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Abstract:

This document accompanies the second prototype release of the adapted EMS in the third phase regarding to the D4.3 “EMS adaption plan”.

Keywords:

EMS Adaption Phase 3

Revision History

Revision	Date	Description	Author (Organisation)
V0.1	01.08.2016	Intial version	Bernd Kratz (enercast)
V0.2	11.09.2016	Added PV forecasting algorithms	Raabe, Pankraz (enercast)
V0.3	26.09.2016	Added experimental evaluation of the PV forecasting algorithms	Raabe, Pankraz (enercast)
V0.4	28.09.2016	ETRA contribution and review	Diego García-Casarrubios (ETRA I+D)
V0.5	29.09.2016	COBRA contribution and review	Jorge Mejuto (COBRA)

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1. Introduction

1.1. Purpose of the Document

The objective of WP4 is to tackle the integration with the different Energy Management Systems (EMS) deployed in a Smart city in order to enable the interaction with/of them in a service oriented way. The latter aspect implies functionality wrapping where it is not there, and the installation and hosting of the services being delivered by the open trustworthy energy service platform (OTESP) developed in WP3. Specifically this WP will:

- Integrate with existing EMSs and other information systems existing in the test sites today that contain data used for the BESOS business cockpit and BESOS DSS.
- Integrate with the EMS for energy generation purposes to be used in the pilot sites in BESOS.
- Integrate with the EMS for district public facilities (buildings) to be used in the pilot sites in BESOS.
- Integrate with the EMS for public lighting systems to be used in the pilot sites in BESOS.
- Integrate with the EMS systems for transport to be used in the pilot sites in BESOS.
- Create a blueprint containing general guidelines for the integration of EMS and lessons learned during the process.

1.2. Scope of the Document

The deliverable D4.3 “Guidelines for transferability of EMS adaptation strategies”, is part of the work done in the task T4.3 “Guidelines and support for the adaption of various EMS to the BESOS Architecture”. It provides:

- Lessons learned from integrating the different EMS systems into the BESOS platform during the project phase.
- Strategies and best practices to adapt legacy EMS systems into a modern EMS management platform such as BESOS.

The EMS of the demo sites where successfully adapted in the Adaption Phase 4.2 and providing data through the OTESP platform to DSSC and BBSC.

1.3. Structure of the Document

The remainder of this document is structured as follows:

- Section 2 provides a short summary and overview of the BESOS architecture. The purpose of the overview is to locate the adapted EMS in the BESOS architecture. All adapted demo site EMS in both phases are listed in Section 2.
- The best adaption and integration practices for the different, mostly legacy, EMS systems of the demo sites from Barcelona and Lisbon are documented in Section 3. Section 3 contains also the recommendations of the integration of the forecast algorithms developed of this project. In D4.2 enercast has developed new forecasting algorithms for the energy production of Renewable Energy (RE) and the power consumption of public buildings. The results of the accuracy of the developed algorithms will be also presented in Section 3.

- Section 4 contains the strategies and recommendations of integrating such an amount of heterogeneous EMS system. The spectrum of EMS covered by this project is very wide. It covers the whole bandwidth of from the integration of the RE power production of PV and wind production EMS, over a lot of different power consumption EMS such as HVAC of public buildings, public lightning and public power charging points of Electro Vehicles (EV) in two big metropolitan regions of two countries.
- The outlook and the summary is located in Section 5.

2. Summary of the adapted EMS to the BESOS platform

Goal of the BESOS was the integration of different EMS in a common single infrastructure that, at the end, will provide users a unified view of the energy-related elements of a given geographical area. These elements are handled by different and heterogeneous control systems. For the project, we consider these:

- Public light control systems.
- Electric vehicle management systems.
- Building management systems.
- Energy generators (PV, Wind & Micro generation).
- Traffic information systems.

Other types of control systems could be added in the future; in fact the system has been designed to be as much extendable as possible.

Each control system will take control of different devices and will cope with the complexities of the physical connection, specific device drivers, security of the data, etc.

