loads in the system. The critical loads are those that could not be shut-down in case of grid congestion (they have been assigned a high priority when defining situation/contexts for the EMS).

	Energy storage as well as RES generation EMS must provide power firstly to the critical loads within the EMS, before supporting the grid. Other uncritical loads could be shifted. If required the whole EMS can operate in "islanding mode", which means that the EMS generating and consuming are properly optimized so that energy from the grid is not required for a specific period of time. This use-case can be seen as a particular scenario of use-case 01, since a grid failure is a particular situation/context within an EMS.
Pre-condition	• For each context, a municipality has defined critical loads within the EMS (pre-defined critical loads with high priority within an EMS). • Loads within an EMS have been assigned priorities. • EMS already in place and capable of providing energy internally to the grid.
Actors (stakeholders)	• EMS • Municipality • Other third parties
SmartKYE systems involved	• OESP • EMS • MCC
Trigger	Detection of a grid failure by SmartKYE system (or possibly reception of a grid failure message from a utility).
Basic Path	• Detect a grid failure • If this scenario is well-known and identified, proper strategies (load shifting and shedding, etc.) are performed locally in order to guarantee energy supply for critical loads according to a load operation schedule. • EMS generators and, if available, EMS energy storage can be requested to provide support to EMS grid so that the whole EMS can possibly operate in islanding mode. • Municipality can provide further control on specific loads within the EMS so that energy demand of the EMS is further reduced. This can be achieved by defining new scenarios, validating them, and finally sending new operation requirements to the EMSs so that new control schedule strategies are generated locally.
Post-condition	Only critical loads operate according to time schedule operation. Possibly, EMS can operate in islanding mode.
Exception Paths	EMS cannot perform enough energy strategies to assure the energy supply to critical loads. An energy supply failure affects an EMS.

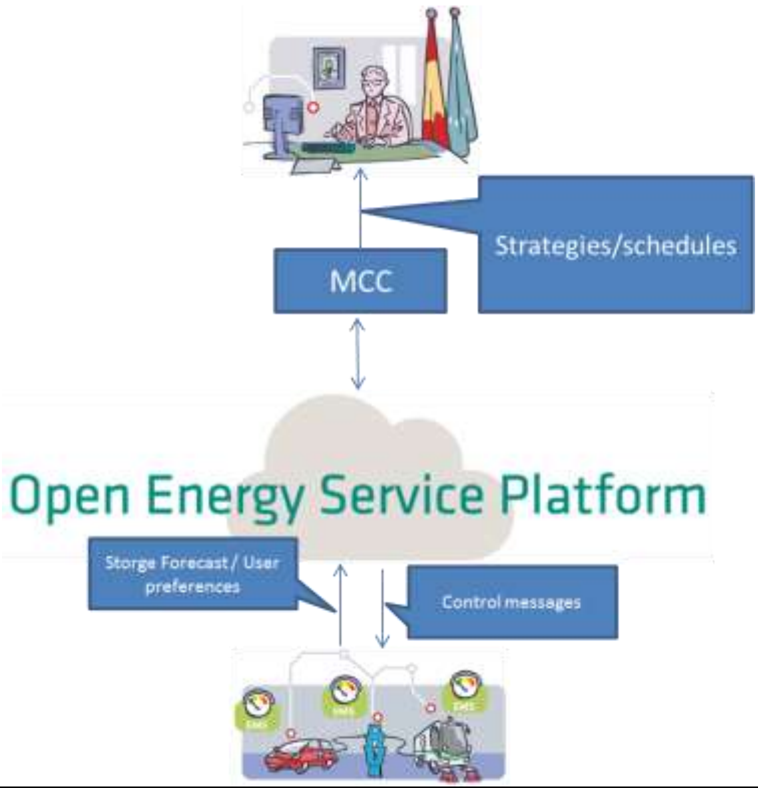
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, ICCS, TECHNOFLEX, BDIGITAL
Priority	High

5.3.5 UC-10: SmartKYE Electrical Vehicles (EV) local optimization and storage capacity forecasting

Table 19 - SmartKYE use-case UC-10

Use Case	
ID	UC-10
Title	**SmartKYE Electrical Vehicles (EV) local optimization and storage capacity forecasting**
Relevant scenario	SC-03
Description (narrative)	When Electric Vehicles (EV) and Plug-in Hybrid Electric Vehicles (PHEV) are available, it will be managed the charging of EVs so this can be used as a mechanism to optimize demand curve of the EMS. EV management application will be responsible at the end for the definition of charging periods, when to extract energy from EVs, etc. The task to actually charging or discharging an EV is left to the charging station (or to the battery management systems). On the other hand, energy storage forecasting mechanisms developed will provide a forecast of the amount of EV storage capacity for a determined period of time. This can be translated either into energy demand from the system or energy source that can be supplied to the system if necessary.

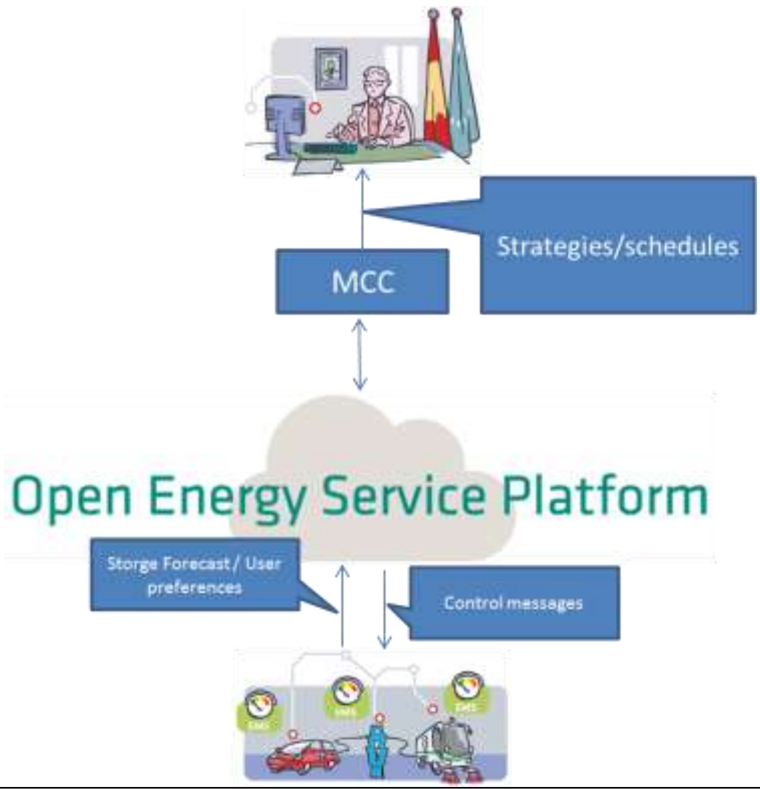
	Data obtained from forecasting mechanism can be used as input by another application to manage EVs on the system. Data gathered by the EMSs can be provided to further optimize EV batteries charging operation (e.g., when more RES are available, price of electricity is cheaper; avoid a peak demand hour, customer requirements, etc.).
Pre-condition	• Proper EV infrastructure is deployed within pilot site and EV or similar (e.g., electrical or hybrid buses, etc.) are available within the EMS. • Proper user-interface for the EV charging stations. This will enable the interaction between users and OESP in order to provide specific requirements regarding the EV charging process.
Actors (stakeholders)	• EV end user • EMS • Municipality
SmartKYE systems involved	• OESP • MCC • EMS
Trigger	An EV is plugged in into an EMS's charging station.
Basic Path	• An end user connects an EV to a proper charging station. • Though the proper EV user interface of the charging station, the EV user introduces a set of parameters or preferences regarding the expected EV charge he expects. Some requirements might be minimum expected EV charge, and charging time (e.g., departure time). • Depending on EV and charging station characteristics, EV charging unit senses it is being plugged and starts a charging state (or any other state according to user defined charging preferences). • Charging station sends proper message, indicating a new EV has been plugged as well as the EV user requirements introduced through the proper interface. • EV storage forecasting applications updates EV forecast and provides this information to EV management applications. • EV charging operation is scheduled according to current and future context e.g., available and future RES and electricity price, EV charging requirements defined by user or municipality, etc. • Proper control messages are sent to the corresponding charging station control system, which acknowledges the reception of messages, and takes control over EV charging process. • EV charging completes successfully before EV is unplugged by its user. • EV user disconnects EV from charging station. • EV disconnection from charging station is notified, updates EV storage capacity forecast, and generates new control schedule plans according to new context.
Post-condition	An end user charges successfully its EV while this has had a minimal impact in the overall EMS energy demand curve,

	mainly due to optimized control of EV charging process.
Exception Paths	• One possible exception path can be the interruption of the EV charging process due to, for example, the reception of a mandatory request from the municipality. Such situation will imply to stop charging EVs and to update the overall EMS schedule. Final state can be an EV not fully charged. • In the same line of previous path, the EV charging is shifted in case of DR request from utility or grid failure. • Other possible exception path can be the detection of a grid failure, and consequently the EV EMS is required to provide support to EMS energy grid so that the energy stored in the EV can be used to supply critical loads within the EMS. • EV user can also disconnect its vehicle from charging station before the charging time specified (e.g., in case of an emergency).
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, ICCS, TECHNOFLEX, BDIGITAL
Priority	Low

5.3.6 UC-11: Municipality EV fleet management

Table 20 - SmartKYE use-case UC-11

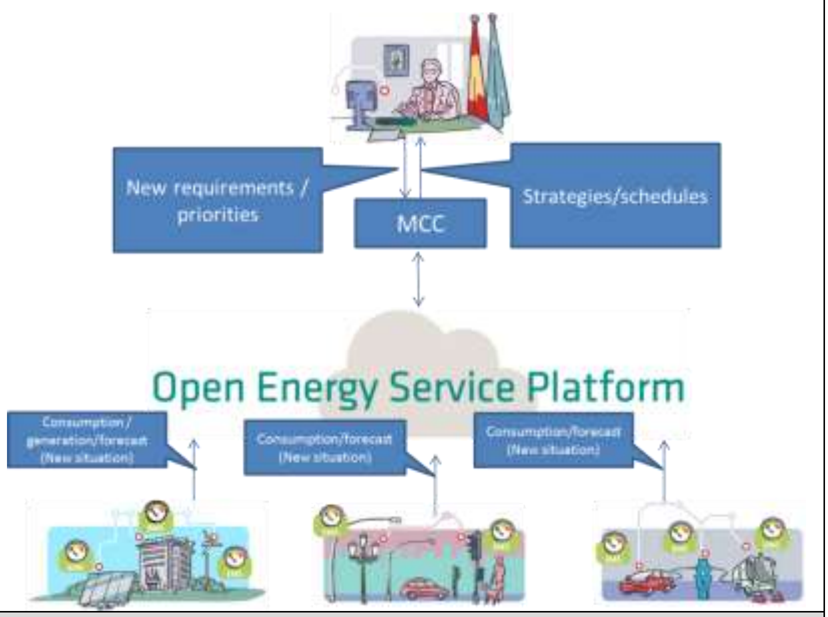
Use Case	
ID	UC-11
Title	**Municipality EV fleet management**
Relevant scenario	SC-03
Description (narrative)	This scenario differs slightly from the scenario previously presented since in this case EV management or even a whole EV fleet management is performed according to municipality requirements. An EV fleet might be available within an EMS besides third party EVs also using EV charging stations available. The entire EV fleet might be managed by the municipality. For example, a municipality should be able to define in a daily basis what should be a minimum acceptable charge for its EV fleet at a specified point in time. Additionally charging process might be further controlled based of external data.
Pre-condition	• Proper EV infrastructure is deployed within pilot site and EV or similar (e.g., electrical or hybrid buses, etc.) are available within the EMS. • Proper EV models and EV systems drivers are properly deployed in OESP. EV systems offer services via the OESP provides for their control.
Actors (stakeholders)	• EMS • Municipality
SmartKYE systems involved	• EMS • OESP • MCC
Trigger	A municipality defines how a part (or an entire) EV fleet charging process should be performed for a specific period of time.
Basic Path	• Municipality checks the state of its EV fleet, and decides to set new requirements to trigger the charging process of part (or the entire) EV fleet. • Depending on the results obtained, the municipality might deploy the requirements to the EMSs. The EMSs will perform new control schedule strategies based on local data obtained from the EV charging stations and the requirements.
Post-condition	EV fleet charging optimized based on EMS requirements/needs.
Exception Paths	• EV fleet charging process should be interrupted due to, for example, the reception of a mandatory request from the municipality. Such situation will have to be notified to the municipality so that updated control schedule strategies have to be generated. Final state can be some EVs not fully charged.

Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA
Contributing partners	UDE, BDIGITAL
Priority	Low

5.3.7 UC-12: Energy demand curve optimization based on a "non-critical" request

Table 21 - SmartKYE use-case UC-12

Use Case	
ID	UC-12
Title	**Energy demand curve optimization based on a "non-critical" request**
Relevant scenario	SC-03
Description (narrative)	This use-case describes the situation where the energy consumption (demand curve) of an EMS should be optimized based on the reception of data from an external source. This is not a critical scenario mainly due to the nature of the information received. For example, this can be the case when new weather forecast information, or new price tariff information is received. Once the information is received, it can be used to generate new control strategies that optimize the operation of the

	different EMS under its control.
Pre-condition	• SmartKYE system properly deployed and in operation. • OESP has control over several different EMS within a city.
Actors (stakeholders)	• EMS • Municipality • Other third parties
SmartKYE systems involved	• OESP • EMS • MCC
Trigger	A third party (e.g., weather forecast provider, etc.) sends updated “non-critical” information to one or more EMS.
Basic Path	• OESP acknowledges the reception of information from an EMS. • Information received is assigned a priority. This can be based on a prioritization mechanism and priority levels defined. • Assuming information received is assigned a priority level that implies a “non-critical” situation, local optimization applications will be triggered in each OESP. • As a result, new control strategies are generated for each of the EMS under control of each OESP. These control strategies are deployed by the OESP so that the operation of the different EMS is adapted to the situation/context.
Post-condition	A municipality energy demand is optimized based on the information received and local data used to generate local control schedule plans by each EMS.
Exception Paths	• One option can be that EMS cannot optimize the energy consumption of the municipality according to the information received, so that EMS continues to operate in the same way they were doing before the information reception.
Diagram (optional)	
Realization	
Main responsible partners (Author)	ETRA

Contributing partners	UDE, BDIGITAL
Priority	Low

5.4 Overview of use-cases and systems

Table 22 provides an overview of all use cases as well as the involved systems considered at this stage. As expected all data comes through EMS and is communicate via the OESP; hence these two are present in almost all UCs. The interaction is happening via the MCC or BC depending on the specific UC.

Table 22 – Overview of Use Cases and involved systems

	EMS	OESP	MCC	BC
UC-01: Visualization and Monitoring of EMS data focus on the technical side	☑	☑	☑	
UC-02: Visualization of Smart City KPIs	☑	☑		☑
UC-03: Asset Overview and Analytics	☑	☑		☑
UC-04: City planning and Business Impact				☑
UC-05: Enhanced energy signature predictability for	☑	☑		☑
UC-06: Cost Assessment based on the Energy Flexibility	☑	☑	☑	☑
UC-07: Scheduling energy demand curve	☑	☑	☑	
UC-08: Optimization of a EMS energy demand curve based on a situation/context information	☑	☑	☑	
UC-09: Optimization in case of foreseen congestions	☑	☑	☑	
UC-10: SmartKYE Electrical Vehicles (EV) local optimization and storage capacity forecasting	☑	☑	☑	
UC-11: Municipality EV fleet management	☑	☑	☑	
UC-12: Energy demand curve optimization based on a “non-critical” request	☑	☑	☑	

Table 23 – Overview of main issues of the BC tackled

	Decision Support	Simulation	Strategies
UC-02: Visualization of Smart City KPIs	☑		
UC-03: Asset Overview and Analytics	☑		(partially)
UC-04: City planning and Business Impact	☑	☑	(partially)
UC-05: Enhanced energy signature predictability for	☑	☑	
UC-06: Cost Assessment based on the Energy Flexibility	☑	☑	☑

Table 24 – Overview of main issues of the MCC tackled

	Decision Support	Monitoring	Control Strategies
UC-01: Visualization and Monitoring of EMS data focus on the technical side		☑	
UC-06: Cost Assessment based on the Energy Flexibility	☑		☑
UC-07: Scheduling energy demand curve	☑		☑
UC-08: Optimization of a EMS energy demand curve based on a situation/context information	☑		☑
UC-09: Optimization in case of foreseen congestions	☑		☑
UC-10: SmartKYE Electrical Vehicles (EV) local optimization and storage capacity forecasting	☑		☑
UC-11: Municipality EV fleet management	☑		☑
UC-12: Energy demand curve optimization based on a "non-critical" request	☑		☑

5.5 Prioritization of scenarios & Use-cases

Along this section we present a prioritization of the scenarios and use-cases provided along this document. At this stage of the project a prioritization of use-cases is not critical, however, the list showed below can be used as a reference (or summary) of all use-cases presented along the document. All these use-cases have been agreed within the project consortium and will be used as the starting point for the SmartKYE system project requirements definition.

Table 25 - Use-cases summary table – Prioritization

Scenario	Use-cases	Priority
SC-01: Visualization and Monitoring of EMS data	Visualization and Monitoring of system data and KPIs UC-01: Visualization and Monitoring of EMS data focus on the technical side	High
	UC-02: Visualization of Smart City KPIs	High
	UC-03: Asset Overview and Analytics	Medium
SC-02: Simulation for decision support	UC-04: City planning and Business Impact	Low
	UC-05: Enhanced energy signature predictability for	Low
SC-03: Control and optimization of EMS	UC-06: Cost Assessment based on the Energy Flexibility	Low
	UC-07: Scheduling energy demand curve	High
	UC-08: Optimization of a EMS energy demand curve based on a situation/context information	High

	UC-09: Optimization in case of foreseen congestions	Medium
	UC-10: SmartKYE Electrical Vehicles (EV) local optimization and storage capacity forecasting	Low
	UC-11: Municipality EV fleet management	Low
	UC-12: Energy demand curve optimization based on a "non-critical" request	Medium

It is important to highlight that the scenarios and use-cases provided have been authored to be as general as possible. From these scenarios and use-cases can be later derived specific use-cases adapted to the particular characteristics of the pilot sites to be used in SmartKYE project, Barcelona and Crete test sites.

5.6 Use-cases workflow

From the scenarios and use-cases analysis performed in the previous sections, it is possible to derive several workflow diagrams that present in a summarized and graphical way the main interaction between the different components of the SmartKYE system.

The workflows presented below have not been created using any particular standard or technology, they simply have been developed to summarize the main concepts gathered through the use-case analysis as well as being a reference point and possibly a tool to trigger the discussion during the requirements analysis stage.

5.6.1 Workflow Scenario 01: Visualization and Monitoring of EMS data

The following workflow illustrates the main steps described in Scenario 01 for the **Visualization and Monitoring of EMS data**.

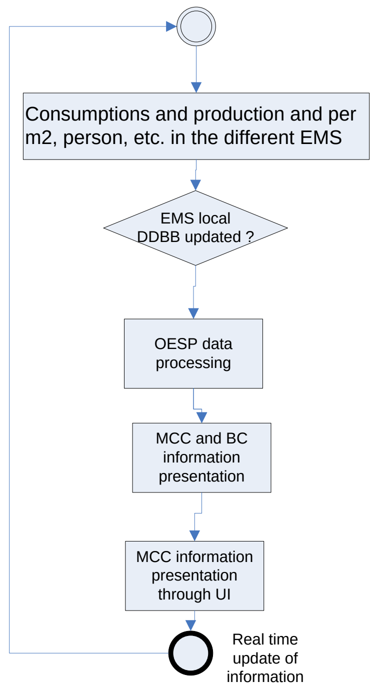


Figure 3 - Workflow – Scenario 01: Visualization and Monitoring of EMS data

5.6.2 Workflow – Scenario 02: Simulation for decision support

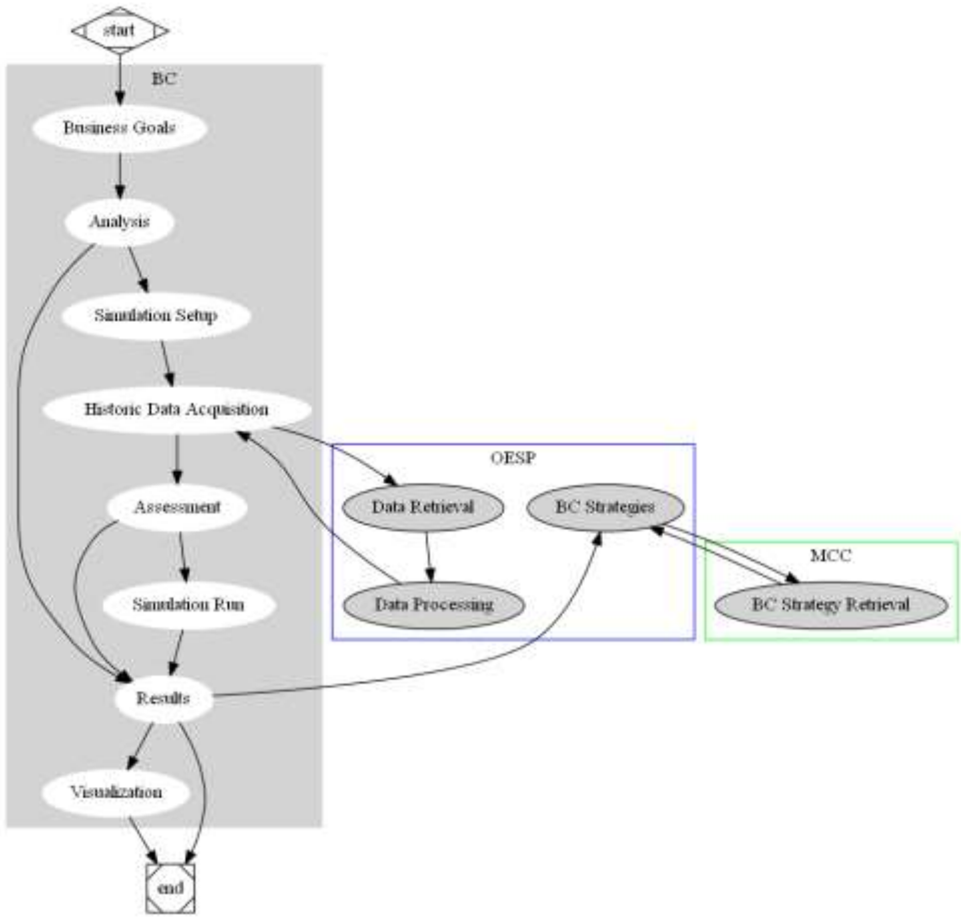


Figure 4 – Example workflow in Scenario 02: Simulation for decision support

Figure 4 depicts an example workflow as these are envisioned in the simulation scenario use-cases. Some aspects though may still change depending on the actual implementation.

5.6.3 Workflow – Scenario 03: Control and optimization of EMS

The following workflow illustrates the main steps described in scenario 03 for the **Control and optimization of EMS.**

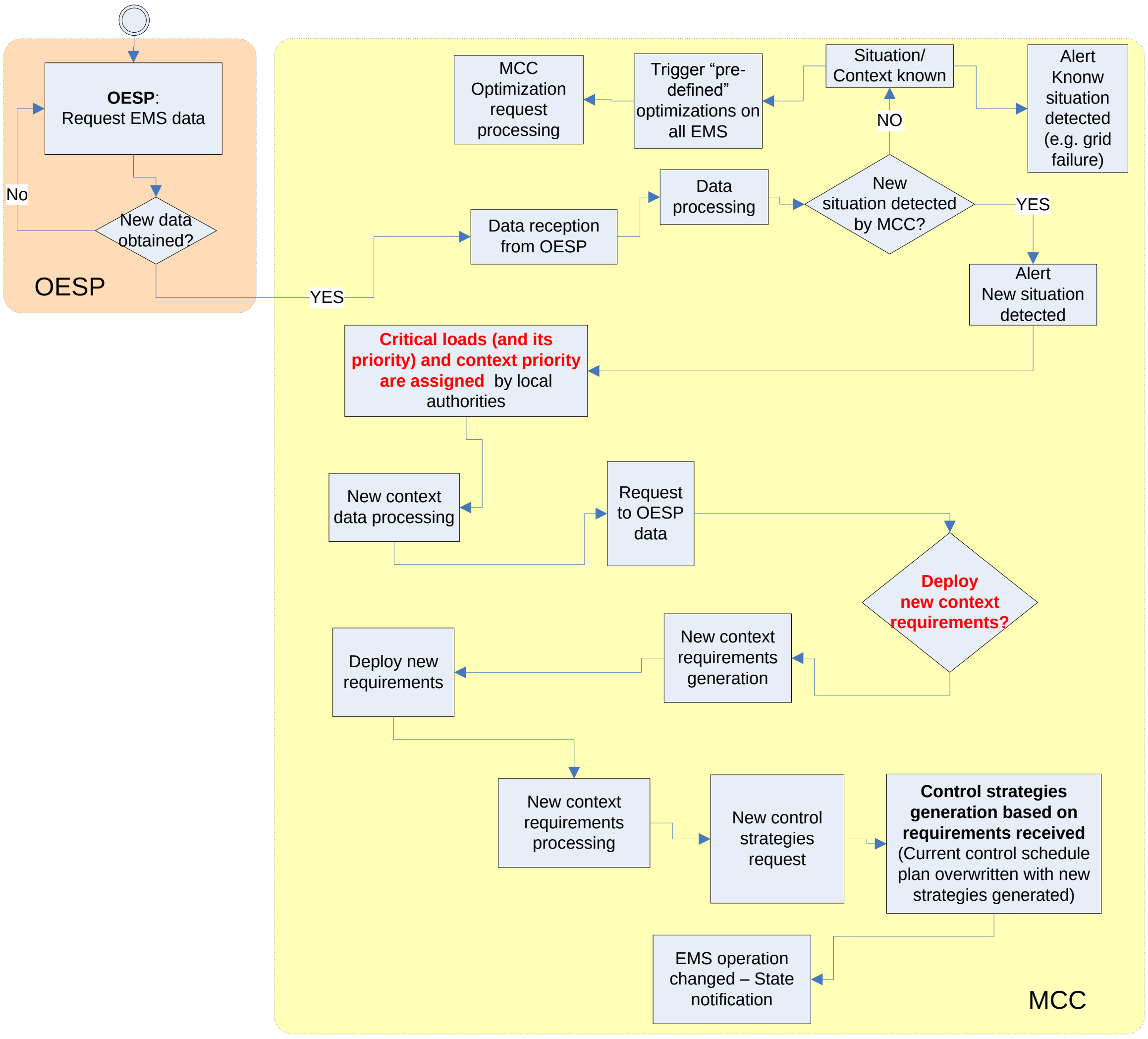


Figure 5 - Workflow Scenario 03: Control and optimization of EMS

6 Pilot sites definition – Initial draft

The following sections present a first draft definition of each of the test sites.

