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Abstract:

This deliverable reports the validation of the different systems developed in the previous work packages and their use by the BESOS pilot sites – the cities of Barcelona and Lisbon.

Keywords:

BESOS Deployment Plan, Lisboa, Barcelona, EMS

Revision History

Revision	Date	Description	Author (Organisation)
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1 Introduction

1.1 Purpose and scope of the Document

This deliverable is the second report about the validation of the different systems developed in the previous work packages and their use by the BESOS pilot sites – the cities of Barcelona and Lisbon. This is the 2nd part of the deliverable submitted in November 2015 (D6.1.1).

The systems are tested according to the evaluation plan delivered by WP7 and the data gathered will be used in such WP to assess the results of the project.

In summary, the objectives of this D6.1 will be: *To report the deployment of the results of WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App) in the pilot sites.*

In the second round of trials, additional use cases were tested and new EMS involved:

UC ID	Use Case	Demonstration activities			
		Barcelona		**Lisbon**	
		Round 1 D6.1.1	**Round 2**	Round 1 D6.1.1	**Round 2**
1	Visualization and Monitoring of Energy Data	X	X	X	X
2	Data analytics on historical information of Prosumer Flexibility	X	X	X	X
3	Energy demand optimization of the public lighting based on light environment	X	X		X
4	Energy management for the use of electric vehicle fleet		X		X
5	Electrical Vehicles (EV) local optimization and storage capacity forecasting		X		X
6	Energy demand curve optimization based on traffic conditions		X		X
7	Energy demand monitoring and optimization in public buildings	X	X	X	X
8	Smart city Energy demand curve optimization	X	X	X	X
9	Optimal Alignment of KPIs with SLAs		X		X
10	Service platform for Public Authorities and ESCO's to access to public tenders information		X		X
11	Modification of user behaviour		X		X
12	Measurement of the renewable energy produced and predicted in the distribution network	X	X	X	X
13	Predict the energy consumption on weather data		X		X
14	Measurement / control of the electric energy quality	X	X	X	X
15	Preventive Maintenance Alarm		X		X

Table 1 – Use cases tested (2nd round of trials)

Barcelona EMS	Round of trials
Ficosa Power Plant – managed by Ficosa	2
Public lighting – managed by IMI	2
Electric Vehicles	1 and 2
BCN Buildings – managed by IMI	1 and 2
Aj. Barcelona Buildings / Sodexo Centre Cívic Orlandai	1 and 2
Aj. Barcelona Buildings / Sodexo Biblioteca Les Roquetes	1 and 2
Aj. Barcelona Buildings / Sodexo Arxiu Municipal Contemporani	1 and 2
Aj. Barcelona Buildings / Sodexo Biblioteca Agustí Centelles	1 and 2
BCN Traffic Level	2
BCN Traffic Consumption	2
Cobra CECOVI Wind Farm (Viudo) – managed by Cobra	2
Energy production forecast	2

Table 2 – EMS used in Barcelona (2nd round of trials)

Lisboa EMS	Round of trials
Campo Grande 25 Building – managed by Lisbon Municipality and ISA	1 and 2
Olivais School - managed by Lisbon Municipality and ISA	1 and 2
Mechanical and Electrical Department from the Municipality managed by Lisbon Municipality and ISA	1 and 2
University of Lisbon PV Park energy production – managed by Conergy/CAPA	1 and 2
Cobra CECOVI Wind Farm (Montegordo) – managed by Cobra	1 and 2
EV Charging points	2
Traffic lights	2
Public lighting	2
Social Services' building	2
Energy production forecast	2
Energy consumption forecast	2

Table 3 – EMS used in Lisbon (2nd round of trials)

1.2 Structure of the Document

The document is structured in three sections: chapter 2 presents the configuration and architecture of BESOS at each of the sites, section 3 the link between demonstration and data collection and section 4 the local trials phases.

1.3 BESOS Project Summary

Following the DoW, BESOS strategic goal is to enhance currently existing neighbourhoods with **decision support system (DSS)** to provide **coordinated** management of **public infrastructures in Smart Cities**, and at the same time provide citizens with information to promote **sustainability** and **energy efficiency**.

The project will target two main stakeholders: the owners of the infrastructure –e.g. **municipalities** – and its operators – e.g. **ESCOs and facility managers (FM)**. The former will be provided with a **Business Balanced Score Card** to audit the **Service Level Agreements** (SLA) established with the ESCOs and FM against a number of **Key Performance Indicators** (KPI). The latter will make use of the same tool to analyse new **business models**, and will be also provided with a **DSS Cockpit** to Monitor and Control (M&C) information from the infrastructure and establish **coordinated energy efficiency strategies.**

Two leading cities in Europe, **Lisbon and Barcelona,** will act as test-beds of the BESOS approach.

High Level Categorization	BESOS Stakeholders
Facility Owners	Municipalities
	Building Owners
	Power Generation Units Owners
	Electric Vehicles Fleet Owners
Facility Operators	ESCOs
	Aggregators
	Facility Managers
	Public Lighting Operators
	Electric Vehicles Operators
	Power Generation Units Operators
Residential Users	Residential Occupants
	School students

Table 4 – BESOS Stakeholder's Analysis

Different Energy Management Systems –e.g. public lighting system, public buildings, electric vehicles, micro-generation, residential prosumers, etc. - within a smart city will be able to share data and services through a new **Open Trustworthy Energy Service Platform** (OTESP) developed in the project. Stakeholders as ESCOS, public authorities, Distribution and Transmission System Operators (DSOs and TSOs), will be able to access and interface the existing infrastructure in smart cities, not only to analyse in real-time the data from such systems but also to implement common strategies enforcing energy efficiency. A key feature of the OTESP will be the adoption of **secure and reliable** protocols – both for communication and data management - to ensure the trustworthiness of the approach and the correct treatment of private information. Moreover, the **data modelling** in the project will consider the openness of the information – both Barcelona and Lisbon already count with beta **opendata** hubs – whilst ensuring the security of the approach.

Hence, the Open Trustworthy Energy Service Platform will act as **gateway** to the different stakeholders at the demand and supply side on a smart city, who already count with their own Energy Management Systems for local decisions and energy management.

As an additional benefit the deployment of an open infrastructure for data and service management, will open new opportunities to **mobile application** developers willing to increase energy efficiency awareness among **citizens**. As a proof of concept, the project will implement and test an interface to inform citizens and try to modify their **behaviour** by means of challenges – e.g. challenge to students in order to reduce consumption in a school to match a certain load profile.
All these applications will be finally tested in two leading cities: **Lisbon and Barcelona**. The assets that are available for the trials include: public lighting, public buildings, PV micro-generation, wind turbines, smart heating, electrical vehicle charging points and mobility systems.

1.4 Demonstration of BESOS results

The objective of WP6 is to validate the different systems developed in the previous work packages so that they can be used by the BESOS pilot sites – the cities of Barcelona and Lisbon.

In addition, WP6 will host the demonstration activities to enlarge the impact of the project and raise the attention of the main stakeholders.

In summary, the objectives will be:

- To deploy the results of WP2, WP3, WP4 and WP5 in the pilot sites.
- To gather the needed data for further evaluation in WP7.
- To host the public demonstration activities in coordination with WP8.

Two different test campaigns were planned (Trial 1 and Trial 2). This will provide two different datasets for comparison in two different seasons, and will enable an incremental deployment of the solutions being provided by the project. It is noteworthy mentioning that the evaluation in WP7 will be made against a pre-record set of data, so direct analysis on the impact of BESOS in terms of energy savings can be performed.

Last but not least, this WP also tackles the public demonstration activities to enhance the dissemination and impact of the project.

1.4.1 Local integration in the Test Sites

Led by the pilot site leaders (Lisboa E-Nova, the Ajuntament de Barcelona, SODEXO, Cobra and Ficosa), and in close collaboration with the user group supporting the pilots (eg Lisbon Municipality), the different systems were deployed in the test sites with the support of the technical partners ETRA, PTIN and ENERCAST.

In this context:

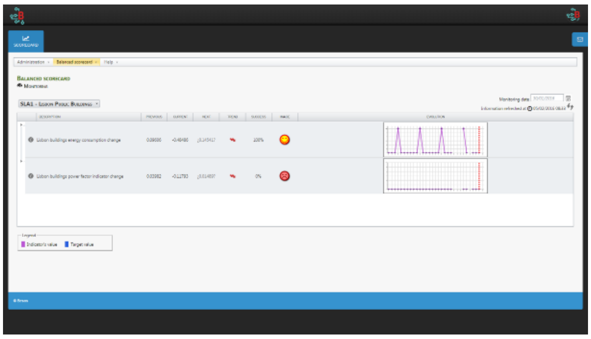
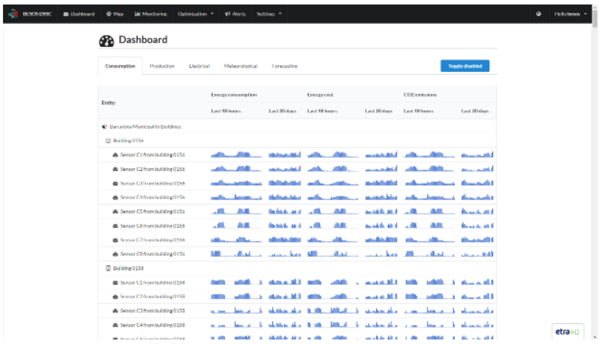
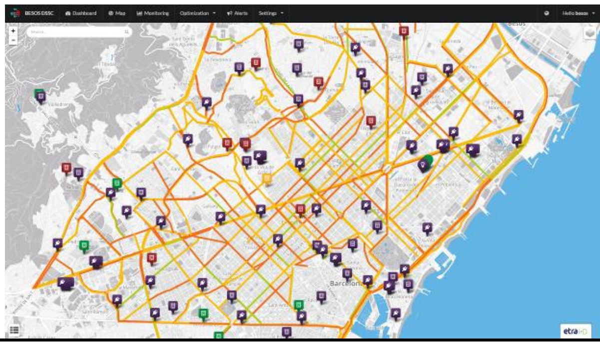
- The EMS adapted in WP4 that are configured in an controlled environments identified for the trials, the use cases defined in WP1, and integrated in the Evaluation Plan, have to be validated.
- The OTESP developed in WP3 and installed in the large deployments of Barcelona and Lisbon.
- The Business Balanced Score Card and DSS Cockpit (WP5) installed under the

supervision of the end-users (Barcelona municipality, Lisbon E-Nova, Sodexo and ETRA).

- An android application will be make publicly available for the trials with the citizens – specifically with the students in the affected schools and universities, involved in the trials.

All three developments will be described in the frame of the report for two different test campaigns (divided each by 2 months of set up and 4 months of running).

	Example **UC1 - Visualization and Monitoring of energy data - real time operational**
1) Demo site	Lisbon and Barcelona
2) EMSs, assets and applications involved	Lisbon: Public Buildings, Generation, Traffic Consumption BCN: Public Buildings, EVs, Public Lighting, Generation Applications: BBSC, DSSC
3) Partners involved	ETRA, LBN, PTIN, SODEXO, COBRA, FICOSA, BCN
4) Stakeholders involved	FM, ESCOs, public authorities
5) Test Case description	The objective of the test case is to check the correct integration of the whole system. All EMS included in phase 1 must have their corresponding GW (WP4) up and running, and ready to serve the expected information (entities, attributes, metrics) following the structures defined in the architecture and the data model (WP2). They must be integrated to the OTESP (WP3), which must be ready to receive requests from the different applications (WP5) and query the appropriate EMS GW to gather the necessary information to form the responses. The first versions of the BBSC and the DSSC must be ready to gather information from the OTESP (mainly metrics and KPIs) and display it to the user. Mobile Application must be ready to present energy data to stakeholders. The scope of the functionalities of the first versions of the applications is further described in D5.1.1.
6) Test Case expected result	The user is able to successfully retrieve data from the different EMS through the functionalities provided by the BBSC (KPI monitoring, VA tool…) and the DSSC (system & asset monitoring, metrics evolution visualization, situation detection…). The BBSC and the DSSC are able to access the information of the EMS through the OTESP. Mobile Application is also linked to OTESP to retrieve energy related data. The OTESP can successfully query each EMS by means of their implemented GW. It also provides access to data through its defined web services (supporting both pull and push retrieval options), as well as other defined services (groups, CEP, etc.). All GW follow the same approach and provide/integrate data in a homogeneous manner.

7) Images/Graphics	Second versions of all the parts of the system (EMS GWs, OTESP, and applications) are completed and being tested. Issues found in the first round of trials were corrected and feedback from users led to changes and new developments.
8) Constraints	Main sections of the 2nd version of the applications: **BBSC** Allows the user with high- and low-profile visions of the KPIs of the system.  **DSSC** Provides the system manager with a technical tool to monitor the status of the assets and their properties.  