Each EMS must do the following in order to join the BESOS platform:

- Implement the service interfaces used for the platform to access the EMS (defined in BESOS deliverable document D2.1). The concepts handled by the EMS must be translated to those handled by the platform (devices, metrics, etc.).
- Provide the access point URL for the implemented services to the platform managers, and let request coming from the platform reach the services.
- The EMS GW must handle subscriptions to attributes to react on changes. The OTESP will take inform all subscribers and handles the pub-sub mechanisms.
- The EMS GW uses the BESOS the data model as described in WP2.

2.1. Architectural Overview

To provide a better understanding of the scenario and the participating EMS, this sections repeats the architectural overview presented in D4.2 and provides a short summary of the different EMS demo sites of both phases.

For an Energy Management System (EMS) to interact with the Open Trustworthy Energy Service Platform (OTESP), a series of web services, databases or other data providers must be implemented. These services are grouped together according to the entity of the system model they are more related to.

A brief generic description of the architecture and services are provided below. On subsequent sections, more specific information on the implementation for each kind of EMS can be found. For a detailed listing of the architecture and actual data model, refer to the document D2.1 of this same project.

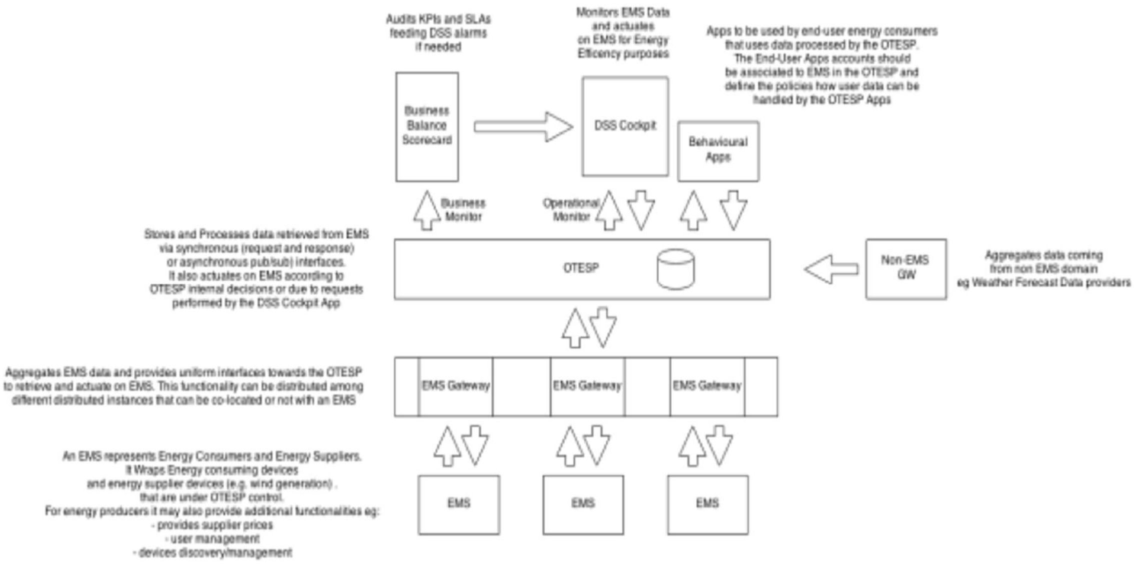


Figure 1 – BESOS Architectural Overview

2.1.1. Definition of historical and real time data

The wording "historical data" and "real-time data" used in the document got the following meaning:

- "Historical data": The data records are based on events in the past, which cannot be received online currently. The data records are mostly exported via third party system and provided in a file based way.
- "Real-time data": The data records are based on events in the past. But can be received online with a short delay up to 30 minutes.

2.2. EMS adapted in Phase 1 and Phase 2

The adaption phase 2 will tackle selected EMS from Lisbon and Barcelona. According to the Description of Work (DoW), the selection was done after studying the provided APIs from the different EMS manufacturer.

2.2.1. Selected EMS Lisbon in Phase 1

The following EMS from Lisbon demo site were integrated in Phase 1:

- Campo Grande 25 Building.
- Olivais School.
- Mechanical and Electrical Department from the Municipality.
- University of Lisbon PV Park energy production.
- Cobra CECOVI Wind Farm (Montegordo).