6.1 Barcelona Test site - 22@ District

6.1.1 The environment: 22@ District in Barcelona

22@Barcelona project transforms two hundred hectares of industrial land of Poblenou into an innovative district offering modern spaces for the strategic concentration of intensive knowledge-based activities. This initiative is also a project of urban refurbishment and a new model of city providing a response to the challenges posed by the knowledge-based society.

It is the most important project of urban transformation of Barcelona city of the last years and one of the most ambitious of Europe of these characteristics, with a high real state potential and a 180 million Euros public investment of infrastructure plan

One of the aims of the 22@Barcelona municipal company is to consolidate the role of Barcelona as an innovative city. In this framework, a specific line of action is to foster the use of the city as an urban laboratory with the **22@Urban Lab** project, set up in the 22@Barcelona district as a testing ground for innovative solutions for companies seeking to implement tests in any field: urban planning, education, mobility, etc.

The aim of this project is to provide companies that are developing innovative projects and that are in the pre-commercialization stage with the possibility of testing them in the district through pilot trials.

In this context, SmartKYE will run its main demonstrator in the 22@Barcelona district, following up the developments in previous projects addressing energy efficiency. Bdigital has played a leading role in such projects, coordinating in most cases the R&D activities.

6.1.2 Barcelona LED public lighting platform

Within the context of a municipal energy efficiency program developed by the Barcelona City Council, there have been deployed in several streets of the city LED lamps that have replaced old incandescent lamps. Information regarding these new lamps as well as old lighting systems is gathered in different “control cabinets” (CM) spread across the city. In particular, there is currently in Barcelona 3000 CM from which approximately 1100 CM can be remotely monitored and controlled

Figure 6 illustrates the architecture of the system deployed. It can be seen how the different street lights are centrally controlled by a control cabinet. Each control cabinet can monitor and control for example one street or several streets in the same geographic area. Additionally, some cabinets could be capable of control additional systems, other than lighting. However, this capability will not be consider within SmartKye project.

Within the scope of SmartKye project, it will only be possible to gather monitoring data from several control cabinets, while control is restricted to municipal authorities.

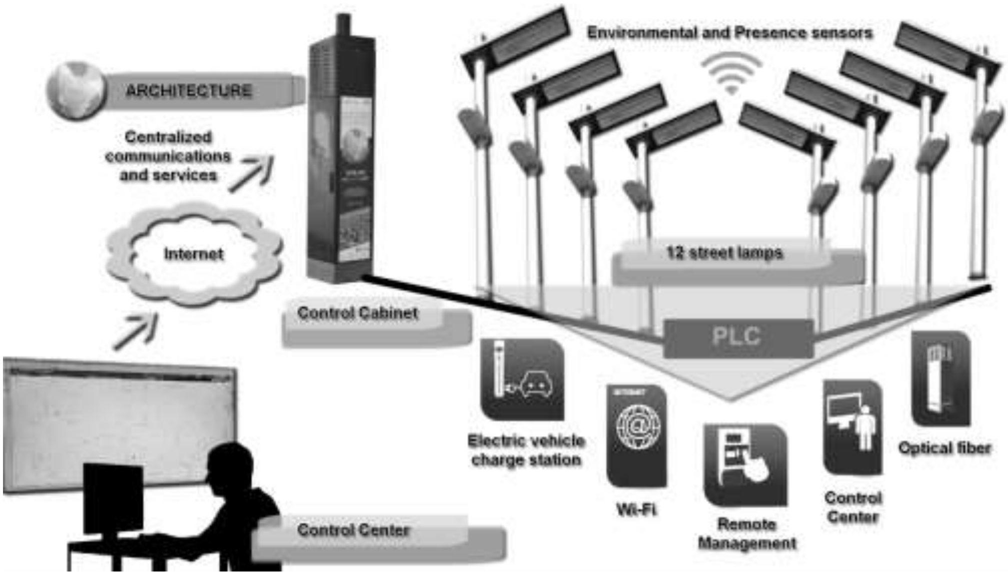
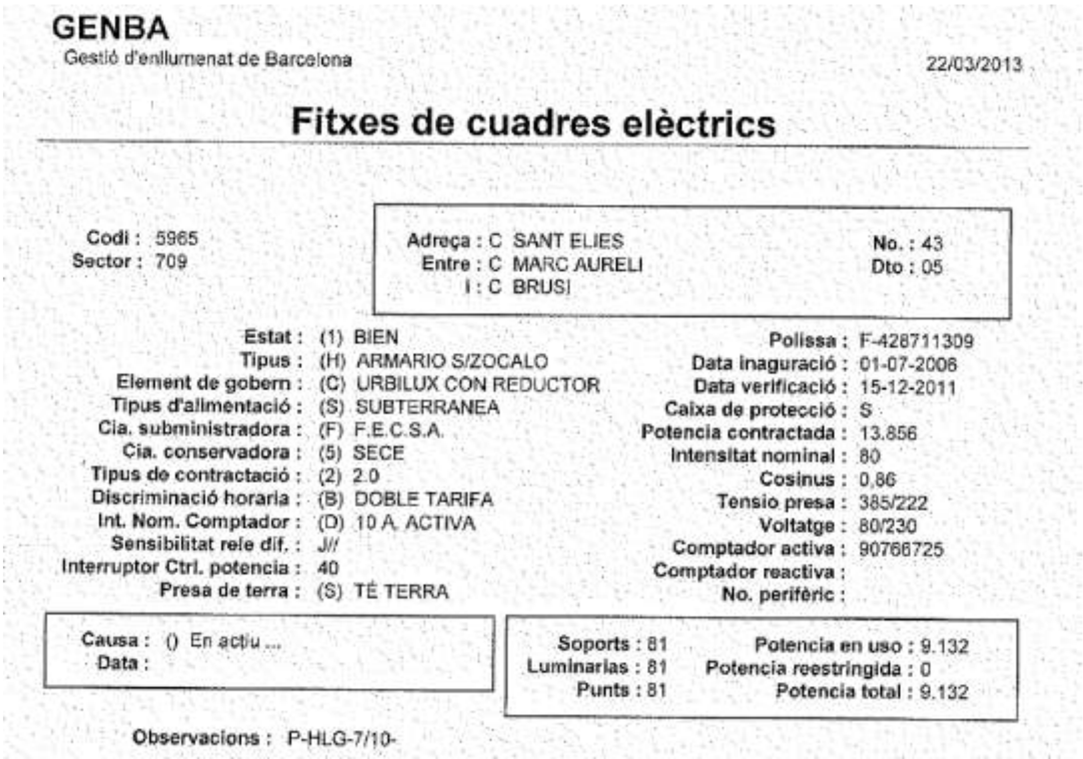


Figure 6 - Barcelona public lighting infrastructure (Source: SIIUR project)

For each single control cabinet to be integrated within SmartKye project, it is possible to obtain concrete data regarding the characteristics of the cabinet as well as its electrical installation. An example of the information that can be obtained is illustrated in Figure 7:



GENBA
Gestió d'enllumenat de Barcelona
22/03/2013

Fitxes de cuadres elèctrics

Codi : 5965
Sector : 709

Adreça : C SANT ELIES
Entre : C MARC AURELI
I : C BRUSI
No. : 43
Dto : 05

Estat : (1) BIEN
Tipus : (H) ARMARIO S/ZOCALO
Element de gobern : (C) URBILUX CON REDUCTOR
Tipus d'alimentació : (S) SUBTERRANEA
Cia. subministradora : (F) F.E.C.S.A.
Cia. conservadora : (5) SECE
Tipus de contractació : (2) 2.0
Discriminació horaria : (B) DOBLE TARIFA
Int. Nom. Comptador : (D) 10 A ACTIVA
Sensibilitat rele dif. : J//
Interruptor Ctrl. potencia : 40
Presa de terra : (S) TÉ TERRA

Polissa : F-428711309
Data inaguració : 01-07-2006
Data verificació : 15-12-2011
Caixa de protecció : S
Potencia contractada : 13.856
Intensitat nominal : 80
Cosinus : 0,86
Tensio presa : 385/222
Voltatge : 80/230
Comptador activa : 90766725
Comptador reactiva :
No. perifèric :

Causa : () En actiu ...
Data :

Soports : 81
Luminarias : 81
Punts : 81
Potencia en uso : 9.132
Potencia reestringida : 0
Potencia total : 9.132

Observacions : P-HLG-7/10-

Figure 7 - Barcelona Public Lighting control cabinet data

From all parameters provided in the previous Figure, the following table summarizes the most relevant parameters from the point of view of SmartKye project:

Table 26 - Barcelona Public Lighting control cabinet data – Summary table

Parameter	Description	Example
Public Lighting control cabinet – Technical data		
Unique ID	Unique identifier of the cabinet within the municipality street lighting system.	5965
Address	Location of the cabinet (plain text)	Sant Elies Street
Control cabinet state (1)	State of operation of the cabinet.	OK
Energy retailer (F)	Name of the energy retailer company	FECSA
Contract type (2)	Type of power supply contract	2.0
Max power by contract	Maximum power that can be supplied to the cabinet determined by the contract with the energy retailer	13.856
Cabinet nominal voltage	Nominal voltage of the power provided by the cabinet (to the street lights)	80 V
Power supply grid	Grid voltage provided to the cabinet (range)	385/222 V
Public Lighting control cabinet – Street lights data		
Current Power used	Power used by the control cabinet	9.132 A
Number of street lights under control	Current number of street lights under control	81
Total number of control points supported	Maximum number of control points by the control cabinet	81

Finally, regarding the power consumption (and related measurements) that can be obtained from each control room, Figure 8 illustrates an example of the type of data that can be obtained.


Registro de Medidas

Ajuntament de Barcelona

Fecha	Tensión	Pot.Activa	Pot.Reactiva	Fact.Potencia	Activa	Reactiva	Ent.An.
25/02/2013 6:37:15	195	5856	2804	0,9	26273	12989	0
25/02/2013 5:37:15	196	5899	2848	0,9	26270	12987	0
25/02/2013 4:37:15	196	5904	2786	0,9	26264	12984	0
25/02/2013 3:37:15	193	5709	2640	0,91	26258	12982	0
25/02/2013 2:37:15	193	5673	2620	0,91	26252	12979	0
25/02/2013 1:37:15	194	5727	2682	0,9	26246	12976	0
25/02/2013 0:37:15	197	5929	2836	0,9	26241	12974	0
24/02/2013 23:37:15	195	5789	2780	0,9	26235	12971	0
24/02/2013 22:37:15	195	5813	2921	0,89	26229	12968	0
24/02/2013 21:37:15	206	6536	3423	0,88	26223	12965	0
24/02/2013 20:37:15	221	7589	4085	0,88	26217	12962	0
24/02/2013 19:37:15	221	7572	4054	0,88	26209	12958	0
24/02/2013 18:37:15	218	7192	4104	0,86	26201	12953	0
23/02/2013 19:44:00	220	7510	4049	0,88	26131	12918	0
23/02/2013 18:44:00	219	7216	4171	0,86	26123	12914	0

Figure 8 - Barcelona public Lighting control cabinet measurements data

The parameters provided in Figure 8 are fully described in Table 27. The data provided is related to all the control cabinet, not for each single street light.