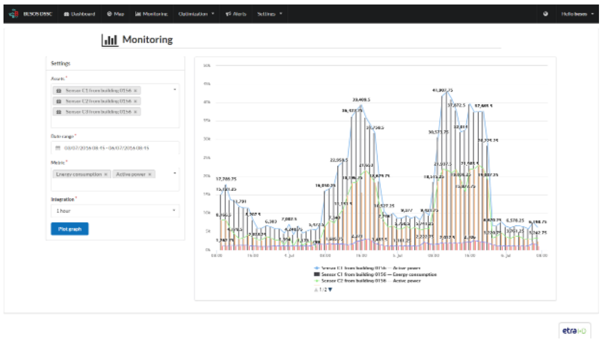
	 **Mobile Application**: The mobile application for behavioural modification aims at promoting a sustainable usage of energy in order to create public awareness campaigns to inform the citizens about the energy spent to support public services. 
9) Lessons learned	Due to the nature of each underlying system, some EMSs are not able to provide actual real-time data, but make available batches of real-time measurements one or more times a day. This can affect the normal functioning of the applications during the time window without new data, but it is corrected as soon as the new batch is received.

Table 5 – Example for demonstration description

1.4.2 Data gathering for Evaluation

The collection of data follows the indicators identified in the evaluation plan (D7.1). The indicators will help to measure not only the technical performances and new capabilities of the system, but also the user acceptance and impact (social and economic).

Thus, besides the log files gathered during the normal operation of the different applications, the data gathering task also covers the interviews with the relevant stakeholders involved in the project to retrieve their opinion (Public authorities, facility owners, facility managers, DSO, TSO and ESCOS).

The Data for evaluation will also serve as main feedback tool to the technological work packages.

ID	Metrics	System Component					
		EV	RES	PLS	Reside	Public	Forec ast
1	Public/ Residential Facility Consumption				x	x	
2	RES Energy Production		x				
3	Potential renewable energy production of the current installation		x				
4	EVs Energy consumption	x					
5	PLS Energy consumption			x			
6	Indoor Air Temperature					x	
7	Electricity Prices/ Cost of Energy	x		x		x	
8	Metrological Data - Weather Conditions	x	x	x	x	x	x
9	Total CO2 emissions	x		x		x	
10	Forecast for energy to be consumed						x
11	Forecast for energy to be produced						x
12	Usage of each entity	x	x	x	x	x	
13	Mobility Parameters (for PLS management)			x			
14	Number of Messages through Mobile App				x		
15	Total Distortion Harmonics Indicator					x	
16	Power factor					x	
17	Voltage root mean square					x	
18	Control Commands to EV	x					
19	Control Commands to PLS			x			
20	Control Commands to Facility Premises					x	
21	Estimation of the load reduction	x	x	x		x	

Table 6 – Data for evaluation (following WP7)

1.4.3 Demonstration activities

In coordination with WP8, a number of demonstration activities are planned in order to maximise the impact of BESOS in the relevant stakeholders. Barcelona and Lisbon are member of the covenant of Majors and Barcelona, and within the cities, there is a large number of activities towards the improvement of energy efficiency. Demonstration activities will help citizens to be aware of how much electricity can be saved through the use of most efficient system by the public authorities. These activities are coordinated by ETRA. The results from demonstration activities in Pilot sites are reported in "D6.2 Demonstration Activities".

2 Demonstration sites architecture and configuration

This chapter presents the identification of the different EMS and their providers, the Use Cases defined in WP1, divided by each of the test cities, after the adaptation and integration reported in D4.1. Many EMS got different databases or interfaces for the real time and historical data. Both data will be integrated in the BESOS project.

All the following mentioned assets – both for Lisbon and Barcelona – will be used in the project as sources of information, since the equipment needed for the retrieval of data is already deployed. Thus, the adaptation required to interact with BESOS solution and to obtain a common monitoring and analysis will be soft-based.

2.1.1 Demonstration Sites

Validation in real-life environment is one of the core objectives of the project. The two pilot cities participating in the project are leading metropolis on the energy efficiency arena for Smart Cities.

They both have committed a number of assets for the demonstration and validation of BESOS main results. The description of the public services and infrastructure available in BESOS – jointly with the available energy data and services – can be found in the following lines.

It is not the intention of the project – due to obvious budgetary constraints – to propose a full-scale smart city deployment. On the contrary, it is more interesting to involve as many different energy management systems in a city as possible, with a limited – but relevant -number of monitored and controlled resources per EMS – i.e. it is not necessary to affect more than 100.000 luminaries in Barcelona to demonstrate a new coordinated strategy for saving energy with a public lighting system.

	USE CASES (List according to D1.1)	Public building system	Energy generation system	Electric Vehicles	Public lighting system	Traffic lighting system	Public building system & Energy generation system
UC1	Visualization and Monitoring of energy data	x	x	x	x	x	x
UC2	Data analytics on historical information of Prosumer Flexibility-	x	x	x	x	x	x
UC3	Energy demand optimization of the public lighting based on light environment				x		
UC4	Energy management for the use of electric vehicle fleet			x			
UC5	Electrical Vehicles (EV) local optimization and storage capacity forecasting			x			
UC6	Energy demand curve optimization based on traffic conditions				x	x	
UC7	Energy demand monitoring and optimization in public buildings	x					x
UC8	Smart city Energy demand curve optimization	x	x	x	x	x	x
UC9	Optimal Alignment of KPIs with SLAs	x	x	x	x	x	x
UC10	Service platform for Public Authorities and ESCO's to access to public tenders information	x	x	x	x	x	x
UC11	Modification of user behaviour	x					x
UC12	Measurement of the renewable energy produced and predicted in the distribution network		x				x
UC13	Predict the energy consumption on weather data	x					x
UC14	Measurement / control of the electric energy quality (in the distribution network)	x	x	x	x	x	x
UC15	Preventive Maintenance Alarm	x	x	x	x	x	x

Table 7 – Use cases vs EMS (For more information go to D1.1)

On the other hand, in order to propose new control strategies, it will be needed to affect the Energy Management System with new hardware. This imposes a constraint on the number of elements involved in order to keep a reasonable budget for the project.

The following table presents the Use case tested and the EMS affected, for this 2nd round of trials, as well as the chronogram followed:

2.1.2 Energy Management Systems involved in each site, use cases tested and timeline for the 2nd round of trials

2.1.2.1 Barcelona

UC1 - Visualization and Monitoring of energy data	Pilot	EMS	Partners	fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Barcelona buildings	BCN	ETRA								
Public building system	Sodexo buildings	SODEXO	ETRA								
Energy generation system	W.F. VIUDOI	COBRA	COBRA								
Energy generation system	Sant Guim Power Plant	FICOSA	ETRA								
Electric Vehicles	Barcelona	BCN	ETRA								
Public lighting system	Barcelona	BCN	ETRA								
Traffic status system	Barcelona	BCN	ETRA								
Traffic consumption system	Barcelona	BCN	ETRA								
Public building system & Energy generation system	Barcelona	DEXMA	ETRA								

UC2 - Data analytics on historical information of Prosumer Flexibility				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Barcelona buildings	BCN	ETRA								
Public building system	Sodexo buildings	SODEXO	ETRA								
Energy generation system	W.F. VIUDOI	COBRA	COBRA								
Energy generation system	Sant Guim Power Plant	FICOSA	ETRA								
Electric Vehicles	Barcelona	BCN	ETRA								
Public building system & Energy generation system	Barcelona	DEXMA	ETRA								

UC3 - Energy demand optimization of the public lighting based on light environment				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16

Public lighting system	Barcelona	BCN	ETR A								
Traffic status system	Barcelona	BCN	ETR A								
Traffic consumption system	Barcelona	BCN	ETR A								

UC4 - Energy management for the use of electric vehicle fleet				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Electric Vehicles	Barcelona	BCN	ETR A								

UC5 - Electrical Vehicles (EV) local optimization and storage capacity forecasting				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Electric Vehicles	Barcelona	BCN	ETR A								

UC6 - Energy demand curve optimization based on traffic conditions				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Public lighting system	Barcelona	BCN	ETR A								
Traffic status system	Barcelona	BCN	ETR A								
Traffic consumption system	Barcelona	BCN	ETR A								

UC7 - Energy demand monitoring and optimization in public buildings				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC8 - Smart city Energy demand curve optimization				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Energy generation system	Sant Guim Power Plant	FICO SA	ETR A								

UC9 - Optimal Alignment of KPIs with SLAs				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Public lighting system	Barcelona	BCN	ETR A								
Traffic status system	Barcelona	BCN	ETR A								
Traffic consumption system	Barcelona	BCN	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC10 - Service platform for Public Authorities and ESCO's to access to public tenders information				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Public lighting system	Barcelona	BCN	ETR A								
Traffic status system	Barcelona	BCN	ETR A								
Traffic consumption system	Barcelona	BCN	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC11 - Modification of user behaviour				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC12 - Measurement of the renewable energy produced and predicted in the distribution network				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16

Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Energy generation system	Sant Guim Power Plant	FICO SA	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC13 - Predict the energy consumption on weather data				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC14 - Measurement / control of the electric energy quality (in the distribution network)				**dez/ 15**	**jan/ 16**	**jan/ 16**	**mar /16**	**abr/ 16**	**mai /16**	**jun/ 16**	**jul/ 16**
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Energy generation system	Sant Guim Power Plant	FICO SA	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

UC15 - Preventive Maintenance Alarm				**fev/ 16**	**mar /16**	**abr/ 16**	**mai/ 16**	**jun/ 16**	**jul/ 16**	**ago /16**	**set/ 16**
Public building system	Barcelona buildings	BCN	ETR A								
Public building system	Sodexo buildings	SOD EXO	ETR A								
Energy generation system	W.F. VIUDO I	COB RA	COB RA								
Energy generation system	Sant Guim Power Plant	FICO SA	ETR A								
Public building system & Energy generation system	Barcelona	DEX MA	ETR A								

Table 8 – Timeplan for Barcelona (red setup; green trial)

2.1.2.2 Lisbon

UC1 - Visualization and Monitoring of energy data	Pilot	EMS	Partners	fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Campo Grande Building	ISA	LBN, PT								
Public building system	DRMM Building	ISA	LBN, PT								
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	University PV Park	Coenergy	ENERCAST								
Energy generation system	W.F. Montegordo	COBRA	COBRA								
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								
Public lighting system											
Traffic lighting system			ETRA								
Public building system & Energy generation system	Olivais school	ISA	LBN, PT								

UC2 - Data analytics on historical information of Prosumer Flexibility				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Energy generation system	W.F. Montegordo	COBRA	COBRA								
Public building system & Energy generation system	Olivais School	ISA									

UC3 - Energy demand optimization of the public lighting based on light environment				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public lighting system	Lisbon	Philips	LBN, PT								
Traffic lighting system			ETRA								

UC4 - Energy management for the use of electric vehicle fleet				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC5 - Electrical Vehicles (EV) local optimization and storage capacity forecasting				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC6 - Energy demand curve optimization based on traffic conditions				fev/16	mar/16	abr/16	mai/16	jun/16	jul/16	ago/16	set/16
Public lighting system	Lisbon	Philips	LBN, PT								
Traffic lighting system			ETRA								

UC7 - Energy demand monitoring and optimization in public buildings				**fev/16**	**mar/16**	**abr/16**	**mai/16**	**jun/16**	**jul/16**	**ago/16**	**set/16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system & Energy generation system	Olivais school	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC8 - Smart city Energy demand curve optimization				**fev/16**	**mar/16**	**abr/16**	**mai/16**	**jun/16**	**jul/16**	**ago/16**	**set/16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	W.F. Montegordo	COBRA	COBRA								
Public building system & Energy generation system	Olivais school	I									
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC9 - Optimal Alignment of KPIs with SLAs				**fev/16**	**mar/16**	**abr/16**	**mai/16**	**jun/16**	**jul/16**	**ago/16**	**set/16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	University PV Park	Coenergy									
Public lighting system	Lisbon	Philips	LBN, PT								
Traffic lighting system			ETRA								
Public building system & Energy generation system	Olivais school	ISA									
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC10 - Service platform for Public Authorities and ESCO's to access to public tenders information				**fev/16**	**mar/16**	**abr/16**	**mai/16**	**jun/16**	**jul/16**	**ago/16**	**set/16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	University PV Park	Coenergy									
Public lighting system											
Traffic lighting system			ETRA								
Public building system & Energy generation system	Olivais school	ISA									
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC11 - Modification of user behaviour				**fev/16**	**mar/16**	**abr/16**	**mai/16**	**jun/16**	**jul/16**	**ago/16**	**set/16**
Public building system & Energy generation system	Olivais school	ISA									
Electric Vehicles	EV Campo Grande	ISA	PTIN, LBN								