2.2.2. Selected EMS Barcelona in Phase 1

The intention was to finish a basic adaption of all EMS from Barcelona in Phase 1, except the traffic lights. While Phase 2 is dedicated to expand and improve the initial result and integrate the traffic lights. In some cases Phase 2 includes the addition of more assets (e.g. more buildings in the Sodexo EMS), while in others more functionalities are developed (e.g. complex metrics, security, performance improvement, etc.).

The list of EMS from Barcelona demo site integrated in Phase 1 is:

- Energy Production of Ficosa Renewable Plant site.
- Public Lighting energy consumption (simulated, not yet connected to actual HW at the streets).
- Public Buildings controlled by the Barcelona Municipality.
- Public Buildings managed by Sodexo.
- Cobra CECOVI Wind Farm (Viudo).
- Electric Vehicle charging points energy consumption.

2.2.3. Integration of the energy production and weather forecast systems

In the first adaption phase, the data storage system, the energy production forecast, the energy consumption forecast and weather forecast system “Meteostore2” of enercast was already adapted as EMS.

2.2.4. Selected EMS Lisbon in Phase 2

The following EMS from Lisbon demo site were integrated in Phase 2:

- Municipality Social Service Building.
- Public Lightning alerts.
- Traffic Lights consumption.
- Electrical Vehicle Charging Points.

2.2.5. Selected EMS Barcelona in Phase 2

The only remaining EMS in Barcelona whose adaption was postponed until Phase 2 was the traffic system, which integrates both traffic level and traffic lighting consumption. Besides, modifications were performed and additional entities and/or metrics were included in EMSs that were adapted on Phase 1.

3. Best integration practices and lessons learned of the adapted EMS demo sites

This section provides a short introduction of the different EMS sites, followed by the best integration practices and the lessons learned for each EMS. To provide following up projects with the experienced gained in the project, the best practices are summarized in a "do's and don'ts" section for each adapted EMS type.

3.1. TU Lisbon

3.1.1. Introduction

The PV power production site of the University of Lisbon consists of 8 different roof mounted PV power production installations. Each production site is mounted on a different building of the university. All 8 PV power production sites was build, operated and maintained by by Conergy AG. Unfortunately Conergy AG was bankrupt in 2013. The operation and maintainenced is performed by Conergy Systems GmbH, which is the successor company of former operating company Conergy AG.

The project has started in the same year as Conergy AG was bankrupt. During the first project phase, it was not clear, that there will be any support from Conergy. Fortunatly Conergy System GmbH was founded and they were willing to support the project.
In the first step, Conergy Systems provides historical production data of the PV sites. The historical data is necessary to calibrate the forecast production engine.
In a next step, the existing data logger where replaced by new one. Because the old data logger provides no API nor possibility to get the power production data. The new data logger where installed and is uploading the data to the enercast EMS.

To downscale the costs only one PV site is upgraded with a new data logger. All buildings are located nearby and all PV sites are oriented in a similar way. The remaining four PV production sites will be interpolated.

3.1.2. System description

The PV Park consists of 8 independent PV plants:

- Faculdade de Letras - Biblioteca Lisboa
- Faculdade de Letras - Edifício Principal Lisboa
- Cantina 1 Lisboa
- Faculdade de Ciências - C7 Lisboa
- Faculdade de Ciências - C2 Lisboa
- Faculdade de Psicologia - Parking Lisboa
- Faculdade de Ciências - C4 Lisboa
- Faculdade de Psicologia - Edifício Lisboa

Figure 2 - Images from the University of Lisbon EMS PV-Park

3.1.3. System Architecture

The PV TU Lisbon EMS consists of four parts:

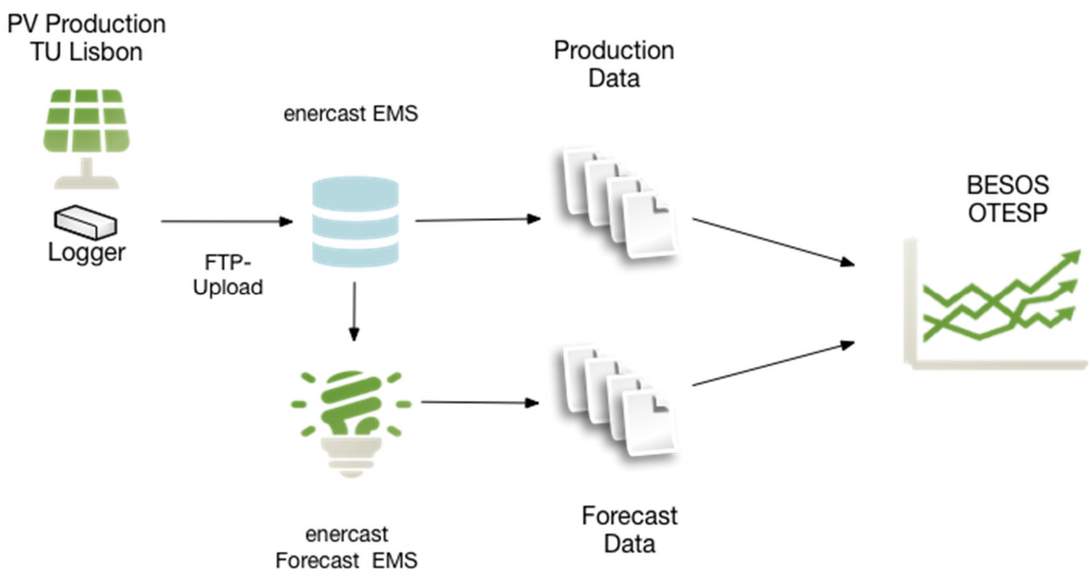
- “Gather and upload” phase: The data is gathered by the PV panels and and upload it. This job is done by the new data logger Conergy SCP 100DL. The data logger gathers the data from the inverter and upload it via the University network to a FTP server provided by enercast. All buildings are located nearby and all PV sites are oriented in a similar way. The remaining PV production sites will be interpolated.

- Validate and store” phase: To provide reliable informations to the rest of the system, the uploaded data is validated. Only after successful validation, the data will be released to the rest of the systems. The data provided by data loggers is sometimes wrong, e.g. timestamps, peak power, etc. To ensure a minimum of data quality, each uploaded data is run through a simple validation process. In a future release, the validation process could be more sophisticated. Currently only basic checks are performed, such as:
  - Check the data against the nominal capacity of the PV power site.
    A measurement data with a power output higher than the installed peak power. To downscale the costs only one PV site is upgraded with a new data logger.

- Power production at night times. Measurement data with a time stamp after sunset and before sunrise are not valid and will be filtered.

- "OTESP Bridge" After the validation process, the data can be obtained by the OTESP for further processing.

- "Forecasting phase" The forecasting engine is using numerical weather predictions (NWP) of different weather services, such as the European Weather Service, ECMWF, located in Reading, UK, the German Weather Service DWD, located in Offenbach, Germany, the UK Weather service MetOffice, located in UK and the US Weather Service NOOA, located in Boulder, CO, USA. The forecasting engine computes a forecast for each NWP and build a site specific ensemble. For the real time forecast, the site specific ensemble is adjusted with the current power production.
  The power production forecast can be accessed via the OTESP gateway. The forecasting engine needs a validated input to provide an ac-



curate real time forecast.

Figure 3 - Architecture of the PV TU Lisbon EMS

3.1.4. Provided entities and service

The adapted EMS provides the following services to the platform:

Table 1 – TU Lisbon provided entities and services

Provided Service	Supported EMS ID	Supported Types
AttributeService	TU_LISBON_PV_PRD 1001440003805	ENTITY_INFORMATION LOCATION