Table 27 - Barcelona public Lighting control cabinet measurements data – Summary table

Parameter	Description	Example
Public Lighting control cabinet – Measurement data		
Date	Date at which the current data provided was recorded.	25/02/2013 6:37:15
Voltage	Voltage measurement at the control cabinet at the date indicated.	220 V
Active power for the measurement period	Active power measurement at the control cabinet at the date indicated. This parameter is recorded in an hourly based.	5856 Wh
Reactive power for the measurement period	Reactive power measurement at the control cabinet at the date indicated. This parameter is recorded in an hourly based.	2682 VAr
Power factor	Power factor measurement at the control cabinet at the date indicated. This parameter is recorded in an hourly based.	0.91
Active power – Meter reading	Active power measurement provided by the control cabinet electricity meter. This is the accumulated value for the active power indicated above.	26273kWh
Reactive power – Meter reading	Reactive power measurement provided by the control cabinet electricity meter. This is the accumulated value for the reactive power indicated above.	12989 kVArh

Once it is clear how street lighting control operates in Barcelona, and what kind of information it would be possible to obtained, the next step would be to define concrete control cabinets to monitor within the scope of SmartKYE project. It will be possible to have access to some data from specific streets of the city of Barcelona. It worth mention that some of these street might be within the 22@ district while others don't. The following table summarizes some information regarding the public lighting systems that will be available within the context of the project:

Table 28 - Barcelona SmartKYE pilot site - Public lighting data

	Asset1 **Public lighting Control Room**
Location	Initially, the following streets will be monitored within the project(Figure 9): 1. Hercegovina, 2. Joaquim Valls 3. Marc Aureli Additional streets might be added later on based on the proper agreement reached with the

	municipality.
Owner	Barcelona City Council
Operator	Barcelona City Council (through the department “Gestió d’enllumenat de Barcelona”)
Number of users affected	Undefined
Type of users	Citizens of Barcelona
Number of elements involved (lamps, vehicles, wind turbines, charging points)	LED streetlamps and incandescent lamps. Depending on the type of control cabinet the number of lamps might be different. For example, the control cabinet for the Marc Aureli street (number 3 in the list previously provided) can control up to 81 lamps.
Energy Consumed/produced last year	Approximately 5000-7000Wh per hour, which lead to an approximately 168 kWh per day or 61320 kWh per year.
CO2 emissions last year	Undefined
Energy Management System deployed	It is being confirmed.
Energy Management System Provider	Barcelona City Council (through the department “Gestió d’enllumenat de Barcelona”)
Smart meter Manufacturer	Undefined
Communication technology	It is being confirmed.
Data resolution	One hour (data consumption from street lamps will be aggregated in periods of one hour)

The following Figure illustrates some of the streets that might be integrated within the project. The definitive number of streets to be monitored might increase in the near future.

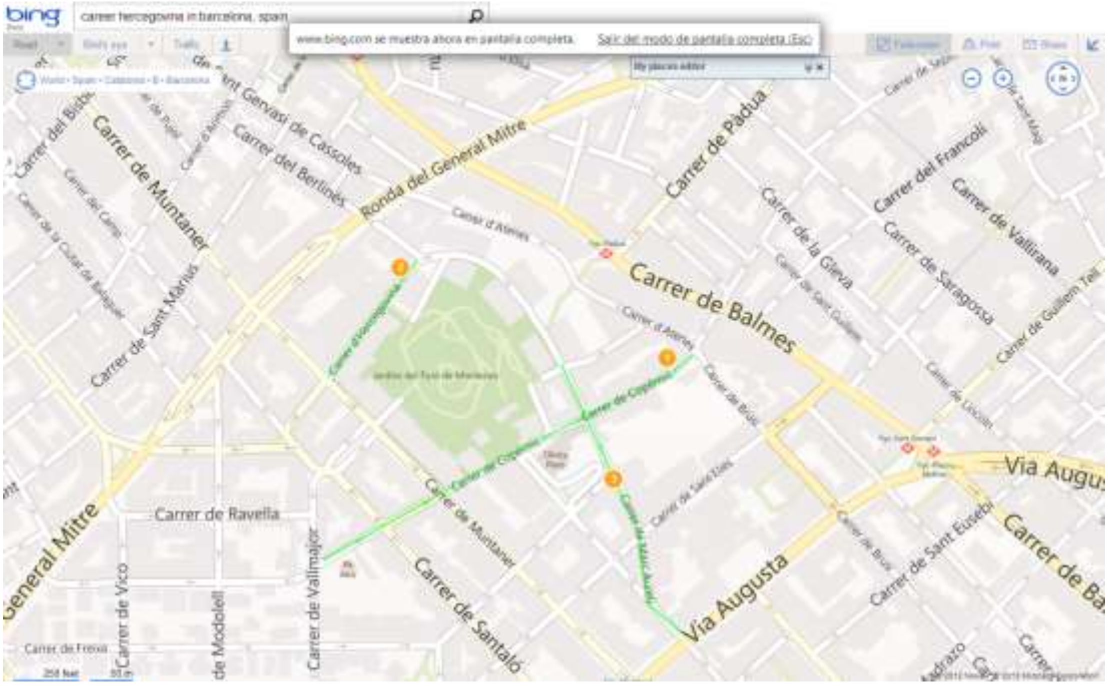


Figure 9 - Barcelona pilot – Public lighting streets to be monitored

The following Figure illustrates an example of the distribution of street lights along Marc Aureli Street in Barcelona. It is interesting to see how different types of lamps can be controlled by a single cabinet (even combining LED and other type of lamps).

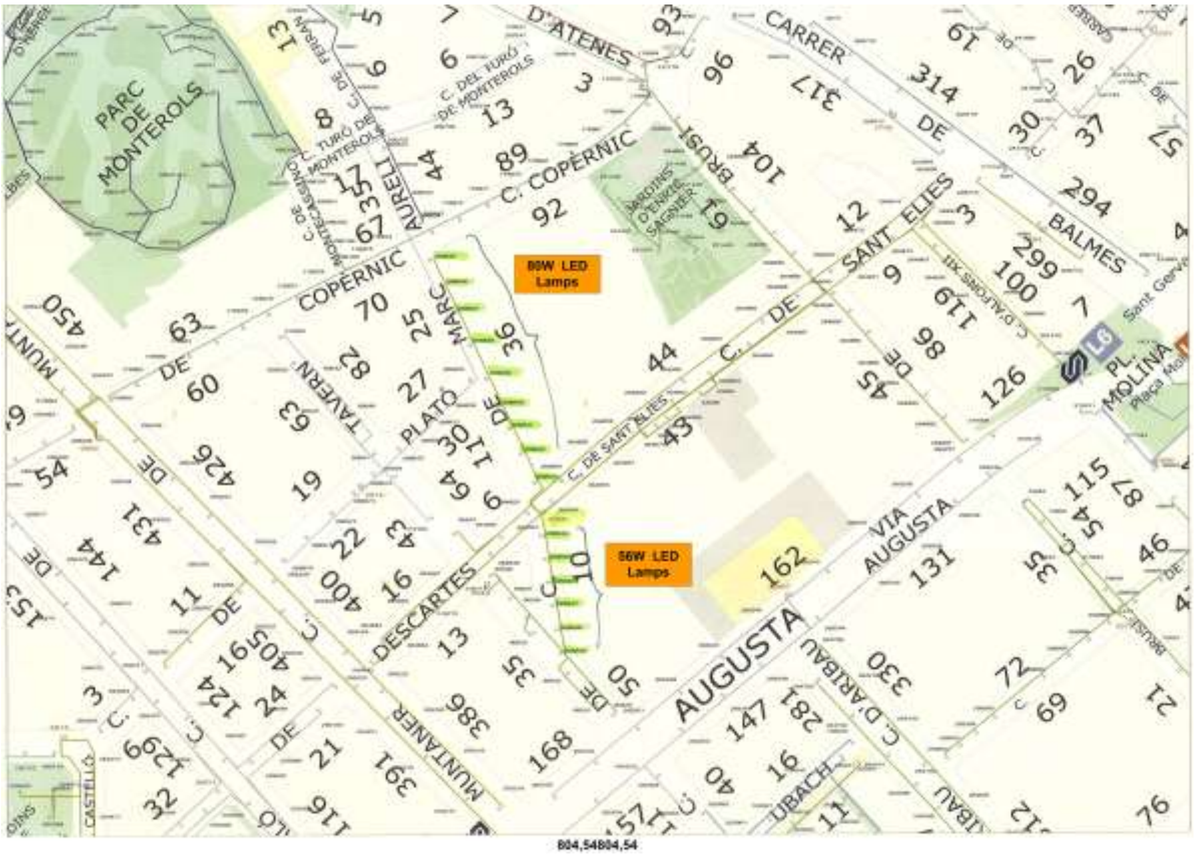


Figure 10 - Barcelona pilot – Marc Aureli street to be monitored (Street lights detail)

6.1.3 Mediatic Building BMS integration

BDigital facilities are located in the 22@ district in Barcelona in the MediaTIC building, located in Roc Boronat Street 117. The building (see following Figure) is already an example of energy efficient architecture, with one of the highest marks (42/57) on the national decree on Criteria for Environmental Ecoeficiency energy in Buildings.

Figure 11 - MediaTic Building at 22@ district in Barcelona

All systems within this building are constantly monitored and controlled by a building management system (BMS) integration provided by Controlli. The following Figure illustrates the architecture of this system:

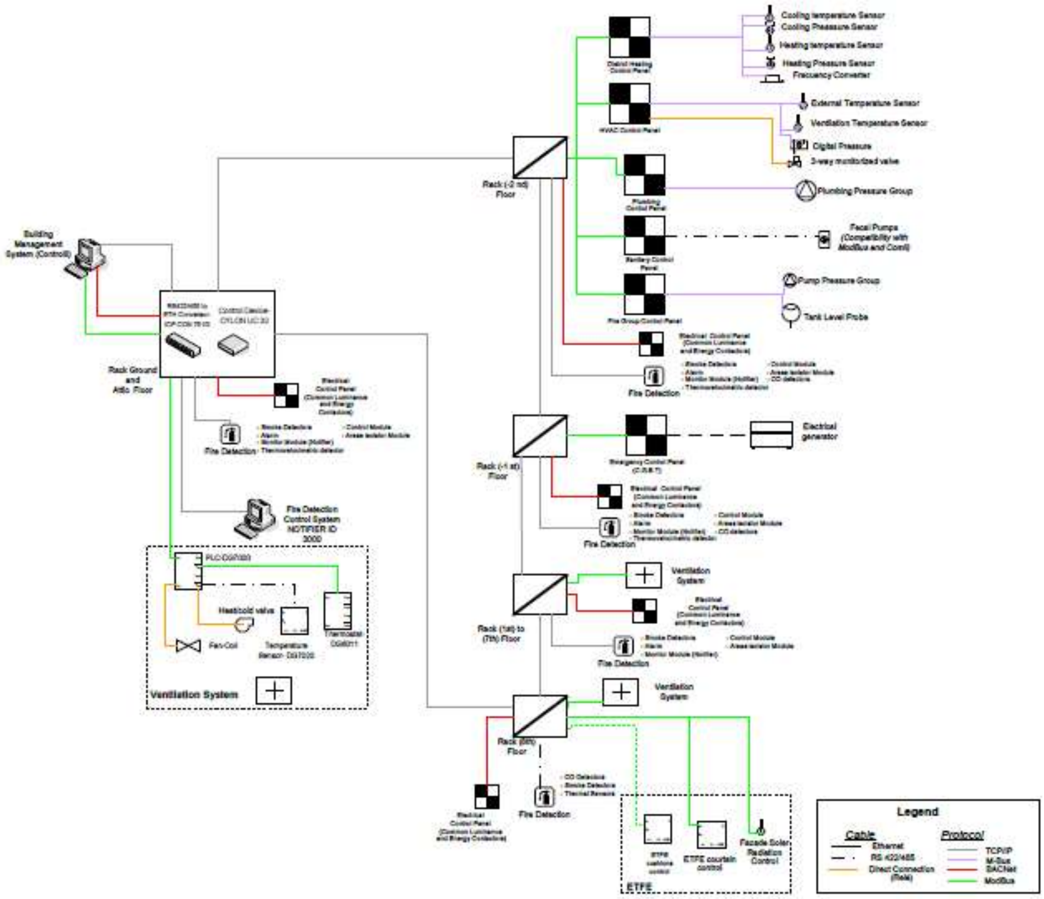


Figure 12 - Mediatic building's BMS system

Due to the criticality of some systems, within the scope of SmartKYE project, monitoring information will be available, but no control will be possible. Additionally, the use of the data described in the following table is restricted to the use within the scope of the project, and requires a formal authorization by the building manager, which it has been already requested (but still waiting for the final confirmation).