UC12 - Measurement of the renewable energy produced and predicted in the distribution network				**fev/16**	**mar /16**	**abr /16**	**mai /16**	**jun /16**	**jul/ 16**	**ago /16**	**set/ 16**
Energy generation system	University PV Park	Conergy									
Energy generation system	W.F. Montegordo	COBRA	COBR A								
Public building system & Energy generation system	Olivais School	ISA									

UC13 - Predict the energy consumption on weather data				**fev/16**	**mar /16**	**abr /16**	**mai /16**	**jun /16**	**jul/ 16**	**ago /16**	**set/ 16**
Energy generation system	University PV Park	Conergy									
Public building system & Energy generation system	Olivais School	Olivais school									

UC14 - Measurement / control of the electric energy quality (in the distribution network)				**fev/16**	**mar /16**	**abr /16**	**mai /16**	**jun /16**	**jul/ 16**	**ago /16**	**set/ 16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	W.F. Montegordo	COBRA	COBR A								
Public building system & Energy generation system	Olivais school	ISA									

UC15 - Preventive Maintenance Alarm				**fev/16**	**mar /16**	**abr /16**	**mai /16**	**jun /16**	**jul/ 16**	**ago /16**	**set/ 16**
Public building system	Campo Grande Building	ISA									
Public building system	DRMM Building	ISA									
Public building system	Social Services	LMIT	LBN, PT								
Energy generation system	W.F. Montegordo	COBRA	COBR A								
Public building system & Energy generation system	Olivais school	ISA									
Public lighting system	Lisbon	Philips	LBN, PT								

Table 9 – Timeplan for Lisbon (red setup; green trial)

3 Local Integration – 2nd round of trials (February 2016 - September 2016)

3.1 Introduction

WP6 is the product of 18 months of preparation that ranged from the requirements and use cases definition, which were the basis for the design of the architecture, the development of the Open Trustworthy Energy Services Platform, the integration of the different EMS and the development of the DSSC and BBSC.

This WP summarizes and collects the demonstration activities across the 2 cities: Lisboa and Barcelona, which will provide data to WP7.

It was decided to describe the tests, per use case (total of 15) and according to the following parameters:

1) Demo site
2) EMSs, assets and applications involved (e.g.: Public lighting)
3) Partners involved
4) Stakeholders involved
5) Test Case description
6) Test Case expected result
7) Images/Graphics
8) Constraints
9) Lessons learned

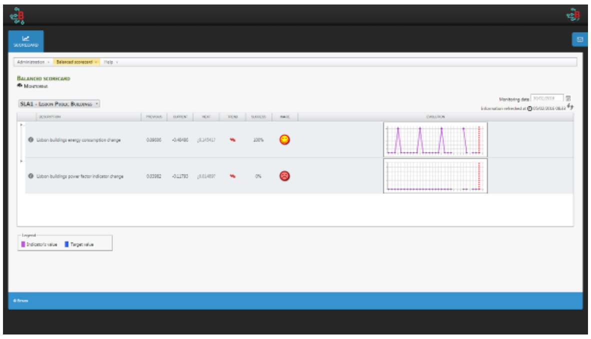
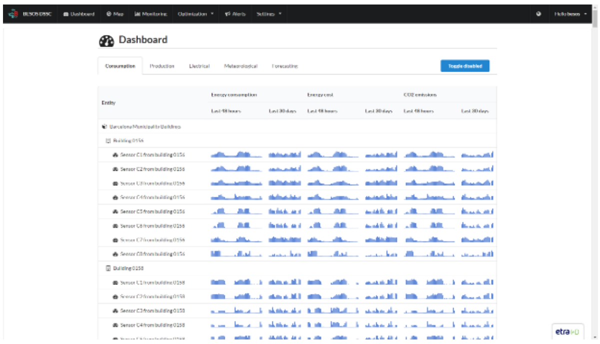
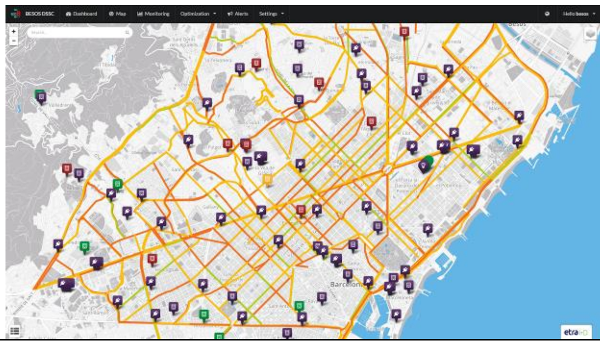
3.2 Test cases for the experiments

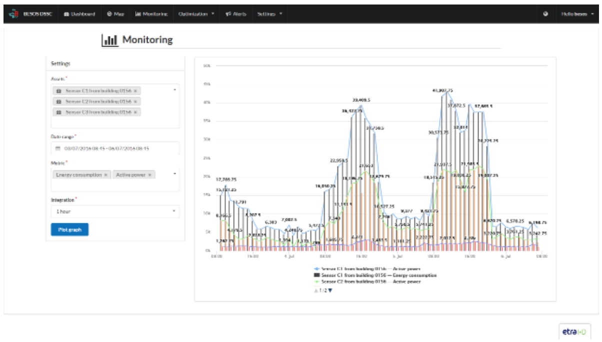
Based on the uses cases identified in D1.1, a number of uses cases have been selected for the first round of trials. The detailed planning for demonstration of evaluation scenarios is provided in the next table:

UC ID	Use Case	Demonstration activities			
		Barcelona		Lisbon	
		Round A	Round B	Round A	Round B
1	Visualization and Monitoring of Energy Data	X	X	X	X
2	Data analytics on historical information of Prosumer Flexibility	X	X	X	X
3	Energy demand optimization of the public lighting based on light environment	X	X		X
4	Energy management for the use of electric vehicle fleet		X		X
5	Electrical Vehicles (EV) local optimization and storage capacity forecasting		X		X
6	Energy demand curve optimization based on traffic conditions		X		X
7	Energy demand monitoring and optimization in public buildings	X	X	X	X
8	Smart city Energy demand curve optimization	X	X	X	X
9	Optimal Alignment of KPIs with SLAs		X		X
10	Service platform for Public Authorities and ESCO's to access to public tenders information		X		X
11	Modification of user behaviour		X		X
12	Measurement of the renewable energy produced and predicted in the distribution network	X	X	X	X
13	Predict the energy consumption on weather data		X		X
14	Measurement / control of the electric energy quality	X	X	X	X
15	Preventive Maintenance Alarm		X		X

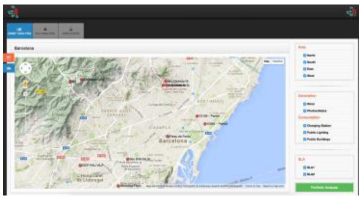
Further details on this uses cases can be found in D1.1.

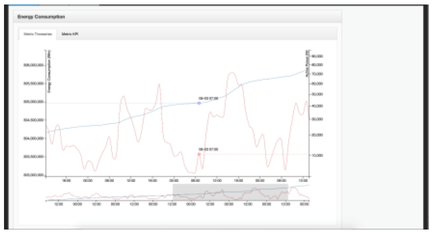
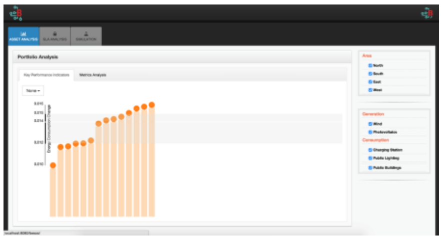
Use Case number and name:	3.2.1.1 **UC1 - Visualization and Monitoring of energy data - real time operational**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, Generation, Traffic Consumption BCN: Public Buildings, EVs, Public Lighting, Generation Applications: BBSC, DSSC
Partners involved:	ETRA, LBN, PTIN, SODEXO, COBRA, FICOSA, BCN
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs, public authorities
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The objective of the test case is to check the correct integration of the whole system. All EMS included in phase 1 must have their corresponding GW (WP4) up and running, and ready to serve the expected information (entities, attributes, metrics) following the structures defined in the architecture and the data model (WP2). They must be integrated to the OTESP (WP3), which must be ready to receive requests from the different applications (WP5) and query the appropriate EMS GW to gather the necessary information to form the responses. The first versions of the BBSC and the DSSC must be ready to gather information from the OTESP (mainly metrics and KPIs) and display it to the user. Mobile Application must be ready to present energy data to stakeholders. The scope of the functionalities of the first versions of the applications is further described in D5.1.1.
Test Case result (How is it worsking?)	The user is able to successfully retrieve data from the different EMS through the functionalities provided by the BBSC (KPI monitoring, VA tool…) and the DSSC (system & asset monitoring, metrics evolution visualization, situation detection…). The BBSC and the DSSC are able to access the information of the EMS through the OTESP. Mobile Application is also linked to OTESP to retrieve energy related data. The OTESP can successfully query each EMS by means of their implemented GW. It also provides access to data through its defined web services (supporting both pull and push retrieval options), as well as other defined services (groups, CEP,

	etc.). All GW follow the same approach and provide/integrate data in a homogeneous manner.
How is it working?	Second versions of all the parts of the system (EMS GWs, OTESP, and applications) are completed and being tested. Issues found in the first round of trials were corrected and feedback from users led to changes and new developments.
Images/Graphics:	Main sections of the 2nd version of the applications: **<u>BBSC</u>** Allows the user with high- and low-profile visions of the KPIs of the system.  **<u>DSSC</u>** Provides the system manager with a technical tool to monitor the status of the assets and their properties.  

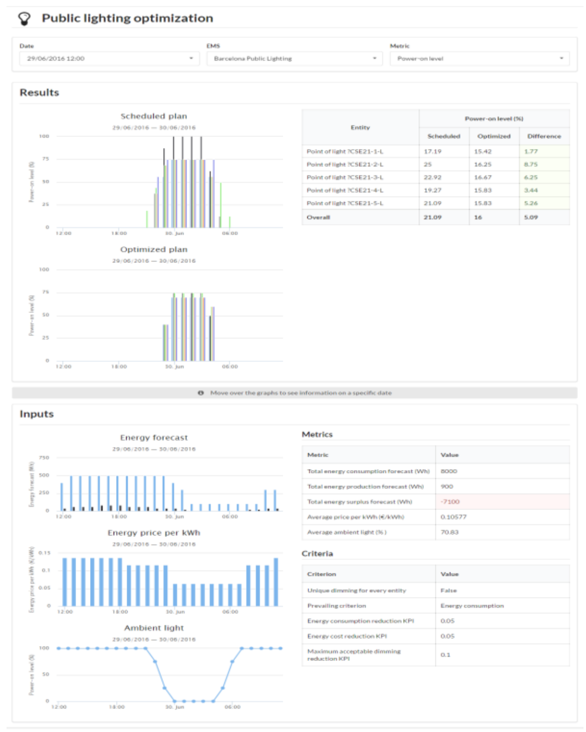
	 **Mobile Application**: The mobile application for behavioural modification aims at promoting a sustainable usage of energy in order to create public awareness campaigns to inform the citizens about the energy spent to support public services. 
Constraints:	Due to the nature of each underlying system, some EMSs are not able to provide actual real-time data, but make available batches of real-time measurements one or more times a day. This can affect the normal functioning of the applications during the time window without new data, but it is corrected as soon as the new batch is received.
Lessons learned	Some aspects of the architecture at application level were corrected based on the outcome of the 1st round of trials, as well as some sections of the applications themselves; for instance, the dashboard in the DSSC was completely reimagined, while other sections underwent minor changes.