	1001440003821 1001440003835 1001440003812 1001440001774 1001440001861 1001440003824 1001440003890	ORGANISATION_INFORMATION PV_GENERATING_UNIT_INFOR MATION
EntityService	TU_LISBON_PV_PRD 1001440003805 1001440003821 1001440003835 1001440003812 1001440001774 1001440001861 1001440003824 1001440003890	ORGANISATION USER GENERATION_UNIT PV_GENERATING_UNIT
MetricService	TU_LISBON_PV_PRD 1001440003805 1001440003821 1001440003835 1001440003812 1001440001774 1001440001861 1001440003824 1001440003890	ENTITY_COUNT POTENTIAL_CAPACITY_OF_PO WER_PRODUCTION ENERGY_PRODUCTION

3.1.5. Best integration practices and lessons learned

The bankruptcy of the supplier was an unexpected issue that had to be managed. After all every think went well. But this was an issue that had to be taken into account for further projects. One possible solution could be, to provide the necessary hardware within the consortium. Another option might be to establish a service agreement with an independent third party or solution provider as a backup.

3.1.6. Summary: the “do’s and don’ts” of the integration

- Perform a validation on the measurement data.
- Avoid “daylight saving time” aware timestamps. This could be achieved either by using a time zone such as UTC or providing the used time zone by a format specified by the “IANA standard”.
- Establish a way to transfer maintenance or outtake information to the upper layers.

3.2. ISA EMS, Lisboa

3.2.1. Introduction

Lisboa E-Nova will provide energy management services for three different buildings. The first phase of the integration process encompasses the **Campo Grande 25 Building**, the **Olivais School** and the **Mechanical and Electrical Department from the Municipality**.

Campo Grande 25 is a 5 block building, where most administrative part of the Municipality work is performed. It has got around 2000 people working every day and many other are visiting the building, as it hosts some important public services, open to the citizen. The building is fed with medium-voltage and has an average yearly consumption of 3,2 GWh, and is owned and managed by the Municipality.

The Olivais School has been serving as a primary school and kindergarten since 1970. The building is fed with normal –low– voltage, and is managed by the Municipality of Lisbon, which has got a double role: facility manager and facility owner. Moreover, the building is equipped with a PV system for micro generation with an installed power of 3,68 kWp.

DRMM Building is one of the most important hubs of the municipality services. It is within its borders that all the mechanical and maintenance activities are performed, as well as the entire city's metrology control, in what respects to the calibrating inspections of all the commercial sector of the city. Finally, it hosts all the solid waste and urban cleaning fleet, and makes the reparation of the majority of the municipality vehicles. All these buildings have a common interface provided by ISA and may, therefore, be seen as a unique EMS. The information provided must be adapted to the BESOS data model and made available to OTESP in order to allow the access from BESOS cockpit.

3.2.2. System description

The solution is based on remote units to acquire data (sensors) using wireless communication setups based on 868 MHz proprietary protocol. In aggregations terms it is also used RS485 between the aggregation modules that allow the deployment of data into TCP/IP format, and can then be forward to ISA servers.

After being collected and transformed to TCP/IP protocol, data is forwarded to ISA servers. At ISA servers, data can be treated for further interactions or simply for access and visualization.

Data can be easily accessible through several ways:

- Online GUI
- Array of Web Services

The monitoring solution is based in the deployment of several sensors (electricity, gas, energy production, temperature, CO2, relative humidity, etc.) that get their data aggregated at one unit called iHub. The iHub is a multiprotocol gateway capable of receiving data from several sources, such us RS 485 (electric meters) and RF868 MHz (comfortable sensors).