Table 29 - MediaTIC building

#	Data	Detail Level	Sensor	Data Type	Granularity (min)
1	Outside Temperature	MediaTIC building	Temperature Sensor located in MediaTIC roof.	FLOAT	15
2	Solar Radiation	MediaTIC building	Solar radiation Sensor located in MediaTIC roof	FLOAT	15
8	District heating and Cooling	MediaTIC Building	No sensor; manual reading.	--	
9	Fan-Coil Temperature	MediaTIC Building	Temperature of fan-coils placed in Bdigital Office	ANA	15
10	Main Air Valves Temperature	MediaTIC Building	Main ventilation device; Temperature of air impulsion and Temperature of air returned	ANA	15
11	Device Working hours	MediaTIC	Working hours for pumps of the main systems	ANA	

In addition, Bdigital has developed and deployed a system to monitor and control the energy consumption of its own facilities. Several different sensors and actuators have been included in order to get the overall and disaggregated energy consumption data of the office. The following Figure illustrates how these sensors are distributed within bDigital's office:

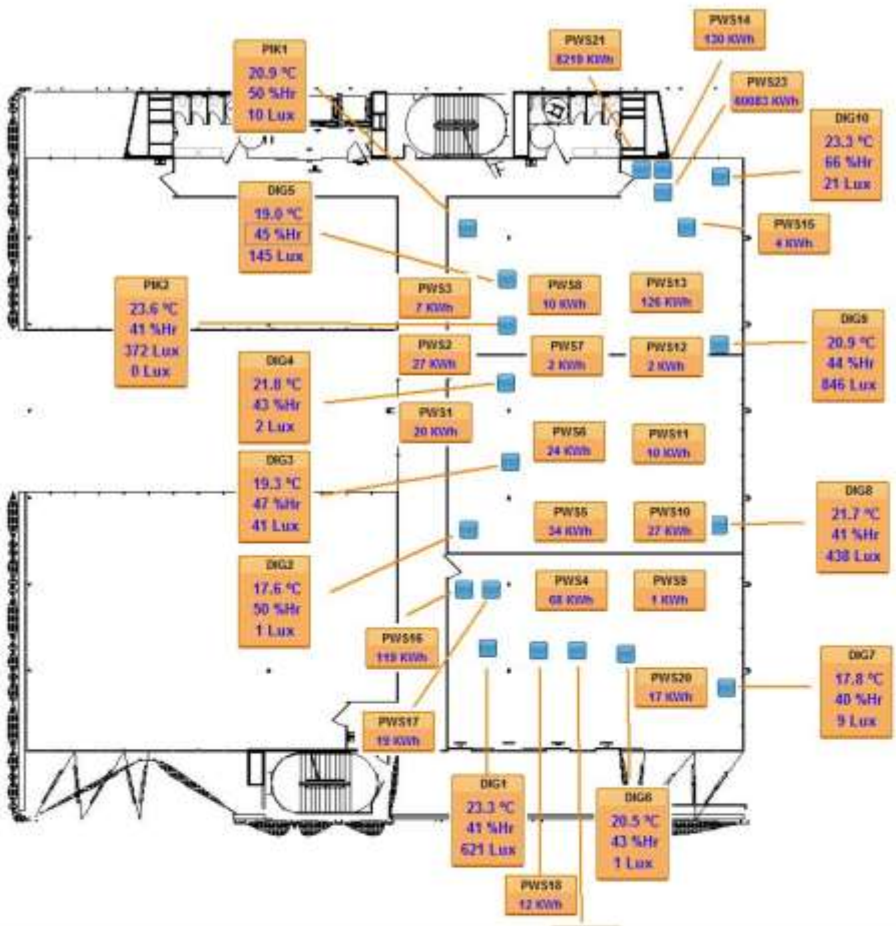


Figure 13 - Bdigital's office sensor and actuators distribution

The data to be included within SmartKYE project is summarized in the following table:

Table 30 - Summary of equipment already available in the Barcelona test site (I)

	Asset2 **BDigital office energy management platform**
Location	MediaTIC Building (Roc Boronat 117, 5^{th} floor ,Barcelona)
Owner	Bdigital
Operator	Bdigital
Number of users affected	100
Type of users	Office Workers
Number of elements involved (lamps, vehicles, wind turbines, charging points)	• 12 Temperature, humidity and brightness sensors • 10 power plugs (with energy monitoring capabilities) • 1 global lighting energy consumption sensor • 1 global plugs energy consumption sensor (This data together with lighting data provide the total energy consumption data of Bdigital's office)

Energy Consumed/produced last year	a)Demand: Total Lighting: 84.553,32 kWh Total Electrical Equipment (Except Lighting): 103.867,80 kWh Total Office – One year 188.421,12 kWh b) Producing: N/A
CO2 emissions last year	Approximate CO2 emissions can be calculated from energy consumption.
Energy Management System deployed	Bdigital's proprietary. A web service interface to external systems should be developed
Energy Management System Provider	BDigital
Smartmeters Manufacturer	a-) SACI (Electrical panel meters TIDL three-phase meter) d) Pikkerton (Individual consumption meters)
Communication technology	a) 4Nocks (Gateway e Electrical panel meters) b-) Digi (Wireless Sensors Network Gateway) Technologies: - TCP/IP - ZigBee - ModBus
Data resolution	Ten minutes (data consumption from the different sensors is gathered every ten minutes)

The following Figure illustrates the graphical user interface for the energy consumption data previously described.

Figure 14 - BDigital EMS graphical user interface

Furthermore, data obtained could be further processed and analyzed. The following two Figures illustrates in a graphical way the energy consumption data of Bdigital's office for a period of four months, as well as the detail for the lighting system energy consumption along a week:

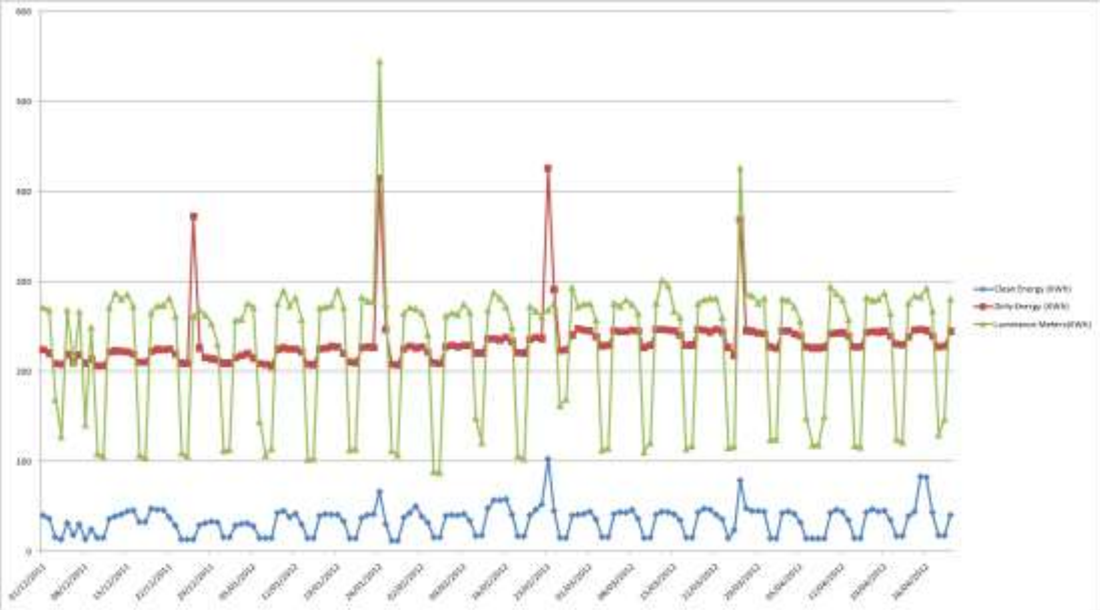


Figure 15 - Bdigital's office overall energy consumption (disaggregated by lighting and power plugs)

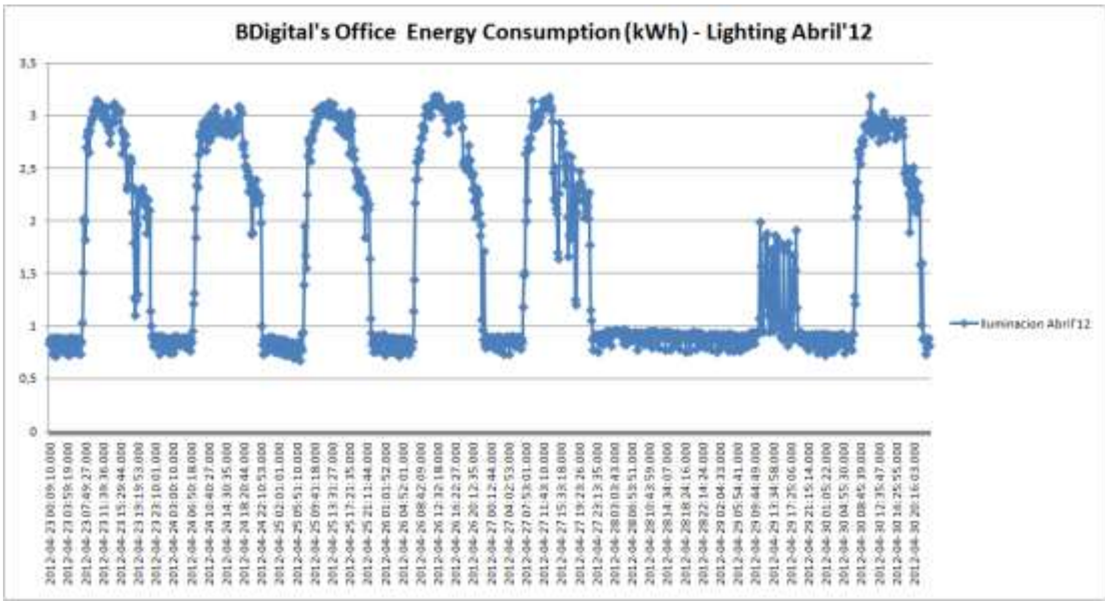


Figure 16 - Bdigital's office overall lighting energy consumption

6.1.4 Urban wind mills integration

When it comes to power generation, SmartKYE will use the existing Ficosa Renewable plants settled in Masnou, close to Barcelona city. These micro-wind installations include a range of the Ficosa product portfolio, which covers from 1KW to 5KW last generation mini aero-generators. The management system included in this installation guarantee the data access to as much information as desired for the analysis and study of new strategies oriented towards the definition of energy positive neighborhoods.

Figure 17 - Ficosa Renewable wind turbine

The current pilot site – to be used in a preliminary urban lab phase – will be not only extended by means of micro-generation. The current available EMSs (for public lighting and EV point of charges) will be also extended through the integration of ETRA's large scale solutions running in the city.

6.1.5 ECOVE© system

ETRA provides and run the EV control management center of the city. The ECOVE© system deployed in Barcelona is a platform that enables the management of rechargeable points in public spaces. It not only provides for the necessary roaming services for end-users, but also gathers information about timing, and charge status. Moreover, ETRA will be coordinating the MOLECULES project, where new electro-mobility concepts – integration of the EV with other transport modes–- will be tested in the city of Barcelona. This will grant a great opportunity to scale SmartKYE trials.

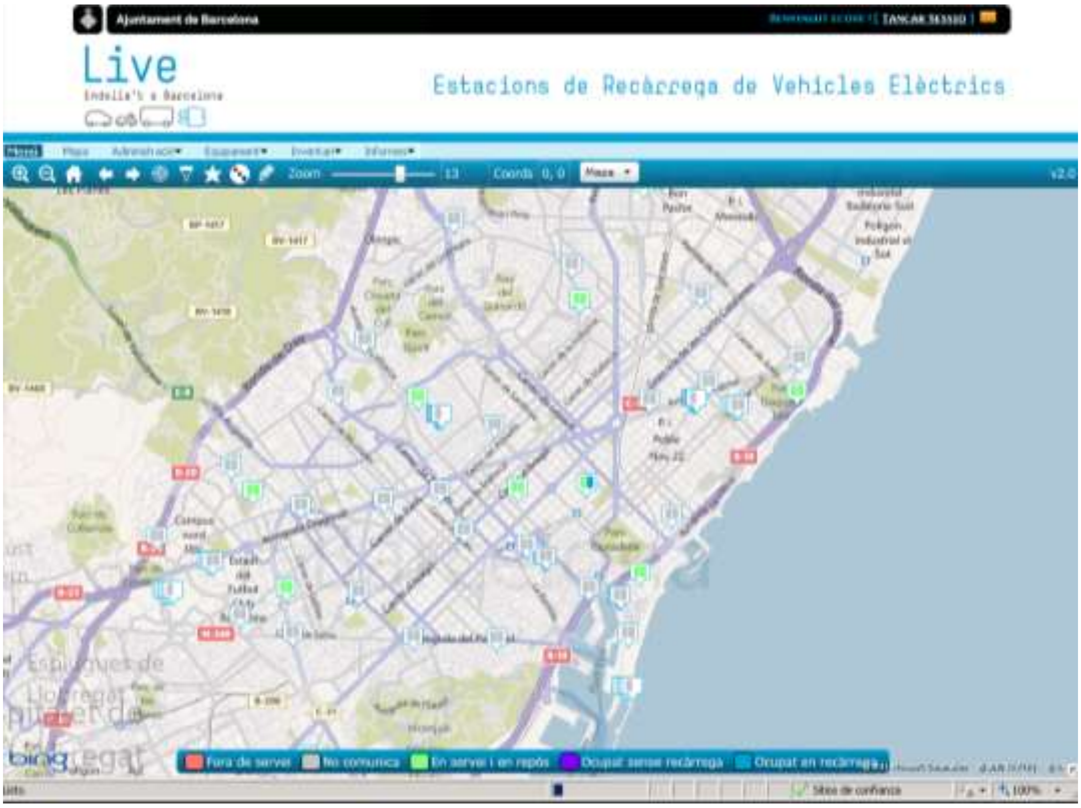


Figure 18 - EV EMS run by ETRA in Barcelona (ECOVE)