Use Case number and name:	3.2.1.2 **UC2 - Data analytics on historical information of Prosumer Flexibility**
Demo site (Lisbon or Barcelona)	Lisbon & Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, Generation, Traffic Consumption, EVs BCN: Public Buildings, EVs, Public Lighting, Generation
Partners involved:	HYPERTECH, ETRA, PTIN, Pilot sites
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs, public authority
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The main objective of this use case is to test BESOS BBSC tool and more specifically the functionalities offered by Visual Analytics component. Following the 1st round of trials (where most of the functionalities were already in place), we are examining the final deployment of BESOS VA component and further integration with the rest of BESOS platform. More specifically, and taking into account the perspective of this use case, the user may get an overview of the portfolio performance, considering the full list of assets integrated in the platform (also assets integrated during the 2nd demonstration period of the project). Then by further exploiting the different filters offered by the tool (spatial, time, operational – types of EMSs & types of metrics), the end user may retrieve a customized view of his portfolio. In addition, the business stakeholder is able to drill in on a specific asset and get an overview of metrics (time-series analysis) and KPI values. The analysis is performed taking into account EMSs/Assets historical data for KPIs calculation. Therefore, BESOS VA tool will access low level/asset level data from the different EMSs (WP4) {retrieving both static (entity point parameters, nominal power etc...) and dynamically updated (metric values) information}, and through OTESP layer (WP3) to process and further visualize the respective information. In addition, OTESP layer (WP3) provides the business logic for assets aggregation and calculation of KPI values. The development of the VA tool is in line with the definition of BESOS architecture (WP2) and the associated data model

	(considered for interfaces of BESOS VA with the rest of BESOS system components) The goal of this test scenario for the 2nd demonstration period is to examine the final deployment of the VA tool, considering also the integration of the full list of assets during the reporting period. The focus of this use case is on the enriched visualization of portfolio performance that will further facilitate the business stakeholders at the optimal management of portfolio assets (examined in the following use cases).
How is it working?	The end user of the system, by providing "username/ password" credentials is able to get insights about the performance of his portfolio. Multi-parameter analysis and spatial and temporal correlation of asset loads is performed. Alternative visualization techniques and representation models (visual, textual, time-series, graphs, etc.) are utilized towards identifying commonalities and complementarities between asset loads. In order to retrieve the data required for the different BBSC VA functionalities, interfaces with OTESP Middleware platform are defined. OTESP is the common platform of BESOS framework, providing interfaces for accessing real time and historical data from the different types of EMSs integrated. Towards this direction, data coming from heterogeneous types of EMSs are available to the VA tool via OTESP Middleware. A detailed presentation of the final views of the BBSC analytics tool is available in D5.2.
Images/Graphics:	The updated views of the system (following the final deployment and integration of VA tool), setting the functional layer of the Visual Analytics tool are presented: **Main screen:** The section provides an overview of the fully list of assets of the portfolio, along with filters for customized visualizations for the stakeholders of the systems.  **Drill-in analysis:** The same functionality offered during the 1st demonstration period, further extended to address the assets integrated during the 2nd evaluation period.

	 **Portfolio analysis:** Comparative view among the different types of assets, considering the full list of assets integrated. 
Constraints:	During the 2nd demonstration period we are addressing the main constrains from the 1st round of trials. Though still some constrains are defined as the main boundary to address the full functionality offered by the BESOS VA tool. Due to the nature of each underlying system, some EMSs are not be able to provide continuous and reliable metric data (e.g. public lighting system in PT pilot site). To this end, lack of any type of information from asset level, may lead to constrains on the implementation of this use case.
Lessons learned	Following the final deployment of BESOS VA during the 2nd round of trials, it is clear that the design and the development of the VA tool (and any business application tool) should be modular in order to address the integration of heterogeneous asset types. This approach will further facilitate the transferability of BESOS VA to other case studies.

Use Case number and name:	3.2.1.3 **UC 3 - Energy demand optimization of the public lighting based on light environment**
Demo site (Lisbon or Barcelona)	Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	BCN: Public Lighting Applications: DSSC
Partners involved:	ETRA, SODEXO, BCN, ENERCAST
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, DSOs, FM
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The goal of this test case is to implement a high-level consumption optimization algorithm performed by the DSSC (WP5) that improves the energy consumption of the two public lighting systems integrated in BESOS. The DSSC will use the consumption information from these and other EMSs (WP4), as well as other elements (RES production, restrictions of the type of asset, user/SLA constraints…), as inputs to calculate the adequate actions to be taken. The outcome of the algorithm will be a set of actions that will be sent to the EMS through the OTESP (WP3).
How is it working?	Public lighting optimization algorithm was finished and tested during the 1st round of trials using inputs that were simulated as no real public lighting system was integrated at the time. During the 2nd round and after its integration, the same algorithm will be tested using the information from the public lighting system in Barcelona.
Images/Graphics:	Results of the algorithm can be accessed via DSSC:

	
Constraints:	Due to the lack of control, the results of this UC will be theoretical. The inputs will be based in real measurements, but the results will not operate over the real system – they will just be presented to the user in the form of a report.
Lessons learned	The main problem with this UC was external, as the integration with the real public lighting system in Barcelona was delayed several times due to political changes in the municipality. This led to the decision of using a simulated system instead of waiting until access to the real system was granted, as many components of the application level depended on public lighting information to be available for their correct functioning.

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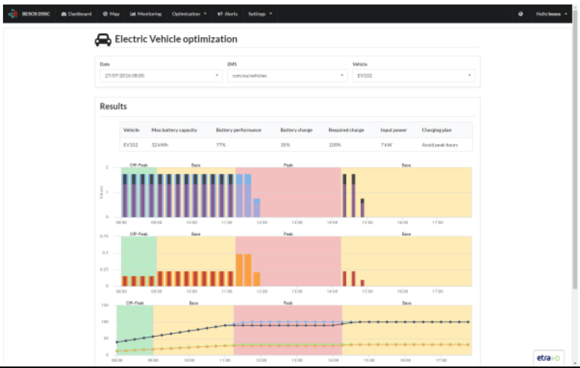
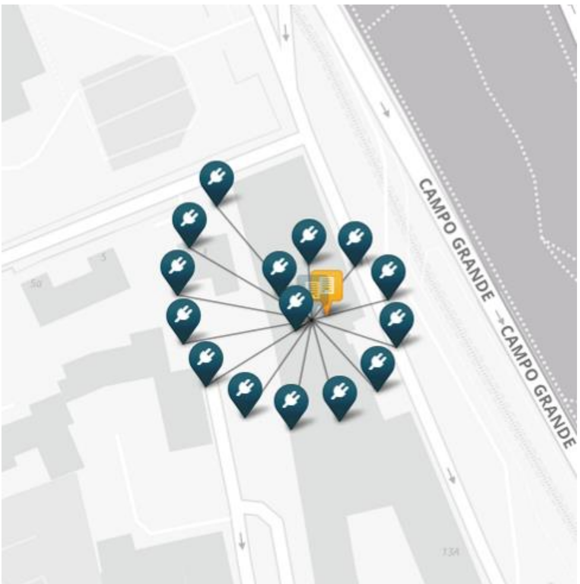
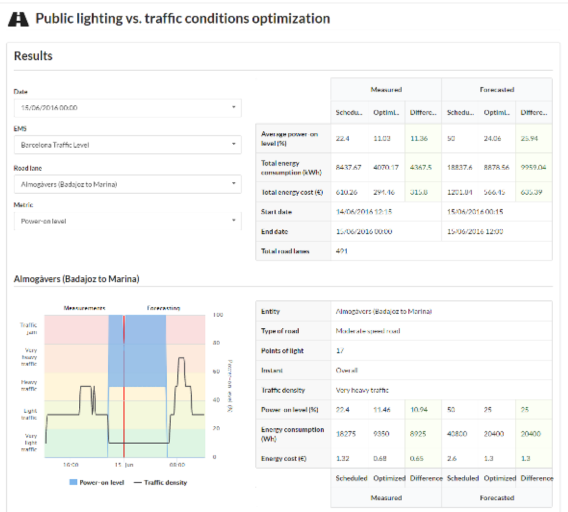
Use Case number and name:	3.2.1.4 **UC 4 - Energy management for the use of electric vehicle fleet**
Demo site (Lisbon or Barcelona)	Lisbon
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: EV EMS Applications: DSSC
Partners involved:	PTIN, ETRA, LBN
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, DSOs, FM
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	This use case aims to promote the optimization of energy (electricity) used to charge electric vehicles that are part of a municipality fleet that operates on a not individualized use (vehicle pool system). The energy consumption is being monitored over EV EMS (WP4) throughout OTESP (WP3). The driver requests the charging of the vehicle using for that the EMS equipment in premises (WP4). The DSSC (WP5) uses the available information to calculate and set the most appropriate charging profile of that specific vehicle.
How is it working?	The EV energy consumption is being provided over the EMS GW. The EMS system is offering an interface that allows reading and actuating in the system.
Images/Graphics:	Results of the algorithm will be accessed via DSSC: 
Constraints:	The algorithms to compute the most appropriate period for charging can only use input parameters provided by real systems. The usage of new data mandates the update of deployed EMSs, which comprises risks and costs.

Lessons learned:	A core issue on this use case was related with acting in real environments. While readings do not affect the system, actuations may cause real disturbances if something goes wrong.

Use Case number and name:	3.2.1.5 **UC 5 - Electrical Vehicles (EV) local optimization and storage capacity forecasting**
Demo site (Lisbon or Barcelona)	Lisbon
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Electric Vehicle Applications: DSSC
Partners involved:	ETRA, LBN, PTIN
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, DSOs, FM
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The main goal of this UC is the optimization of the charging process of the EVs in the system, mainly centred in the EV system in Lisbon. The system is integrated in BESOS (WP4) via OTESP (WP3), their metrics being monitored in the DSSC (WP5). Moreover, the underlying system notifies BESOS when an end-user plugs an EV in and introduces the charging parameters they desire. Based on this information, the optimization algorithm generates a plan that minimizes the cost of the charge while complying with the settings the user specified, and sends this plan back to the charging system.
How is it working?	The underlying system (ISA) has provided an interface to both check how many EVs are currently charging and send modifications on their charging process. Both this service and the optimization algorithm will be tested as part of the 2nd round of trials.
Images/Graphics:	Location of the EV charging points in Lisbon pilot site:

	
Constraints:	The integration with the ISA services is in the works due to the complexity of the understanding between the two systems.
Lessons learned:	As the only EMS in the system that allowed some control from the applications, the main concern with this UC was that the tests performed to assess the optimization algorithm did not affected – negatively – the everyday functioning of the users of the system. This was achieved among others by agreeing some dates for testing and informing the users both about the tests and the BESOS system in general.

Use Case number and name:	3.2.1.6 **UC 6 - Energy demand curve optimization based on traffic conditions**
Demo site (Lisbon or Barcelona)	Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	BCN: Public Lighting, Traffic Level Applications: DSSC
Partners involved:	ETRA
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, DSOs, FM
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	This UC aims to promote the optimization of energy used in public lighting based on traffic conditions. Both systems are integrated in BESOS (WP4) via OTESP (WP3), their metrics being monitored in the DSSC (WP5). Depending on the type of road and the traffic level, an optimization over public lighting that affects each road is generated, trying to compensate the lack of illumination in light-traffic roads and avoiding over-illumination in heavy-traffic roads.
How is it working?	Both the data and the algorithm have been made available for the 2nd version of the applications. The algorithm is currently being tested in the 2nd round of trials.
Images/Graphics:	Results of the algorithm can be assessed via DSSC: 
Constraints:	-

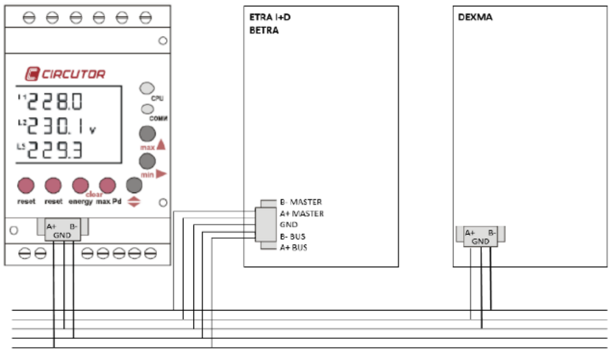
Lessons learned:	In a real system, and having that a public lighting optimization already existed, traffic conditions would have to be included as an additional input to this algorithm and decide the weight (i.e. the importance) of this parameter in the overall calculation. However, and given that the system does not count with control capabilities in any of the public lighting EMS that have been adapted, the decision was taken to explore this scenario independently, though based on the same conditions as the previous one.

Use Case number and name:	3.2.1.7 **UC 7 - Energy demand monitoring and optimization in public buildings**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, Generation BCN: Public Buildings, Generation Applications: DSSC
Partners involved:	SODEXO, BCN, ETRA, LBN, PTIN
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, FM, other third parties
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	This test case aims at optimizing the consumption of the different subsystems of public buildings. Consumption and production information from the different building EMS (WP4) in Barcelona and Lisbon will be gathered by the DSSC (WP5) through the services (WP2) exposed by the OTESP (WP3). The DSSC will analyse this information and feed it to an optimization algorithm based on this and other data from the rest of the system. The outcome of this process will be presented to the system manager as a matter of help to take decisions that would aim to ultimately improve the usage and minimize the costs of the energy demand of the system.
How is it working?	Both historical and real-time data are successfully being retrieved from the different BMS integrated in BESOS. For some of them (e.g. municipality buildings in Barcelona), the underlying mechanism to gather the data was already in place, thus the integration being straightforward. However, the integration of other systems was not so easy. For example, to obtain real-time data from the existing power analysers from Sodexo buildings, a single-board computer (BETRA) was specifically developed and is being installed in them. BETRA consists of an electronic board that includes both the hardware and software necessary to read all data from the existing analysers. It can work in parallel with other master equipment (such as DEXMA). Energy production data from PV panels located on buildings in both pilot sites is being retrieved as well. The optimization algorithm takes into account the different measurements retrieved – including active power, consumption, and cost – and compares them to a large set of tariffs that are available in both pilot sites markets. The results are presented to the system

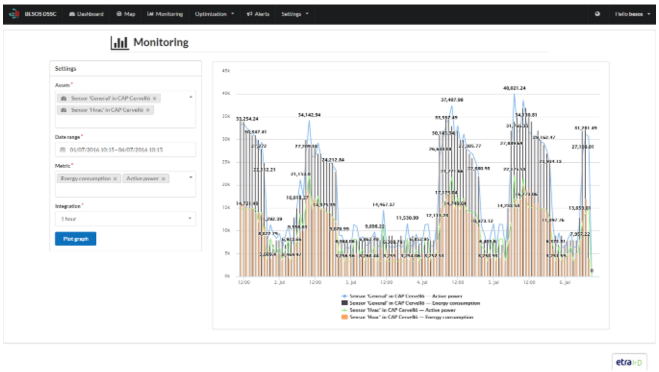
manager to help them decide whether a change in wither the current tariff plan or the energy demand habits would be recommendable.

Images/Graphics:

Connecting diagram of BETRA board:

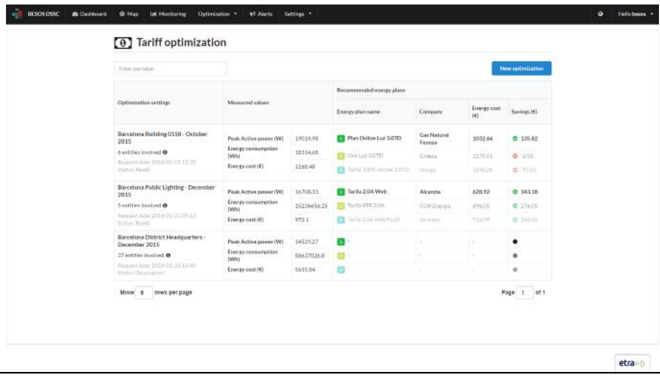


Example of historical consumption data from Sodexo buildings integrated in BESOS:



BETRA installed in Filmoteca de Catalunya

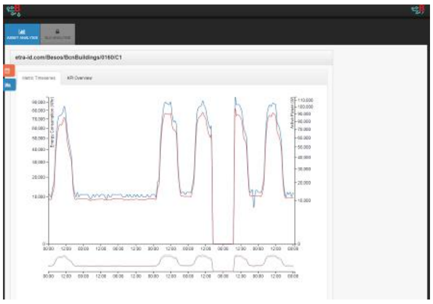
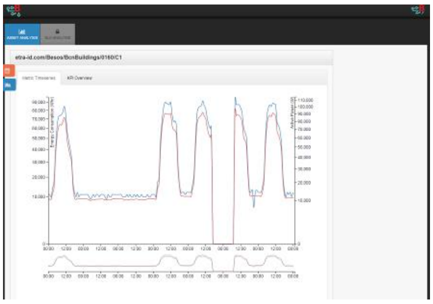
Algorithm results as presented to the user in the DSSC:

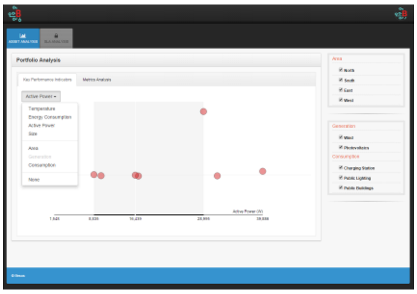
	
Constraints:	The adoption of the tariff-based approach, although proved useful by the users, was taken as a result of the lack of control by the DSSC to the different BMS in the system. Had actuations over on site components been allowed in BESOS, a different functionality would have been implemented.
Lessons learned	Thanks to this UC, the expertise from ETRA in the hardware field was put into practice and proved to accomplish the stated objectives. The design and development of the BETRA board resulted in a valuable solution to the lack of real-time metrics in Sodexo buildings. Moreover, the development of a tariff-based optimization algorithm carried out a deep analysis on the functioning of the energy market in both pilot sites.

Use Case number and name:	3.2.1.8 **UC8 - Smart city Energy demand curve optimization**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, Generation, EVs, Traffic consumption BCN: Public Buildings, EVs, Public Lighting, Generation Applications: BBSC, DSSC
Partners involved:	ETRA, BCN, LBN, SODEXO, COBRA, FICOSA, PTIN
Stakeholders involved: (FM, ESCOs, public authority, citizen, others)	Municipalities, ESCOs, FM, other third parties
Test Case description (Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (Cockpit):	The goal of this test case is to perform an overall optimization of all the systems integrated in the BESOS architecture. This task will mainly be performed by the Strategic Control module of the DSSC by means of the detection of situations depending on the type of EMS and/or asset. The situations for each type of asset will be defined based on the analysis of his historical data. Moreover, a set of strategies (i.e. actions) to be applied depending on the situation detected will as well be defined. The more data available for each EMS, the more refined the strategies will be. Additional parameters defined by the user can be received from the BBSC in the form of specific objectives and/or constraints to be considered when applying strategies. It is still to be defined which part of the BBSC will allow this functionality and how will the interaction between both cockpits be performed.
How is it working?	The Strategic Control part of the DSSC – responsible for the detection of situations and the application of strategies – is already developed and is being configured with information from the OTESP. Data from the different EMS is being analysed in order to adjust the profile of each asset and optimize the results of the application.
Images/Graphics:	Although originally envisioned as a separate part from the monitoring tool component, a decision was taken to incorporate its expertise into this part of the DSSC rather than creating a different GUI that would in the end duplicate

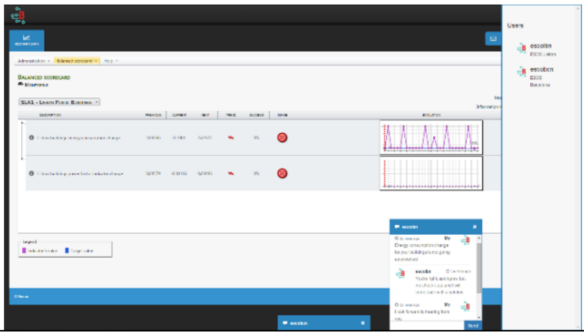
	functionalities (e.g. geolocation, status of the assets, etc.).
Constraints:	• Historical data from EMS may not be enough to generate the most suitable situations/strategies. • Lack of control on almost every EMS.
Lessons learned	The decision of integrating the data generated by the Strategic Control instead of created a separate GUI led to the development of a more solid application (DSSC).

Use Case number and name:	3.2.1.9 **UC 9 - Optimal Alignment of KPIs with SLAs**
Demo site (Lisbon or Barcelona)	Lisbon & Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, Generation, Traffic Consumption, EVs BCN: Public Buildings, EVs, Public Lighting, Generation
Partners involved:	HYPERTECH, ETRA, PTIN, Pilot sites
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs, public authority
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (Cockpit):**	The main objective of this use case is to provide the business oriented view of BESOS Visual Analytics component, by analysing the evolution of KPI values under specific business strategies/SLA to further identify anomalies and outliers as well as indicate specific factors and metrics that are potentially relevant to these situations. Initially, a list of SLAs are defined setting that way the business framework of the project. Following contractual agreements (SLAs) definition, ESCOs will implement the control strategies aiming at the optimal balancing of pre-selected KPIs (that consist of the SLA) within specific boundaries. For that reason, it is mandatory to provide a tool that will facilitate the business stakeholders on the optimal monitoring of control strategies performance towards SLAs fulfilment. In case of abnormal situations (or deviations), the end user of the tool will be able to reform the control strategies or even renegotiate the SLAs. The Visual Analytics system will access low level data from different EMSs (WP4) {both static (entity point parameters, e.g. location, nominal power etc...) and dynamic (metric values) information}, captured by OTESP layer (WP3) and will further process and further visualize this. Furthermore, OTESP layer (WP3) provides the business logic related to Assets aggregation and KPIs calculation. In addition, and as part of the business oriented view of BESOS Visual Analytics component, the SLAs examined in the project are defined with a common view for the different business applications (WP5) of BESOS platforms. The development of the VA tool is in line with the definition of BESOS reference architecture (WP2) while the SLAs definition follows the principles specified in BESOS CIM (WP2).
How is it working?	Each business stakeholder (Portfolio Owner or Manager) set the “username/ password” credentials for accessing VA tool specific functionalities and services. Then, by selected “KPI analysis” from the main menu, the user will access the SLAs analysis towards the associated KPIs. The main objective of this use case is to analyse the

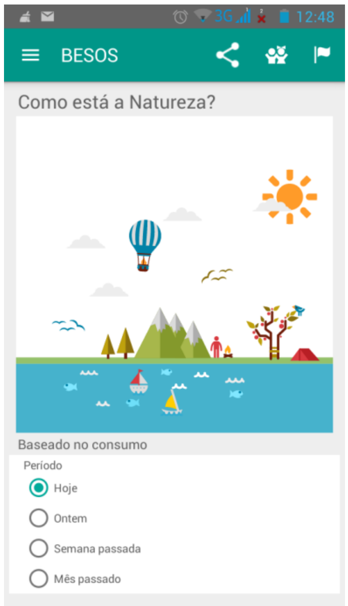
	evolution of different KPI values under specific control strategies/SLAs, identify anomalies and outliers as well as indicate specific factors and metrics that are potentially relevant to these situations. Highlighting these factors, the tool will allow ESCOs to select implement corrective control strategies or even re-define the KPIs boundaries/ thresholds which will serve these SLAs in a more efficient manner. To proceed with SLAs analysis towards specific KPIs, the VA tool interfaces with OTESP, the middleware layer responsible for capturing information from the different EMSs integrated in the platform (further participating at the different SLAs). A detailed presentation of this functionality supported by the VA tool of BESOS platform is reported in D5.2 about the final development of BESOS business applications.
Images/Graphics:	This use case scenario is associated with a specific functionality offered by VA tool (KPI analysis). The **main screen** of the system provides an overview of assets performance participating at a specific SLA. The business stakeholder is able to select from the different SLAs participating to get a customized view about portfolio performance.  By further **drilling in**, the business stakeholder is able to get a detailed view for each specific asset participating in a SLA. Again, the analysis is customized to the specific metrics and KPIs associated with this SLA.  The main feature of the KPI analysis functionality offered by the VA tool is the **comparative analysis** for the assets participating at a specific SLA. This analysis, defines the clusters of assets with similar performance characteristics, enabling that way the optimal management of assets participating in SLA.

	 During the 2nd demonstration period we are considering the full integration of assets in BESOS platform, enabling that way the evaluation of this use case in the 2 pilot sites of the project.
Constraints:	At the 2nd demonstration period we are addressing the main constrains identified during the 1st round of trials (lack of integrated EMSs, lack of available metrics and attributes, lack of Control Strategies Implementation). Though, we are still defining some constrains mainly related to reliable access on historical data from the different EMS types. Due to the nature of each underlying system, some EMSs are not being able to provide continuous and reliable metric data (e.g. public lighting system in PT pilot site). To this end, lack of information from assets, may lead to constrains on the implementation of this use case.
Lessons learned	Following the final deployment of BESOS VA during the 2nd round of trials, it is clear that the design and the development of the VA tool (and any business application tool) should be dynamic enough to enable the definition of different business scenarios. Towards this direction, a dynamic model for the definition of business strategies (SLAs and KPIs) is defined in the project and further adopted in the development of the business applications of BESOS platform.