Table 31 - Summary of equipment already available in the Barcelona test site (II)

	Asset 3 EV fleet management	Asset 4 Generation system
Location	SIIUR (Passatge Mas de Roda, Barcelona)	San Guim de Freixenet, Lérida
Owner	Barcelona City Council	TECHNOFLEX
Operator	Barcelona City Council	TECHNOFLEX
Number of users affected	Undefined	Undefined
Type of users	Citizens of Barcelona	For the trials, Citizens of Barcelona
Number of elements involved (lamps, vehicles, wind turbines, charging points)	2 EV charging points	1 Wind Turbine 1KW 1 Wind Turbine 5KW
Energy Consumed/produced last year	a)Demand: Not available at this moment b) Producing: N/A	b) Producing: 1599.37KWh

CO_2 emissions last year	These data is being collected	NA
Energy Management System deployed	EV charging point ECOVE	SMA
Energy Management System Provider	Circutor ETRA	SMA
Smart meter Manufacturer	Circutor	
Communication technology	Orange (Switch Cisco Catalyst 2960, 100BASE-T to optical fiber adapter, Router Cisco 1841)	
Data resolution	15 minutes	20 seconds

6.2 Crete test site

Crete is the largest and most populous island in Greece with a population of 650 000. It has a thermal installed capacity of 815 MW with twenty-eight generation engines, with peak power consumption in 2009 of 611 MW. The electrical system of Crete is isolated, since no interconnection with the main grid exists. The distribution system is organized in four areas: Chania with 58 distribution lines; Agios Nikolaos with 29 distribution lines; Rethymno with 9 distribution lines; and Heraklion with 78 distribution lines at 15 kV and 20 kV voltage levels. It has a transmission network established at 150 kV and 66 kV. There are three Thermal Power Stations (located in Linoperamata – Heraklion, Chania and Atherinolakkos). There are also 25 Wind Farms (WFs) with installed capacity of 160.5 MW. Finally there are installed hundreds of small PV stations with total installed capacity more than 50MW, of which 17MW concern rooftop installations.

The test area for the SmartKYE project will focus in the area of Lasithi, which is the eastern part of the island. The population of Lasithi area is about 75000 citizens and includes one major power station (200MW).Furthermore Lasithi has a great share of the installed W/Fs (70 MW) and installed PVs (~20MW). SmartKYE will focus in a subset of this population, matching a number of inhabitants in an extended urban and rural area similar to the number of inhabitants in the Barcelona pilot site –i.e. 5.000 users.

Crete has a summer peaking system due to air conditioning and increased summer tourism. There is also a smaller winter peak, due mainly to heating and lighting loads. The load over these 3 years has remained essentially flat (not counting seasonal changes). This trend is not expected to continue into the future, as load growth should resume once the overall Greek economy rebounds. Typically, the peak load has increased 4% annually. The range between minimum and maximum values is high. The minimums hover around 200MW, while the maximums often exceed 500MW. Thus, HEDNO must continually cycle its generation over a large range during the course of each month.

Figure 19 illustrates the monthly minimum, maximum and average loads for Crete, while Figure 217 illustrates the monthly minimum, maximum and average wind production.

Figure 19 and Figure 20 provide typical days of a substation in Lasithi and one of the selected WF for the demonstration. It can be seen that during most months the minimum wind MW normally is near zero. Thus, there are times that the wind is simply not blowing, over the entire island of Crete. However,

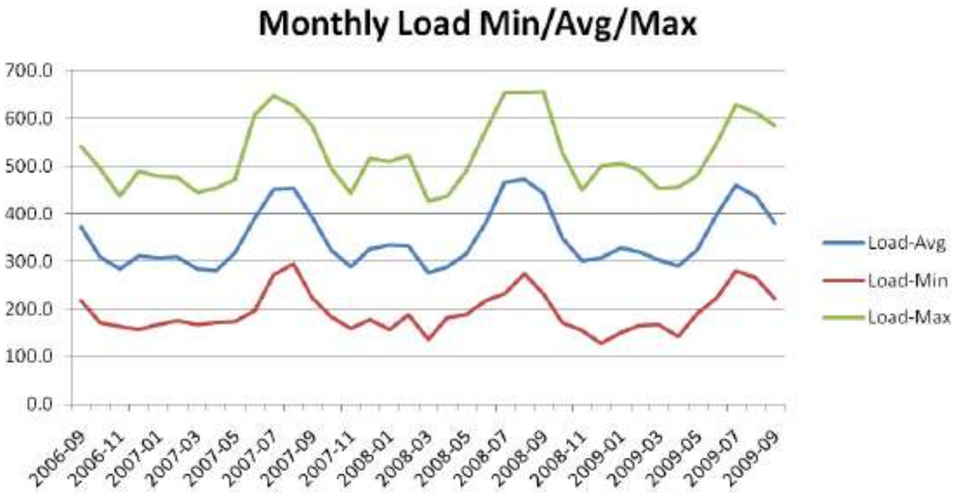


Figure 19 - Min, Max & Average Load of Crete (period 2006-2009)

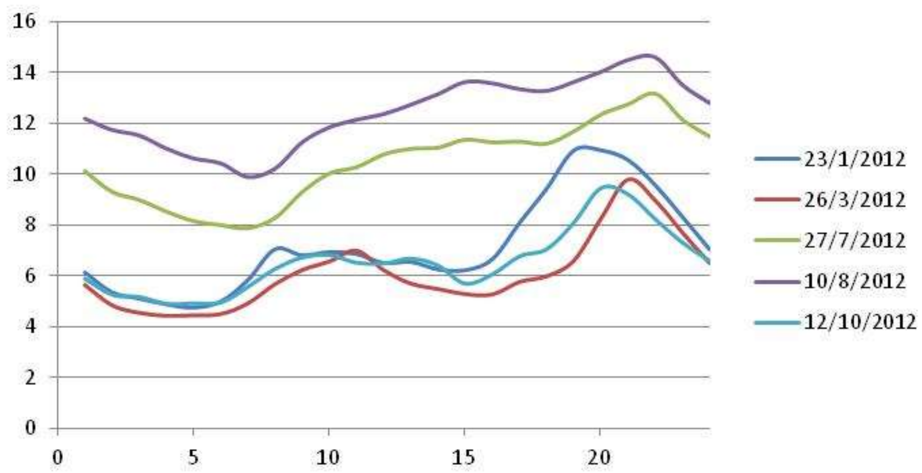


Figure 20 – Typical Load in substation in Lasithi

The average and maximum Wind MW production values are increasing over time, as new wind farms come on line. The maximum value of wind production is approximately 130 MW, which is 82% of the installed wind capacity of 160.5MW. This indicates that the wind potential in Crete is outstanding. It should be mentioned that the average and maximum wind productions are negatively impacted by the dumping of excess wind energy during certain time periods of high wind. Finally, another significant characteristic of the islands and the installed WFs is that the production peak occurs in the summer months when load is at the highest levels, while many wind farms throughout the world see their lowest winds during the summer. This gives credence to the claim of the high potential for wind generation in Crete.

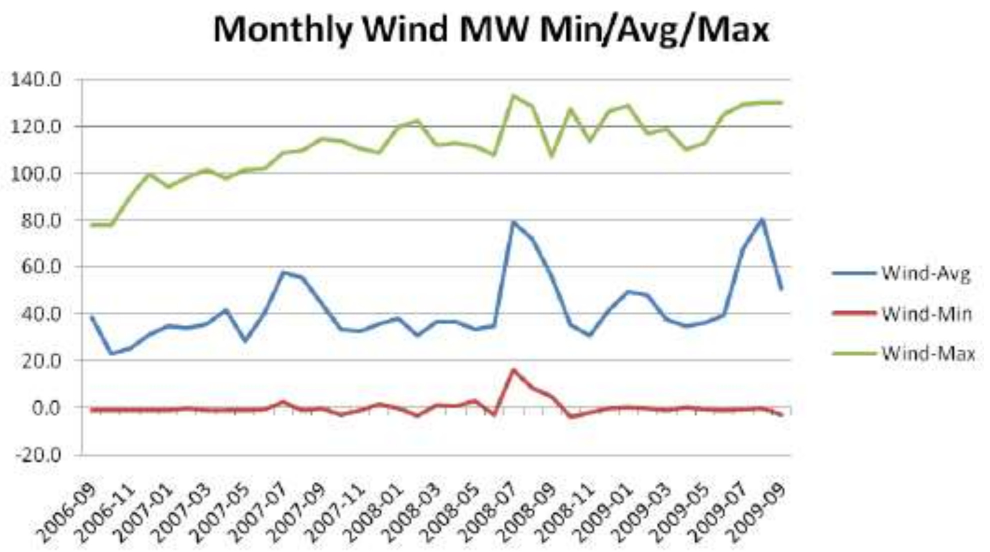


Figure 21 - Min, Max & Average Wind Production of Crete (period 2006-2009).

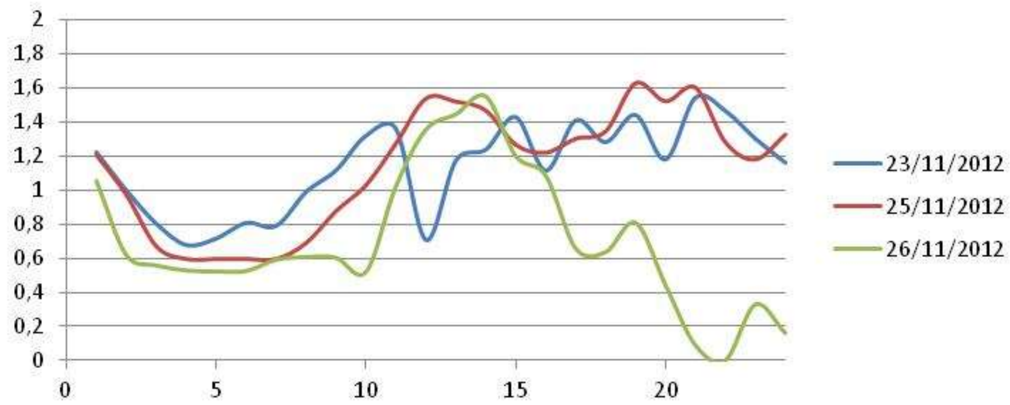


Figure 22 – Typical Production of a wind farm in Crete

Greek islands rely on an EMS design by ICCS: MORE CARE. The system aims to assist the operators of island systems by proposing optimal operating scenarios for the various power units, as well as the various actions needed to avoid dangerous situations, which might result from a poor prediction of load or weather or pre-selected disturbances. The insurance of increased security and reliability of the system will allow maximization of renewable penetration. The system includes various modules of forecasting, operational planning and security assessment. Due to the diverse needs of targeted medium and large scale systems, the software is highly modular, allowing integration of the options that are best suited to the particularities of each system. Figure 23 shows the general MORE CARE system architecture.

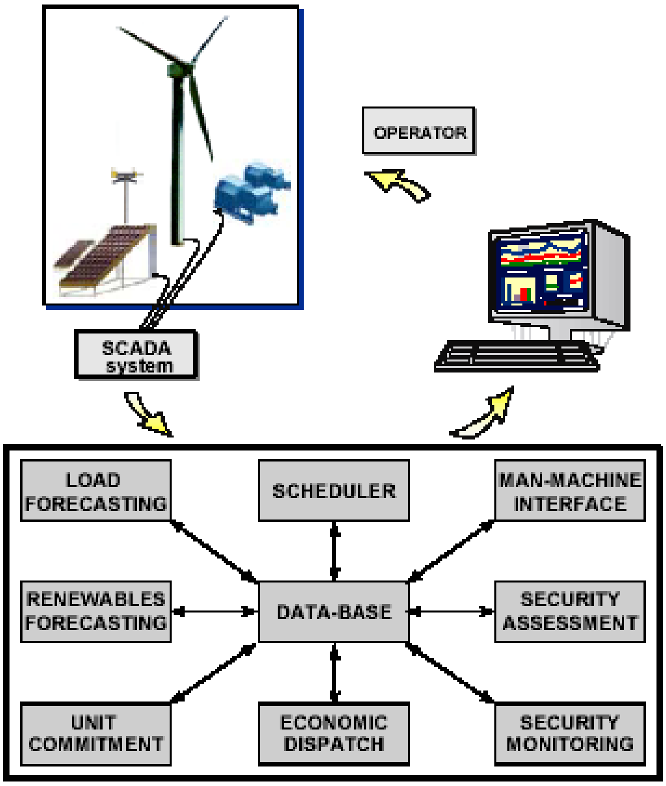


Figure 23 - Overview of MORE CARE functionalities.