Use Case number and name:	3.2.1.10 **UC 10 - Service platform for Public Authorities and ESCO's to access to public tenders information**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Applications: BBSC
Partners involved:	ETRA
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs, public authority
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The main purpose of this UC was to integrate information about public tenders into the BBSC (WP5), for the public authorities to negotiate with the ESCOs. Metrics (WP3, WP4) already managed by the application were to be used as proof of the quality of the service either offered or received.
How is it working?	The initial purpose of this use case was to incorporate into the BESOS system information about public tenders that could be useful both for public authorities and ESCOs to prove/assess the suitability of the applicants using the information managed by the project. Unfortunately, information about public tenders could not eventually be gathered for confidentiality reasons among others. While no explicit information about public tenders is actually managed by the application, the conditions of these tenders are reflected in the SLAs that have been included during the second phase. The messaging tool also developed in this second phase provides a platform for ESCOs and facility owners to discuss the conditions of the contracts and eventually agree in modifications over them.
Images/Graphics:	BBSC messaging tool:

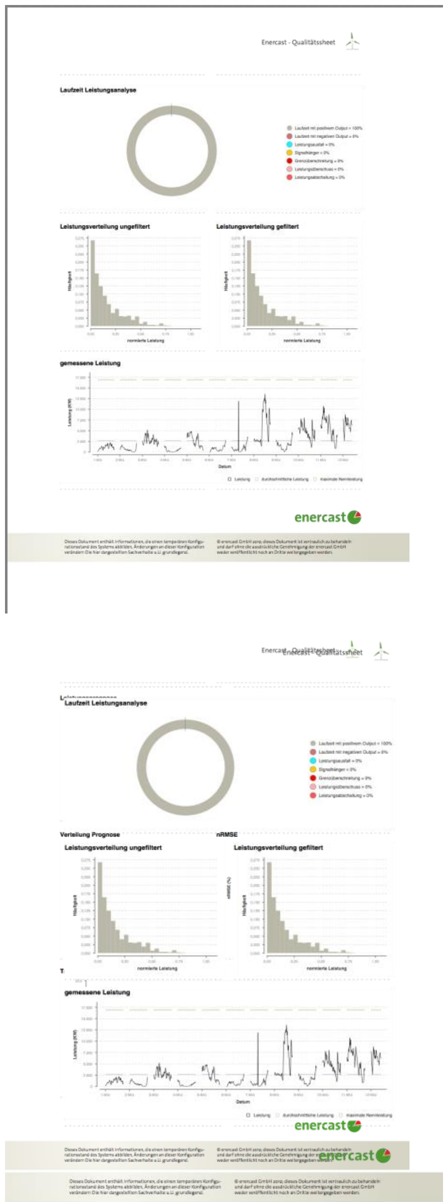
	
Constraints:	Had the public tenders' information been available, a different approach would have been taken.
Lessons learned:	Again, the initial vision of this UC did not take into account the hindrances of accessing public tenders' information. This will be taken into account in future scenarios.

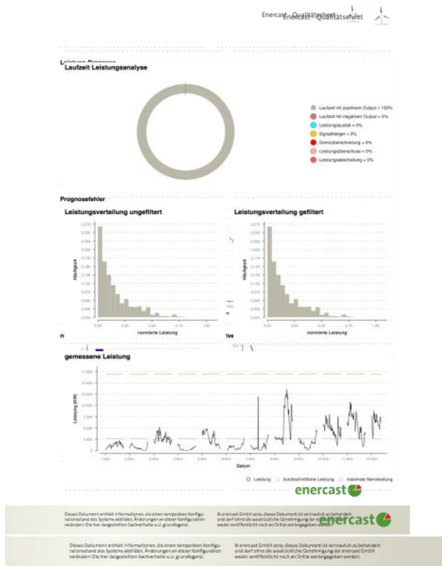
Use Case number and name:	3.2.1.11 **UC11 - Modification of user behaviour**
Demo site (Lisbon or Barcelona)	Lisbon
EMSs, assets and applications involved (e.g.: Public lighting)	Olivais School energy systems
Partners involved:	PTIN, LBN
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	ESCO, Citizen, public authority
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The teaching sector is the third greatest consumer of energy amongst the commercial buildings, being that office buildings, retail and services take the first positions. Information can be presented to citizens using mobile applications promoting the modification of the energy usage. This use case will generally target the entire community, as the application will be available for any citizen, but the specifics objectives to modify the behaviour of end-users will focus on the students of the schools involved in the trials. They will be proposed with games and challenges to compete against other classes and schools, providing valuable feedback at the same time to the relevant facility managers.
How is it working?	It was developed a mobile application for behavioural modification in order to promote a sustainable usage of energy by creating public awareness about the energy spent to support public services. It allows informing citizens about the usage of energy in Olivais School, in Lisbon. The end user through the mobile application can visualize both consumed and produced energy of the involved school. The measurements presented can expose both real time and accumulated values in order to make the perception of the savings and expenses of energy along the time easier. It supports a dynamic comparison between energy spent and consumed facilitating a straight evaluation of the total energy flow. Different layouts are used in order to adapt the information to end users, making the images simpler for young students. The mobile application allows configuring a set of notifications in order to promote a modification of the user's behaviour towards a sustainable world.

Images/Graphics:	  
Constraints:	The addition of real time energy cost coming from EMS would be a value added.
Lessons learned:	The usability of application is a critical point that needs to be taken into account. Mobile applications really need to be user friendly with a good interface.

Use Case number and name:	3.2.1.12 **UC12 - Measurement of the renewable energy produced and predicted in the distribution network**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: PV and Wind Power Production Sites BCN: PV and Wind Power Production Sites
Partners involved:	ETRA, BCN, LBN, COBRA, FICOSA, PTIN, UDE, ECAST
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The objective of this test case is to check that: • Predict the power production of the renewables in an accurate way. • Receive and store the power production data • Validate the received data with a simple validation scheme • Attach the “storage and prediction” EMS (S&P EMS) and the weather data EMS (WD EMS) • as third party EMSs to the BESOS platform • Check that the EMS gateways of WP4 are working proper • Check that the architecture of WP2 is applicable. • Check that OTESP is working fine. To achieve the goals, the following test cases will be performed: • Test the accuracy of the power production forecasts. This will be achieved by comparing the power forecasts against the real power production on a day ahead basis with 15 min resolution over 6 month period. The accuracy forecast will be documented in a quality report. The quality report contains plots such as an error plot of

	the forecast and the power production, a histogram of the power production and forecasts, a line plot of the production and forecasts, etc. The accuracy rated with the following error measurements methods: ○ nRMSE (normalized Root Mean Square Error) ○ nMAE (normalized Mean Absolut Error) ○ nBIAS (normalized systematic error) ○ AD (absolute deviation) • Perform a full black box test of the EMS GW (WP4), the OTESP (WP3) and the architecture. The one gateway will be feed with a special time series. The time series will be transported through the EMS GW and the OTESP and will be stored in the S&P EMS. To validate the data flow, the time series will be requested from the S&P EMS through the OTESP and compared with original time series.
How is it working?	**Wind power production forecast** The wind power production forecast of enercast is based on self-learning algorithms and numerical weather predictions (NWPs). The principle is the following: The power production of wind turbines is based on the weather. The power production is based on parameters such as wind speed, humidity, pressure and others. With the information of the historical power production of the wind parks provided by COBRA, the self-learning algorithms are trained with historical weather forecasts of the different NWPs provided by enercast. With the past production and the weather situations from the NWPs, the self-learning algorithms learn the behaviour of the wind park and the resulting power production. The result is an individual forecast algorithm of the wind park. This will be used to do the short term power production forecast. **PV power production forecast** The PV power production forecast is based on a physical model and numerical weather predictions (NWPs). Similar to the power production of wind turbines, the power production of PV plants is also based on weather parameters such as irradiation, temperature, cloud coverage, precipitation and others. These parameters are extracted from NWPs and are the input of the forecast model. The model needs also to be calibrated with historical power data and the historical weather parameters. The result of the calibration process

	is an individual power prediction forecast model of the PV plant. **NWPs used in BESOS** The power prediction forecasts for wind and PV are based on 6 different NWPs. The amount of NWP data is more than 150 GB/day.
Images/Graphics:	For the production and predictions the following plots will be created: • Histogram of the power production data • Plot of the power production data • Plot of Production and Forecast • Histogram of the forecasts • Error of production and forecasts. 

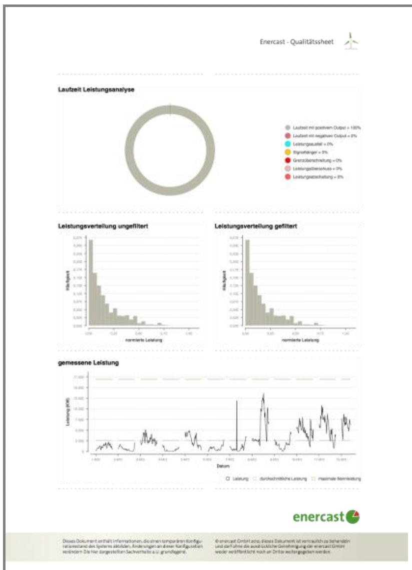
	
Constraints:	Availability of power production data Running EMS GWs, OTESP
Lessons learned	The PV production forecast was enhanced by the use of the ECMWF Weather model (NWP). During the project we learned a lot about the behaviour and influence of the weather situations on PV installed in urban areas such as Lisboa. The forecast accuracy is as expected - very good.

Use Case number and name:	3.2.1.13 **UC13 - Predict the energy consumption on weather data**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: PV and Wind Power consumption sites, Houses, Public buildings BCN: PV and Wind Power con, Houses, Public buildings consumption Sites
Partners involved:	ETRA, BCN, LBN, SODEXO, PTIN, UDE, ECAST
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	FM, ESCOs, public authority
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):**	The objective of this test case is to check that: • Predict the power consumption is in an accurate way. • Receive and store the power consumption data • Validate the received data with a simple validation scheme • Attach the "storage and prediction" EMS (S&P EMS) and the weather data EMS (WD EMS) • as third party EMSs to the BESOS platform • Check that the EMS gateways of WP4 are working proper • Check that the architecture of WP2 is applicable. • Check that OTESP is working fine. To achieve the goals, the following test cases will be performed: • Test the accuracy of the power consumption forecasts. This will be achieved by comparing the power forecasts against the real power consumption on a day ahead basis with 15 min resolution over 6 month period. The accuracy forecast will be documented in a quality report. The quality report contains plots such as an error plot of the forecast and the power consumption, a histogram of the power consumption and forecasts, a line plot of the consumption and forecasts, etc. The accuracy rated with the following error measurements methods: ○ nRMSE (normalized Root Mean Square Error)

	○ nMAE (normalized Mean Absolut Error) ○ nBIAS (normalized systematic error) ○ AD (absolute deviation) Perform a full black box test of the EMS GW (WP4), the OTESP (WP3) and the architecture. The one gateway will be feed with a special time series. The time series will be transported through the EMS GW and the OTESP and will be stored in the S&P EMS. To validate the data flow, the time series will be requested from the S&P EMS through the OTESP and compared with original time series.
How is it working?	**Power consumption forecast** The power consumption forecast is based on self-learning algorithms and numerical weather predictions (NWPs). The principle is the following: The power consumption Based on the historical power consumption of the wind parks provided by COBRA, the self-learning algorithms are trained with historical weather forecasts of the different NWPs provided by enercast. With the past production and the weather situations from the NWPs, the self-learning algorithms learn the behaviour of the wind park and the resulting power production. The result is an individual forecast algorithm of the wind park. This will be used to do the short term power production forecast. **PV power production forecast** The PV power production forecast is based on a physical model and numerical weather predictions (NWPs). The model needs also to be calibrated with historical power data and historical weather data. The result of the calibration process is an individual power prediction forecast model of the PV plant. **NWPs used in BESOS** The power prediction forecasts for wind and PV are based on 6 different NWPs. The amount of NWP data is more than 150 GB/day.
Images/Graphics:	For the consumption and predictions the following plots will be created: • Histogram of the power production data • Plot of the power consumption data • Plot of consumption and forecasts • Histogram of the forecasts • Error of consumption and forecasts.

<table>
<tr>
<td></td>
<td>
For the consumption and predictions the following plots will be created:

Histogram of the power production data
Plot of the power consumption data
Plot of consumption and forecasts
Histogram of the forecasts
Error of consumption and forecasts.



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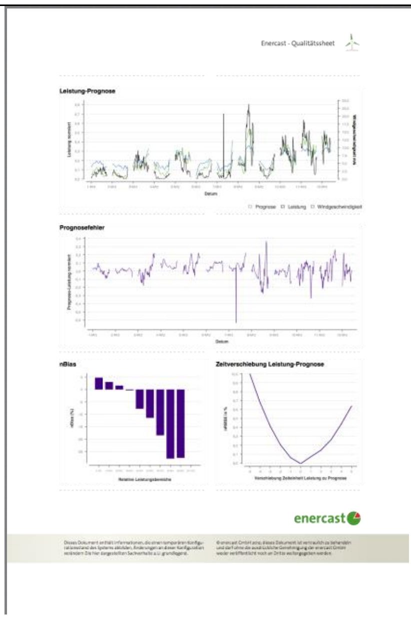
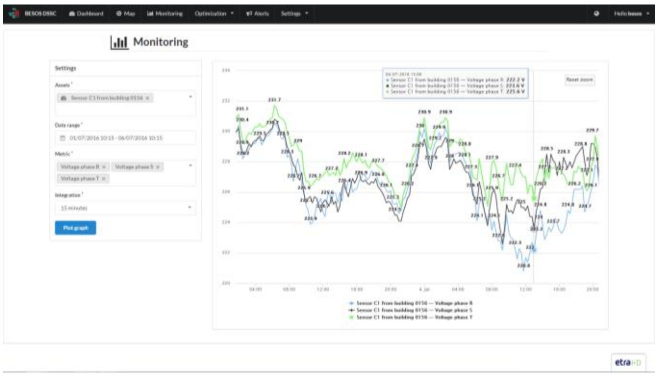
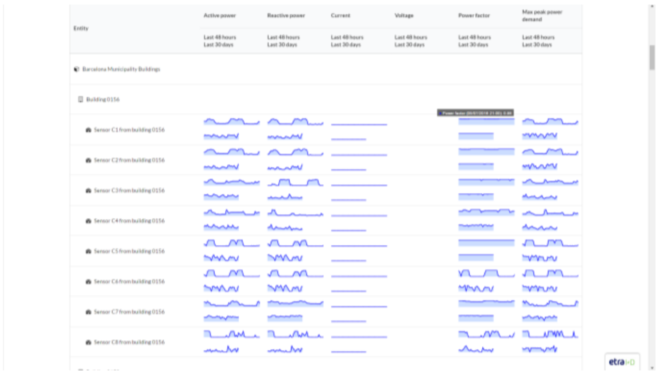
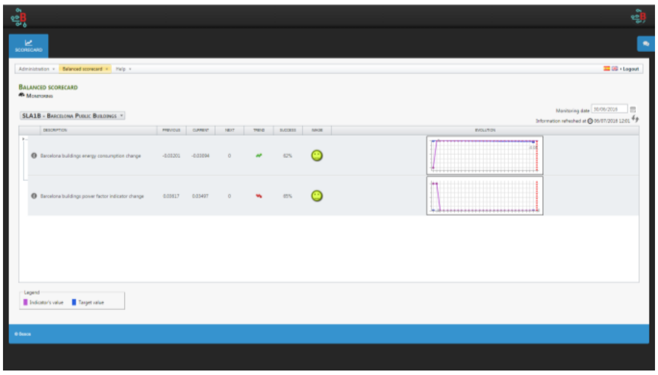
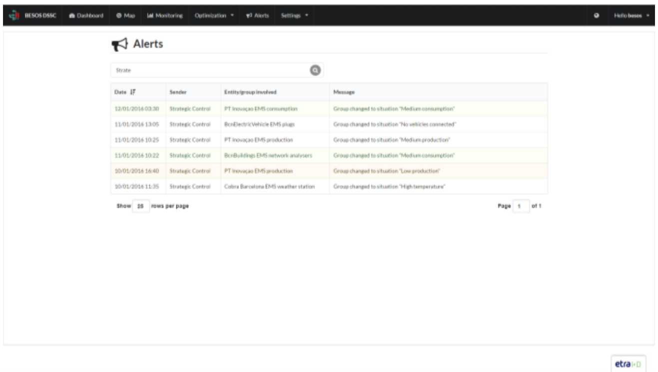
	
Constraints:	Availability of power production data Running EMS GWs, OTESP
Lessons learned:	Power Consumption of Cooling Systems (Air conditioners) is weather dependent. Since the steering of them works by a strategy, we figured out the potential of optimization for them. We learned a lot about the daily and weekly schedule of such systems, which is integrated in the forecast.

Use Case number and name:	3.2.1.14 **UC14 - Measurement/control of the electric energy quality (in the distribution network)**
Demo site (Lisbon or Barcelona)	Lisbon and Barcelona
EMSs, assets and applications involved (e.g.: Public lighting)	Lisbon: Public Buildings, EVs, Public Lighting, Generation BCN: Public Buildings, EVs, Public Lighting, Generation Applications: BBSC, DSSC
Partners involved:	ETRA, PTIN (in the data collection)
Stakeholders involved: **(FM, ESCOs, public authority, citizen, others)**	Municipalities, ESCOs, DSOs, Energy Suppliers, FM
Test Case description **(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (Cockpit):**	The BSSC (WP5) will gather electrical measures from the EMS (WP4) using the services of the OTESP (WP3). With this information – both historical and real-time –, the EPQ of each EMS/asset will be periodically calculated and the user will be provided with this information. Information generated as a result of this analysis can eventually be used to review those SLAs that take the EPQ as one of the parameters specified in the contract. This re-negotiation is part of the functionality developed in UC10. Besides the SLA negotiation, the system will in any case alert the municipality (via DSSC) when the EPQ reaches abnormal levels for a given asset/EMS.
How is it working?	Electrical measurements are being gathered and sent to the DSSC, which presents them in a graphical form to the user to help the identification of possible disturbances in the metrics (current, voltage, etc.). The availability of each asset – also considered in the EPW – is gathered as well from the OTESP. Using the metrics gathered, those KPIs that consider EPQ can be calculated and sent to the BBSC.
Images/Graphics:	Representation of 3-phase voltage from a building in Barcelona:

	 Dashboard view of electrical measures from the assets in the system:  BBSC showing the status of EPQ-related KPIs: 
Constraints:	Few EMSs providing electrical measures.
Lessons learned:	The limitation in the process of reading and delivering metrics from some EMSs led to the decision of discarding the gathering of instant values and instead limiting all measurements to 15-minute intervals. Though proved enough for general purposes, some specific electrical measurements (e.g. active power) resent from this limitation, as the average value of the

	interval may in some cases hide valuable information for the detection of anomalies and other EPQ-related situations. A possible solution for further developments that take the 15-minute approach would be to provide more than one value per interval and metric, namely the maximum, minimum and average measured values for the period, or the amount of time the metric has stayed over/under a given threshold.

<table>
<tr><td>Use Case number and name:</td><td>3.2.1.15 UC 15 - Preventive Maintenance Alarm</td></tr>
<tr><td>Demo site (Lisbon or Barcelona)</td><td>Lisbon and Barcelona</td></tr>
<tr><td>EMSs, assets and applications involved (e.g.: Public lighting)</td><td>Lisbon: Public Buildings, EVs, Public Lighting, Generation
BCN: Public Buildings, EVs, Public Lighting, Generation
Applications: DSSC</td></tr>
<tr><td>Partners involved:</td><td>FICOSA, COBRA, ETRA</td></tr>
<tr><td>Stakeholders involved:
(FM, ESCOs, public authority, citizen, others)</td><td>Municipalities, ESCOs, DSOs, FM</td></tr>
<tr><td>Test Case description
(Please make reference to WP2 (Architecture), WP3 (OTESP), WP4 (Gateways) and WP5 (DSS Cockpit, BBSC and Android App)):</td><td>The DSSC (WP5), specifically the Strategic Control, will be in charge of detecting abnormal situations for both producing and consuming assets, and generating alarms to the user. Measurements will periodically be retrieved from the EMS (WP4) through the OTESP (WP3), and mapped into previously defined situations that will determine if a specific value is acceptable or not.</td></tr>
<tr><td>How is it working?</td><td>The Strategic Control part of the DSSC is already developed and set up with information from the OTESP. The component analyses the historical data for each asset and groups together those with a similar consumption profile. For each group, detects different sets of values that repeat over time; these situations are then used as a basis to generate preventive alarms when new, unknown situations are detected as a result of real-time data monitoring.</td></tr>
<tr><td>Images/Graphics:</td><td>DSSC alerts received from the Strategic Control:

</td></tr>
<tr><td>Constraints:</td><td>Lack of historical data from some assets makes it more difficult to provide an appropriate analysis, which can</td></tr>
</table>

	lead to an inaccurate detection of situations and eventually the generation of false alarms.
Lessons learned:	The detection of situations by means of the strategic control component is not a straightforward process, for it requires both a proper selection of distinguishing metrics to be monitored by the tool and a deep analysis of the results it generates. Although a big effort has been invested in this task, this is a continuous process that has to be supervised and adjusted from time to time to check the alignment of the tool with the behaviour of the different systems.

3.3 BESOS data collection

The following tables summarize the state of the data collection for the different EMS operating in the 2nd round of trials.

Barcelona	Responsible for integration	Sending data to OTESP (Y/N)	Quality of data (Sending at a 24/7 rate or with breaks)	Others:
Ficosa Power Plant – managed by Ficosa	ETRA	Y	24/7	Service is running although few data is available.
Public lighting – managed by IMI	ETRA	Y	24/7	While still a simulated system, the process to acquire real-time data is on progress and will be available in the following weeks. Historical data will as well be requested and integrated into the system GW.
Electric Vehicles	ETRA	Y	24/7	Service is running although few data is available.
BCN Buildings – managed by IMI	ETRA	Y	24/7	Service is up and running, not all sensor provides the same quality of data due to their nature. Real-time data from PV panels located in buildings has been included, while historical data will be added as soon as it is received.
Aj. Barcelona Buildings / Sodexo Centre Cívic Orlandai	ETRA	N	24/7	Real-time data for 1 public building. Deployment scheduled for September.
Aj. Barcelona Buildings / Sodexo Centre Cívic Can Déu	ETRA	Y	24/7	Real-time data for 1 public building. Deployment scheduled for August.
Aj. Barcelona Buildings / Sodexo Biblioteca Les Roquetes	ETRA	Y	24/7	Real-time data for 1 public building. Deployment scheduled for August.
Aj. Barcelona Buildings / Sodexo Arxiu Municipal Contemporani	ETRA	N	24/7	Real-time data for 1 public building. Deployment scheduled for September
Aj. Barcelona Buildings / Sodexo Biblioteca Agustí Centelles	ETRA	Y	24/7	Real-time data for 1 public building. Deployment scheduled for August.
BCN Traffic Level	ETRA	Y	24/7	Already integrated and providing data. This EMS has not been included as a separate system, but its information included in the BCN Buildings EMS instead.

BCN Traffic Consumption	ETRA	N	-	-
Cobra CECOVI Wind Farm (Viudo) – managed by Cobra	COBRA	Y	24/7	Provides real time data
Energy production forecast	ENERCAST	Y	24/7	Integrated
Energy consumption forecast	ENERCAST	N	-	-

Table 10 – Data collection Barcelona (2nd round of trials)

Lisboa	Responsible for integration	Sending data to OTESP (Y/N)	Quality of data (Sending at a 24/7 rate or with breaks)	Others:
Campo Grande 25 Building – managed by Lisbon Municipality and ISA	PT IN	Y	24/7	Service is running
Olivais School - managed by Lisbon Municipality and ISA	PT IN	Y	24/7	Service is running
Mechanical and Electrical Department from the Municipality managed by Lisbon Municipality and ISA	PT IN	Y	24/7	Service is running
University of Lisbon PV Park energy production – managed by Conergy/CAPA	ENERCAST	Y	24/7	Service is running
Cobra CECOVI Wind Farm (Montegordo) – managed by Cobra	COBRA	Y	24/7	Provides real time data
EV Charging points	PT IN	N	24/7	Clarifications with ISA are taking place in order to continue with integration process. Energy consumption Up & Running Energy Consumption data was validated Background work is taking place to prevent faults in the server side

Traffic lights	ETRA	Y	24/7 (updated once a day)	EMS is integrated and providing new data once a day.
Public lighting	PT IN	N		Up & Running. Testing phase
Social Services' building	PT IN	N	24/7	Up & Running. Testing phase Data are under validation. The characteristic of the EMS, which provides cumulative data and not instantaneous information, is causing some difficulties to when transmission errors occur.
Energy production forecast	ENERCAST	Y	24/7	TU Lisbon: integrated COBRA Windparks: integrated Ficossa PV: integrated Ficossa Wind: integrated
Energy consumption forecast	ENERCAST	Y	24/7	Campo Grande: integrated

Table 11 - Data collection Lisbon (2nd round of trials)

4 CONCLUSIONS

The aim of this deliverable was to validate the different systems developed in the previous work packages and their use in BESOS pilot sites –Barcelona and Lisbon.

This document was divided in two parts delivered in different periods in time: November 2015 (M26) and July 2016 (M34).