The MORE CARE system was designed in a modular way in order to facilitate future application and module integration. In order for the Human Machine Interface of MORE CARE to be accessible from remote locations the MORE CARE System was modified to become a service oriented application. As it is depicted in a simplified manner by Figure 24, the system consists of three distinct parts (modules) that can be run on the same or separate machines.

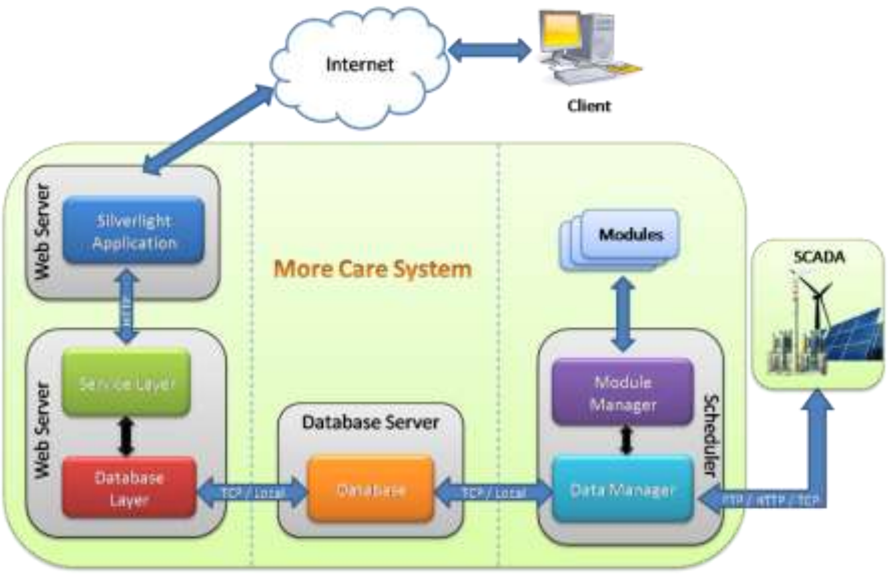


Figure 24 - Overview of new MORE CARE architecture

The Scheduler Service Module is responsible for the acquisition and verification of the power systems SCADA data and the external module run schedule based on existing system settings. It can be divided in two parts. A Data Manager which acquires SCADA and forecast data using HTTP (data file download), FTP or connecting directly using TCP/IP, depending on the case and updates the database ensuring historical data are populated for use in the forecast modules. Furthermore it verifies the retrieved data integrity and attempts correction wherever necessary. This module is independent from the rest of the scheduler to ensure that even when the scheduler is not running, the data are always updated. The Module Manager is responsible for the integration and scheduling of the disparate modules (wind and load forecast models etc.) to the system and facilitates the communication between the modules and the database.

The MORE CARE system uses a relational database which serves as the data container holding current and historical data obtained by the SCADA of the power system, the output of the different forecast modules and various system settings. Furthermore it provides the intermediate between the various disperse modules and unifies the way modules interact with the data. The database can be located either on a separate Database server over the network using TCP/IP for communicating with the other modules or in the same Server as the application.

The Human Machine Interface of the MORE CARE System provides an intuitive visual representation of the data stored in the database by displaying a series of system values and forecast results in a graphical manner enabling the operator to quickly assess the system status. Furthermore it offers the capability of administering system settings, user access restrictions by using user roles and multilingual support.

To enable remote access of the data the MORE CARE system uses a service oriented approach. A Web Server hosts the Windows Communication Foundation (WCF) services, implemented in Microsoft .NET, exposing a service endpoint for use from the Internet. There are two distinct services present in the system, one for data retrieval and one for user identification and authentication. The distinction is made for greater scalability and availability and for using different access policies on the services (e.g., using different communication encryption methods). The Service Layer uses an intermediate Database Layer for retrieving the data necessary to the interface. This layer offers independence from the underlying database changes. The data received by the Database Layer are transformed using an “easy to read” object model and then sent to the client application as a message for interpretation and visualization. This approach offers the capability of implementing different user interfaces using the existing web services for the data acquisition and user authentication.

The graphical interface and data representation are provided by a Silverlight application hosted on a Web Server. Silverlight is a programming model that is ideal for providing Rich Internet Application user experience by using graphical objects, animations etc. The application uses an ASP.NET Web page as a container that delivers the content to the remote client. To retrieve the data for display the application issues requests to the web service over the Internet using Simple Object Access Protocol (SOAP) as the Remote Procedure Call (RPC) mechanism. The HMI refreshes the data in predefined intervals set by the administration or on demand by user request.

The MORE CARE EMS will have to be adapted and integrated in the SmartKYE vision, in order to interact with the OESP and provide the operator with information coming with other EMS in the Lasithi area. Whenever this additional EMS are not available – for cross-evaluation purposes the same type of EMS integrated in Barcelona will be integrated in Greece too - , this EMS will be emulated or run off-line.

Table 32 - Summary of equipment already available in the Crete test site (I)

	Asset 1 Building 1	Asset 2 Building 2	Asset 3 Building 3	Asset4 Building 4	Asset 5 Building 5
Location	Dispatch Center Kastorias & Rodou Str Katsampas Iraklio Crete 71 110	HEDNO Agency, Tsalikaki area A. Papandreou Str. 21 Iraklion	Nursing home. Agia Triada Parish , Lasithi	Sanatorioum for Chronic Diseases , Lasithi	Hotel Havania , Lasithi (operation during summer)
Owner	HEDNO	HEDNO	Private	Private	Private
Operator	HEDNO	HEDNO			
Number of users affected	30	>20	50	>100	>40
Type of users	Office Workers	Office Workers + Clients	Office Workers + inmates	Office Workers + inmates	Office Workers + tourists
Number of elements involved (lamps, vehicles, wind turbines, charging points)	2x250 kVA Active Power real time tele-metering Real time Control of 5 A/C Units and outdoor lighting Electric heaters 4kW, 20 units, A/C 1 kVA, 20 units	1x250 kVA, 1x55kVA A/C 58 KVA, 2 Units	85kVA 1087m2 – 3 floors Active Power real time tele-metering Hydraulic Elevator 15kVA, A/C 9kVA, Fridge 4kVA, Oven 10kVA, Washing machine 5κVA, Outdoor lighting 3kVA	25OkVA 6.000 m2 4 floors Active Power real time tele-metering Hydraulic Elevator 50kvA, A/C 2.5kVA - 35 units, 2 washing machines 5kVA, water pumps 40kVA	35kVA 3ph + 8kVA 1ph 800m2 – 2 floors Power real time tele-metering A/C 1kVA 25 units, oven 5kVA, outdoor lighting 2kVA
Energy Consumed/produced last year	~100.000kWh (exact figure Confidential)	~200.000kWh (exact figure Confidential)	~120.000kWh (exact figure Confidential)	>500.000kWh (exact figure Confidential)	~100.000kWh (exact figure Confidential)
Measurements	Consumption (total and per device), outdoor temperature, indoor temperature	Consumption (total and per device), outdoor temperature,	Consumption (total and per device), outdoor temperature,	Consumption (total and per device), outdoor temperature,	Consumption (total), outdoor temperature,
Granularity	Per 15 min	Per 15 min	Per 15 min	Per 15 min	Per 15 min
Energy Management System deployed	More Care	PLC Controller (to be installed)	PLC Controller (to be installed)	PLC Controller (to be installed)	PLC Controller (to be installed)
Energy Management System Provider	ICCS				
Communication technology	GPRS	GPRS	GPRS	GPRS	GPRS

Table 33 - Summary of equipment already available in the Crete test site (II)

	Asset 6 Wind Farm (WF) 1	Asset 7 WF 2	Asset 8 WF 3	Asset 9 WF 4	Asset 10 WF 5
Location	Lasithi	Lasithi	Lasithi	Lasithi	Lasithi
Owner	O.A_Siteias	ENERCON_Ellas	EN.TE.KA_A/P_Kritis	WRE_Hellas	Rokas_Aioliki_Kriti
Operator	HEDNO	HEDNO	HEDNO	HEDNO	HEDNO
Number of users affected					
Type of users					
Number of elements involved (lamps, vehicles, wind turbines, charging points)	500kW	2500kW	2700kW	3000kW	3000kW
Energy Consumed/produced last year	>1000 MWh (exact figure Confidential)	>5000 MWh (exact figure Confidential)	>5000 MWh (exact figure Confidential)	>6000 MWh (exact figure Confidential)	>6000 MWh (exact figure Confidential)
Energy Management System deployed	Propriety Protocol, Full Control by Dispatch Centre following legal restrictions- More Care	Propriety Protocol, Full Control by Dispatch Centre following legal restrictions- More Care	Propriety Protocol, Full Control by Dispatch Centre following legal restrictions- More Care	Propriety Protocol, Full Control by Dispatch Centre following legal restrictions- More Care	Propriety Protocol, Full Control by Dispatch Centre following legal restrictions- More Care
Measurements	Production (kW), Wind Speed (m/s) Wind Direction (degrees), Temperature, Curtailment set point (%)	Production (kW), Wind Speed (m/s) Wind Direction (degrees), Temperature, Curtailment set point (%)	Production (kW), Wind Speed (m/s) Wind Direction (degrees), Temperature, Curtailment set point (%)	Production (kW), Wind Speed (m/s) Wind Direction (degrees), Temperature, Curtailment set point (%)	Production (kW), Wind Speed (m/s) Wind Direction (degrees), Temperature, Curtailment set point (%)
Granularity	1 measurement per minute	1 measurement per minute	1 measurement per minute	1 measurement per minute	1 measurement per minute
Energy Management System Provider	ICCS/NTUA (MORE CARE)	ICCS/NTUA (MORE CARE)	ICCS/NTUA (MORE CARE)	ICCS/NTUA (MORE CARE)	ICCS/NTUA (MORE CARE)
Communication technology	GPRS/Satellite	GPRS/Satellite	GPRS/Satellite	GPRS/Satellite	GPRS/Satellite

Figure 25 - Dispatch Centre of HEDNO

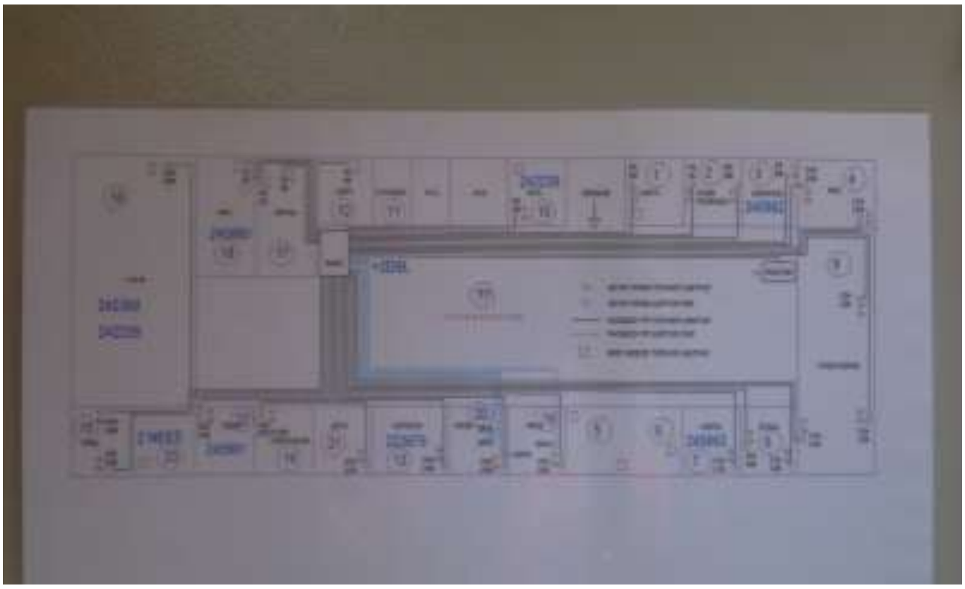


Figure 26 – Schematic of the main floor of the Dispatch Centre

Figure 27 – HEDNO Agency

Figure 28 – Electrical Panel in the HEDNO Agency

Figure 29 – Nursing home Agia Triada Parish

Figure 30 – Electrical Panel in the Nursing home Agia Triada Parish

Figure 31 – Sanatorioum for Chronic Diseases

Figure 32 – Electrical Panel in the Sanatorium for Chronic Diseases

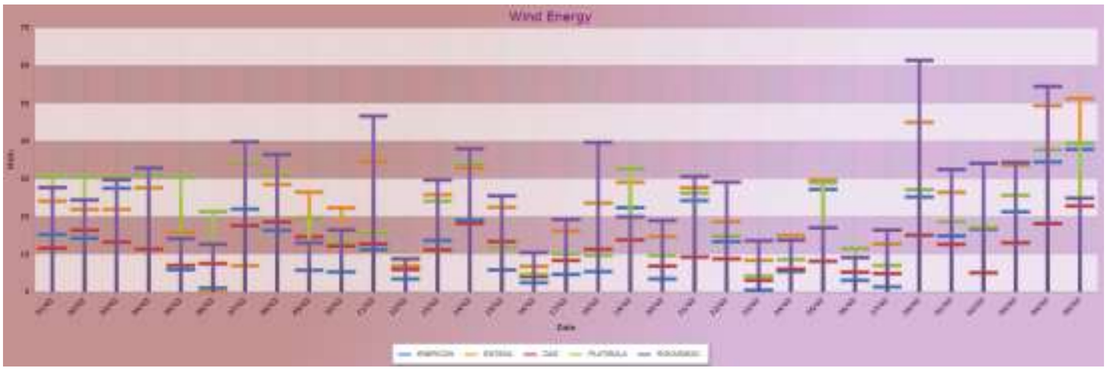


Figure 33 – the production of the WFs during February 2013

7 Key Performance Indicators

Along this section we will describe the KPIs for the use cases defining in the previous sections.