The tests occurred in different EMS as described below:

EMS in Barcelona:

- Ficosa Power Plant – managed by Ficosa
- Public lighting – managed by IMI
- Electric Vehicles
- BCN Buildings – managed by IMI
- Aj. Barcelona Buildings / Sodexo
- Centre Cívic Orlandai
- Aj. Barcelona Buildings / Sodexo
- Biblioteca Les Roquetes
- Aj. Barcelona Buildings / Sodexo
- Arxiu Municipal Contemporani
- Aj. Barcelona Buildings / Sodexo
- Biblioteca Agustí Centelles
- BCN Traffic Level
- BCN Traffic Consumption
- Cobra CECOVI Wind Farm (Viudo) – managed by Cobra
- Energy production forecast

EMS in Lisbon:

- Campo Grande 25 Building – managed by Lisbon Municipality and ISA
- Olivais School - managed by Lisbon Municipality and ISA
- Mechanical and Electrical Department from the Municipality managed by Lisbon Municipality and ISA
- University of Lisbon PV Park energy production – managed by Conergy/CAPA
- Cobra CECOVI Wind Farm (Montegordo) – managed by Cobra
- EV Charging points
- Traffic lights
- Public lighting
- Social Services' building
- Energy production forecast
- Energy consumption forecast

The following table summarizes the results and lessons learned from the use cases tested during the 18 months of the trials.

	Use Case	Results and lessons learned
1	Visualization and Monitoring of Energy Data	The user was able to successfully retrieve data from the different EMS through the functionalities provided by the BBSC (KPI monitoring, VA tool…) and the DSSC (system & asset monitoring, metrics evolution visualization, situation detection…). The BBSC and the DSSC were able to access the information of the EMS through the OTESP. Mobile Application was also linked to OTESP to retrieve energy related data. The OTESP can successfully query each EMS by means of their implemented GW. It also provides access to data through its defined web services (supporting both pull and push retrieval options), as well as other defined services (groups, CEP, etc.). All GW follow the same approach and provide/integrate data in a homogeneous manner. Some aspects of the architecture at application level were corrected based on the outcome of the 1st round of trials, as well as some sections of the applications themselves; for instance, the dashboard in the DSSC was completely reimagined, while other sections underwent minor changes.
2	Data analytics on historical information of Prosumer Flexibility	The end user of the system, by providing "username/ password" credentials was able to get insights about the performance of his portfolio. Multi-parameter analysis and spatial and temporal correlation of asset loads was performed. Alternative visualization techniques and representation models (visual, textual, time-series, graphs, etc.) were utilized towards identifying commonalities and complementarities between asset loads. In order to retrieve the data required for the different BBSC VA functionalities, interfaces with OTESP Middleware platform were defined. OTESP was the common platform of BESOS framework, providing interfaces for accessing real time and historical data from the different types of EMSs integrated. Towards this direction, data coming from heterogeneous types of EMSs were available to the VA tool via OTESP Middleware. Following the final deployment of BESOS VA during the 2nd round of trials, it was clear that the design and the development of the VA tool (and any business application tool) should be modular in order to address the integration of heterogeneous asset types. This approach will further facilitate the transferability of BESOS VA to other case studies.

3	Energy demand optimization of the public lighting based on light environment	Public lighting optimization algorithm was finished and tested during the 1st round of trials using inputs that were simulated as no real public lighting system was integrated at the time. During the 2nd round and after its integration, the same algorithm will be tested using the information from the public lighting system in Barcelona. The main problem with this UC was external, as the integration with the real public lighting system in Barcelona was delayed several times due to political changes in the municipality. This led to the decision of using a simulated system instead of waiting until access to the real system was granted, as many components of the application level depended on public lighting information to be available for their correct functioning.
4	Energy management for the use of electric vehicle fleet	The EV energy consumption is being provided over the EMS GW. The EMS system is offering an interface that allows reading and actuating in the system. A core issue on this use case was related with acting in real environments. While readings do not affect the system, actuations may cause real disturbances if something goes wrong.
5	Electrical Vehicles (EV) local optimization and storage capacity forecasting	The underlying system (ISA) has provided an interface to both check how many EVs were currently charging and send modifications on their charging process. Both this service and the optimization algorithm will be tested as part of the 2nd round of trials As the only EMS in the system that allowed some control from the applications, the main concern with this UC was that the tests performed to assess the optimization algorithm did not affected – negatively – the everyday functioning of the users of the system. This was achieved among others by agreeing some dates for testing and informing the users both about the tests and the BESOS system in general.
6	Energy demand curve optimization based on traffic conditions	Both the data and the algorithm have been made available for the 2nd version of the applications. The algorithm was currently being tested in the 2nd round of trials. In a real system, and having that a public lighting optimization already existed, traffic conditions would have to be included as an additional input to this algorithm and decide the weight (i.e. the importance) of this parameter in the overall calculation. However, and given that the system does not count with control capabilities in any of the public lighting EMS that have been adapted, the decision was taken to explore this scenario independently, though based on the same conditions as the previous one.
7	Energy demand monitoring and optimization in public buildings	Both historical and real-time data were successfully being retrieved from the different BMS integrated in BESOS. For some of them (e.g. municipality buildings in Barcelona), the underlying mechanism to gather the data was already in place, thus the integration being straightforward. However, the integration of other systems was not so

		easy. For example, to obtain real-time data from the existing power analysers from Sodexo buildings, a single-board computer (BETRA) was specifically developed and was being installed in them. BETRA consists of an electronic board that includes both the hardware and software necessary to read all data from the existing analysers. It can work in parallel with other master equipment (such as DEXMA). Energy production data from PV panels located on buildings in both pilot sites was being retrieved as well. The optimization algorithm takes into account the different measurements retrieved – including active power, consumption, and cost – and compares them to a large set of tariffs that were available in both pilot sites markets. The results were presented to the system manager to help them decide whether a change in wither the current tariff plan or the energy demand habits would be recommendable. Thanks to this UC, the expertise from ETRA in the hardware field was put into practice and proved to accomplish the stated objectives. The design and development of the BETRA board resulted in a valuable solution to the lack of real-time metrics in Sodexo buildings. Moreover, the development of a tariff-based optimization algorithm carried out a deep analysis on the functioning of the energy market in both pilot sites.
8	Smart city Energy demand curve optimization	The Strategic Control part of the DSSC – responsible for the detection of situations and the application of strategies – was already developed and was being configured with information from the OTESP. Data from the different EMS was being analysed in order to adjust the profile of each asset and optimize the results of the application. The decision of integrating the data generated by the Strategic Control instead of created a separate GUI led to the development of a more solid application (DSSC).
9	Optimal Alignment of KPIs with SLAs	Each business stakeholder (Portfolio Owner or Manager) set the “username/ password” credentials for accessing VA tool specific functionalities and services. Then, by selected “KPI analysis” from the main menu, the user will access the SLAs analysis towards the associated KPIs. The main objective of this use case was to analyse the evolution of different KPI values under specific control strategies/SLAs, identify anomalies and outliers as well as indicate specific factors and metrics that were potentially relevant to these situations. Highlighting these factors, the tool will allow ESCOs to select implement corrective control strategies or even re-define the KPIs boundaries/ thresholds which will serve these SLAs in a more efficient manner. To proceed with SLAs analysis towards specific KPIs, the VA tool interfaces with OTESP, the middleware layer responsible for capturing information from the different EMSs integrated in the platform (further participating at the different SLAs). A detailed presentation of this

		functionality supported by the VA tool of BESOS platform was reported in D5.2 about the final development of BESOS business applications. Again, the initial vision of this UC did not take into account the hindrances of accessing public tenders' information. This will be taken into account in future scenarios.
10	Service platform for Public Authorities and ESCO's to access to public tenders information	The initial purpose of this use case was to incorporate into the BESOS system information about public tenders that could be useful both for public authorities and ESCOs to prove/assess the suitability of the applicants using the information managed by the project. Unfortunately, information about public tenders could not eventually be gathered for confidentiality reasons among others. While no explicit information about public tenders is actually managed by the application, the conditions of these tenders were reflected in the SLAs that have been included during the second phase. The messaging tool also developed in this second phase provides a platform for ESCOs and facility owners to discuss the conditions of the contracts and eventually agree in modifications over them. Again, the initial vision of this UC did not take into account the hindrances of accessing public tenders' information. This will be taken into account in future scenarios.
11	Modification of user behaviour	It was developed a mobile application for behavioural modification in order to promote a sustainable usage of energy by creating public awareness about the energy spent to support public services. It allows informing citizens about the usage of energy in Olivais School, in Lisbon. The end user through the mobile application can visualize both consumed and produced energy of the involved school. The measurements presented can expose both real time and accumulated values in order to make the perception of the savings and expenses of energy along the time easier. It supports a dynamic comparison between energy spent and consumed facilitating a straight evaluation of the total energy flow. Different layouts were used in order to adapt the information to end users, making the images simpler for young students. The mobile application allows configuring a set of notifications in order to promote a modification of the user's behaviour towards a sustainable world. The usability of application was a critical point that needs to be taken into account. Mobile applications really need to be user friendly with a good interface.
12	Measurement of the renewable energy produced and predicted in the distribution network	**Wind power production forecast** The wind power production forecast of enercast was based on self-learning algorithms and numerical weather predictions (NWPs). The principle was the following: The power production of wind turbines was based on the weather. The power production was based on parameters such as wind speed, humidity, pressure and others. With the information of the historical power production of the wind parks provided by COBRA, the self-learning algorithms were trained with historical weather forecasts of the different NWPs provided by enercast. With the past production and the weather situations from the NWPs, the

		self-learning algorithms learn the behaviour of the wind park and the resulting power production. The result was an individual forecast algorithm of the wind park. This will be used to do the short term power production forecast. **PV power production forecast** The PV power production forecast was based on a physical model and numerical weather predictions (NWPs). Similar to the power production of wind turbines, the power production of PV plants was also based on weather parameters such as irradiation, temperature, cloud coverage, precipitation and others. These parameters were extracted from NWPs and were the input of the forecast model. The model needs also to be calibrated with historical power data and the historical weather parameters. The result of the calibration process was an individual power prediction forecast model of the PV plant. **NWPs used in BESOS** The power prediction forecasts for wind and PV were based on 6 different NWPs. The amount of NWP data was more than 150 GB/day. The PV production forecast was enhanced by the use of the ECMWF Weather model (NWP). During the project we learned a lot about the behaviour and influence of the weather situations on PV installed in urban areas such as Lisboa. The forecast accuracy was as expected - very good.
13	Predict the energy consumption on weather data	**Power consumption forecast** The power consumption forecast was based on self-learning algorithms and numerical weather predictions (NWPs). The principle was the following: The power consumption Based on the historical power consumption of the wind parks provided by COBRA, the self-learning algorithms were trained with historical weather forecasts of the different NWPs provided by enercast. With the past production and the weather situations from the NWPs, the self-learning algorithms learn the behaviour of the wind park and the resulting power production. The result was an individual forecast algorithm of the wind park. This will be used to do the short term power production forecast. **PV power production forecast** The PV power production forecast was based on a physical model and numerical weather predictions (NWPs). The model needs also to be calibrated with historical power data and historical weather data. The result of the calibration process was an individual power prediction forecast model of the PV plant. **NWPs used in BESOS**

		The power prediction forecasts for wind and PV were based on 6 different NWPs. The amount of NWP data was more than 150 GB/day. Power Consumption of Cooling Systems (Air conditioners) was weather dependent. Since the steering of them works by a strategy, we figured out the potential of optimization for them. We learned a lot about the daily and weekly schedule of such systems, which was integrated in the forecast.
14	Measurement / control of the electric energy quality	Electrical measurements were being gathered and sent to the DSSC, which presents them in a graphical form to the user to help the identification of possible disturbances in the metrics (current, voltage, etc.). The availability of each asset – also considered in the EPW – was gathered as well from the OTESP. Using the metrics gathered, those KPIs that consider EPQ can be calculated and sent to the BBSC. The limitation in the process of reading and delivering metrics from some EMSs led to the decision of discarding the gathering of instant values and instead limiting all measurements to 15-minute intervals. Though proved enough for general purposes, some specific electrical measurements (e.g. active power) resent from this limitation, as the average value of the interval may in some cases hide valuable information for the detection of anomalies and other EPQ-related situations. A possible solution for further developments that take the 15-minute approach would be to provide more than one value per interval and metric, namely the maximum, minimum and average measured values for the period, or the amount of time the metric has stayed over/under a given threshold.
15	Preventive Maintenance Alarm	The Strategic Control part of the DSSC was already developed and set up with information from the OTESP. The component analyses the historical data for each asset and groups together those with a similar consumption profile. For each group, detects different sets of values that repeat over time; these situations were then used as a basis to generate preventive alarms when new, unknown situations were detected as a result of real-time data monitoring. The detection of situations by means of the strategic control component was not a straightforward process, for it requires both a proper selection of distinguishing metrics to be monitored by the tool and a deep analysis of the results it generates. Although a big effort has been invested in this task, this was a continuous process that has to be supervised and adjusted from time to time to check the alignment of the tool with the behaviour of the different systems.

Table 12 – Summary of the results for the WP6