Metrics and Indicators are essential for the evaluation and assessment of progress towards sustainable development. A KPI is an indicator that summarizes and simplifies all the data gathered to clarify, make visible and evaluate the required information.

In SMARTKYE context, the KPIs have been defined with the objective to be used by the Business and Monitoring & Control Cockpit, in order to cover the requirements and interests of the public authorities.

The approach took in SMARTKYE project in this area has been, firstly, the definition of the terms needed in order to formulate the metrics and KPIs, secondly, the description of the metrics used to calculate the KPIs and finally, the methodology and formulas of the KPIs, which will cover the assessment of the SMARTKYE use cases performance.

7.1 Definitions

Firstly, in this section, it is included the definition of some terms that will be needed for the proper definition of the SmartKYE metrics and KPIs.

Table 34 - Definitions

Term	Variable	Description
Asset	a	Any object that can provide a specific metric e.g., EV, wind turbine, etc.
Asset	a_i	Asset of specific type.
Entity	ε	A group composed from at least one asset. Over time assets can be added and removed from the group e.g., a group of points of lights in a street.
Interval	x	Metrics are properties depicted as values measured over a period of time (interval).

From the logical perspective, a single asset can be considered as an entity (group with only one member) and will be treated as such in the rest of this section.

7.2 Metrics

In this section, it is described the metrics that will be used to calculate the Indicators defined in the next section.

A metric is essentially just a value, any standard of measurement that can be needed in order to assess a system. In this section, we have differentiated between different types of metrics. Firstly, in Table 35 are included all the metrics that refer only to a single entity within a period of time. Secondly, **¡Error! No se encuentra el origen de la referencia.** ncludes a definition of the metrics calculated based on the metrics of Table 35. And finally, Table 37 describes specific metrics whose objective is to compare two different entities.

Table 35 - All metrics refer to a single ε within a time period.

Variable	Unit	Metric Description
n		Average asset count due the variability of *a* in the composition
E_c	*kWh*	Energy consumption
E_p	*kWh*	Energy production
E_{pp}	*kWh*	Potential energy production of the current installation
E_{ppe}	*kWh*	Potential energy production after the installation expansion
P_{pc}	*kW*	Potential capacity of power production
P_{max}	*kW*	Maximum peak energy demand
ϱ	*kg*	Total CO_2 emissions
φ_c	*kWh*	Forecast for energy to be consumed
φ_p	*kWh*	Forecast for energy to be produced
φ_{pc}	*kWh*	Forecast for energy to be curtailed from production
E_{cost}	€	Total costs for energy
γ_p	€	Budget available for investment
γ	€	Investment
E_{fc}	*kWh*	Potential for reduction in energy consumption due to the flexibility
E_{fp}	*kWh*	Potential for reduction in energy production due to the flexibility
E_m	*kWh*	Absolute value of the total energy managed
E_{rm}	*kWh*	Absolute value of total energy requested to be managed
c	€	Entity operational cost from its entire composition

p	€/kWh	Weighted energy price
ζ	%	Efficiency in energy conversion e.g., 14% of PV conversion
s_{soc}	%	Average state of charge (SoC) of storage asset(s)
u	%	Usage of an entity e.g., 85% of light bulbs are used
φ_u	%	Forecast of entity usage e.g., 70 % of wind hours are predicted to be used
g	%	Goal achievement

Table 36 - Calculated metrics for a single entity

Variable	Formula	Unit	Metric Description
E_{pr}	E_p/E_c	%	Energy production ratio
φ_{ca}	$\lvert\varphi_c - E_c\rvert/\lvert E_c\rvert$	%	Accuracy of the forecast for total energy to be consumed
φ_{pa}	$\lvert\varphi_p - E_p\rvert/\lvert E_p\rvert$	%	Accuracy of the forecast for total energy to be produced
E_{ex}	$E_p - E_c$	kWh	Energy exchange
E_{pc}	$E_{pp} - E_p$	kWh	Total energy curtailed from production
E_{pw}	E_p/E_{ppe}	%	Percentage of energy production of its final potential
E_f	$E_{fc}+E_{fp}$	kWh	Total flexibility in the energy signature
γ_r	γ/γ_p	%	Ratio of the total investments from available investments
E_{ma}	E_m/E_{rm}	%	Achievement in energy management
P_{pe}	P_{pc}/P_{max}	%	Production energy penetration

Finally, in Table 37 it has been described specific metrics whose objective is to compare two different entities.

Table 37 - Calculated metrics of entity comparison

Variable	Formula	Unit	Metric Description
$n^{\varepsilon_1 \varepsilon_2}$	$n^{\varepsilon_1}(x_1)/n^{\varepsilon_2}(x_1)$	%	Penetration of specific assets (e.g., ε_1 composed only of EVs vs. ε_2 composed of all cars)
$E_{pr}^{\varepsilon_1 \varepsilon_2}$	$E_p^{\varepsilon_1} / E_c^{\varepsilon_2}$	%	Energy production ratio of ε_1 over ε_2, where $a \in \varepsilon_1 \subseteq a \in \varepsilon_2$

7.3 Key Performance Indicators

In this section it has defined the Key performance Indicators that will be used along the project, based on the metrics that have been defined previously.

KPIs are specifically designed to measure the smartgrid of the city performance towards the authorities' objectives. KPI is a metric, usually composed by other metrics, used to track some specific performance objective.

In Table 38 it is included the formula of each KPI, the unit used and the use cases where the KPI is relevant.

All KPIs are applied to intervals of the entities, where interval x_1 occurs before the intervalx_2.

Table 38 - Key Performance Indicators

#	KPI	Formula	Unit	Use cases											
				1	2	3	4	5	6	7	8	9	10	11	12
1	Difference in asset count	$n(x_2)-n(x_1)$		x	x	x				x	x	x	x	x	x
2	Change in production penetration	$P_{pe}(x_2)/P_{pe}(x_1)-1$	%	x											
3	Difference in CO_2 emissions	$\varrho(x_2)-\varrho(x_1)$	*kg*		x	x	x								
4	Change in CO_2 emissions	$\varrho(x_2)/\varrho(x_1)-1$	%		x	x	x		x						
5	Difference in energy consumption	$E_c(x_2)-E_c(x_1)$	*kWh*	x	x		x	x		x	x	x	x	x	x
6	Change in energy consumption	$E_c(x_2)/E_c(x_1)-1$	%	x		x	x	x	x	x	x	x	x	x	x
7	Change in energy production	$E_p(x_2)/E_p(x_1)-1$	%				x			x	x	x			x
8	Difference in energy production	$E_p(x_2)-E_p(x_1)$	*kWh*	x	x		x		x	x	x	x			x
9	Difference in energy management	$E_m(x_2)-E_m(x_1)$	*kWh*	x					x	x	x	x	x	x	x
10	Difference in energy management achievement	$E_{ma}(x_2)-E_{ma}(x_1)$	%						x	x	x	x	x	x	x
11	Change in energy management achievement	$E_{ma}(x_2)/E_{ma}(x_1)-1$	%						x	x	x	x	x	x	x
12	Difference in curtailed energy	$E_{pc}(x_2)-E_{pc}(x_1)$	*kWh*	x			x		x	x	x	x			x
13	Difference in energy exchanged	$E_{ex}(x_2)-E_{ex}(x_1)$	*kWh*	x			x			x	x	x	x	x	x
14	Difference in energy cost	*Ecost(x2)−Ecost(x1)*	€		x		x	x							
15	Difference in weighted energy efficiency	$\zeta(x_2)-\zeta(x_1)$	%			x	x	x		x	x	x	x	x	x

16	Difference in weighted energy price	$p(x_2)-p(x_1)$	€/kWh		x	x									
17	Difference in energy production ratio	$E_{pr}^{\varepsilon_1\varepsilon_2}(x_2) - E_{pr}^{\varepsilon_1\varepsilon_2}(x_1)$	%							x	x	x			x
18	Difference in entity usage	$u(x_2)-u(x_1)$	%	x	x	x	x			x	x	x	x	x	x
19	Change in energy cost	$E_{cost}(x_2)/E_{cost}(x_1)-1$	%			x	x	x	x						
20	Change in potential energy flexibility	$E_f(x_2)/E_f(x_1)-1$	%					x	x	x	x	x	x	x	x
21	Change in energy consumption flexibility	$E_{fc}(x_2)/E_{fc}(x_1)-1$	%					x	x	x	x	x	x	x	x
22	Change in consumption forecast accuracy	$\varphi_{ca}(x_2)/\varphi_{ca}(x_1)-1$	%				x	x	x	x	x	x	x	x	x
23	Change in production forecast accuracy	$\varphi_{pa}(x_2)/\varphi_{pa}(x_1)-1$	%				x	x	x	x	x	x			x
24	Change in total energy predictability	$P_a(x_2)/P_a(x_1)-1$	%				x	x	x	x	x	x			x
25	Change in operational cost	$c(x_2)/c(x_1)-1$	%			x		x							
26	Change in overall state of charge (SOC)	$s_{soc}(x_2)/s_{soc}(x_1)-1$	%				x		x	x	x	x	x	x	x
27	Change in asset penetration	$n^{\varepsilon_1\varepsilon_2}(x_2)/n^{\varepsilon_1\varepsilon_2}(x_1)-1$	%	x	x	x		x							
28	Change in production from maximum potential	$E_{pw}(x_2)/E_{pw}(x_1)-1$	%				x	x	x	x	x	x			x
29	Change in goal achievement	$g(x_2)/g(x_1)-1$	%	x	x				x	x	x	x			x
30	Change in investment	$\gamma(x_2)/\gamma(x_1)-1$	%		x			x	x						
31	Change in potential energy production	$E_{pp}(x_2)/E_{pp}(x_1)-1$	%					x		x	x	x			x

8 Conclusions

The final goal of this document has been to constraint and to delimit the scenarios and uses cases demonstrating the validity of the SmartKYE solutions.

In this context, it has been described the systems and stakeholders involved in SMARTKYE project, as well as the high level architecture, in order to defined the use cases. The project architecture will be defined in detail within WP2 “Architecture and energy services”. Based on this information, a list of use cases have been defined, covering the end users’ needs in real world in order to demonstrate them in SmartKYE test sites.

In addition, the test sites involved in SMARTKYE demonstration activities, 22@ district in Barcelona and Lasithi in Crete, have been described in detail, specifying the equipment that will be used for the demonstration, and all the particularities of each asset deployed.

Based on the information previously defined, in deliverable D1.1 “Requirements specification” has been defined all the requirements of each system involved in the project, covering all the use cases defined in deliverable D1.2. Therefore, deliverables D1.1 and D1.2 are complementary.

Finally, in the last section of this document, Key Performances Indicators have been identified that will be used by the end users in order to assess and monitor the SMARTKYE solution based on the authorities interests and requirements. These KPIs will be the basis for the SMARTKYE cockpits, which will be developed in WP5. Therefore, during the work in WP5, the list of KPI described in this deliverable D1.2 could be updated or completed.

9 References and Acronyms

9.1 Acronyms

Acronyms List	
BC	Business Cockpit
BMS	Building Management System
DER	Distributed Energy Resources
DM	Dissemination Manager
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EGS	EMS of Generator System
EMS	Energy Management System
EPB	EMS of Public Lighting System
EPL	EMS of Public Lighting
ESCO	Energy Service Company
ETS	EMS of Traffic System
EU	European Union
EV	Electrical Vehicles
EVE	EMS of Transport System
M&C	Monitoring and Control
MCC	Monitoring and Control Cockpit
MUN	Municipality
OESP	Open Energy Service Platform
PHEV	Plug-in Hybrid Electrical Vehicles
PLS	Public Lighting System
PPP	Public-Private Partnership
PV	Photovoltaic
RES	Renewable Sources
TS	Time Series e.g., TS Data is Time Series Data
UC	Use Case

9.2 References

[1] SMARTKYE Description of Word

[2] http://www.smartgrids.eu/documents/sra2035.pdf