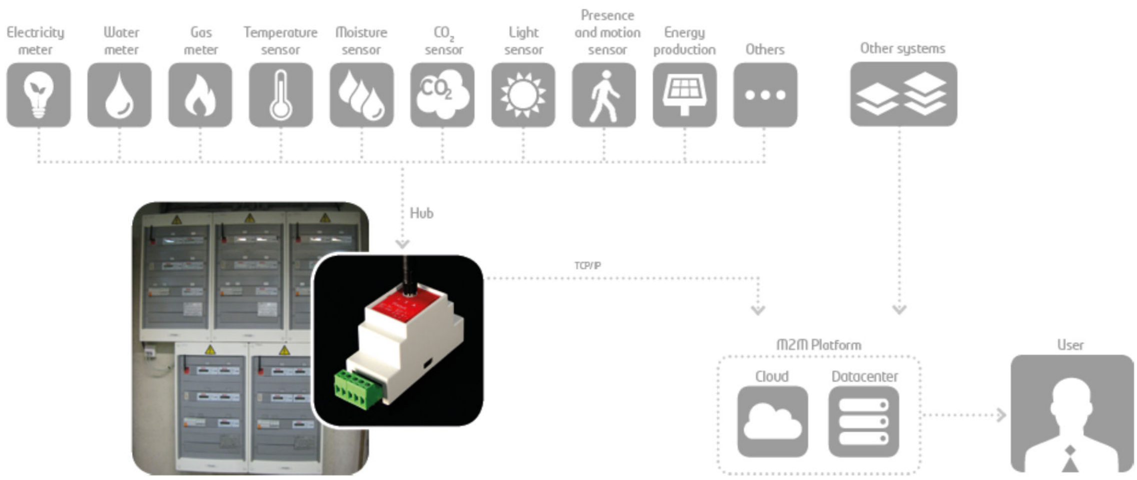


Figure 4 – Lisboa E-Nova ISA EMS B2B Solution

Figure 5 – Campo Grande 25 Building

Figure 6 – PV for micro-generation

Figure 7 – DRMM Building

3.2.3. System Architecture

The Lisboa E-Nova EMSs will be adapted in order to become compliant with BESOS data model allowing the exchange of information with OTESP platform. Moreover, the system is adapted in order to become compliant with ETSI M2M standards ensuring the independence between applications and devices.

The global architecture is presented in Figure 8.

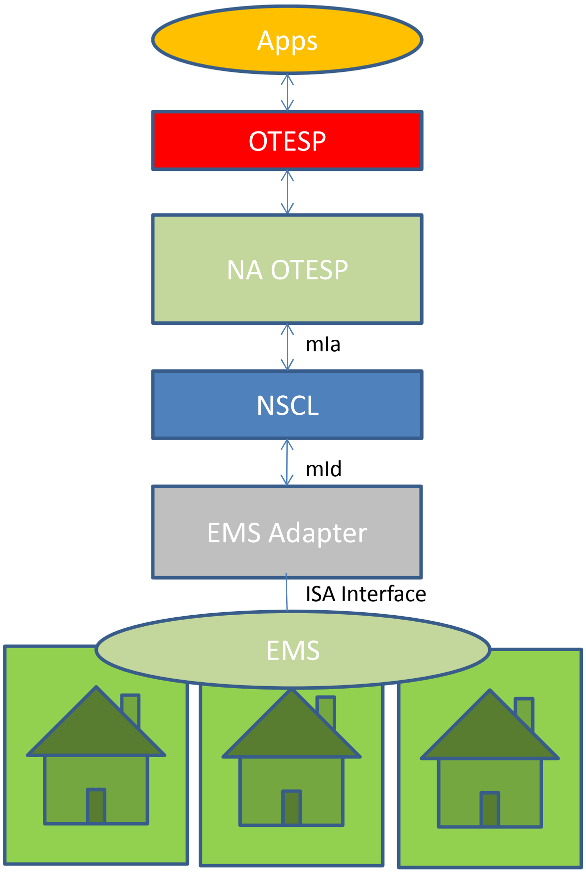


Figure 8 – Architecture for Lisboa-E-Nova ISA EMS adaptation

Each EMS encompasses a set of devices that are skilled to measure the metrics associated with specific entities. The EMS adapter collects the energy measurements and publishes them in a standardized format, using the REST operations, in the NSCL M2M platform in a specific branch of the resource tree.

The NSCL is a data mediation platform that works as a broker between devices and applications. After receiving the EMS information, the NSCL will notify all interested services, in this case the NA OTESP, about the new data available.

The NA OTESP is the central point for EMS adaptation. It makes the bridge between ETSI primitives and the ones used in OTESP. Furthermore, it works as EMS GW by adjusting the data model of each specific EMS into the data model defined in BESOS project. Figure 9 presents the architecture of NA OTESP.

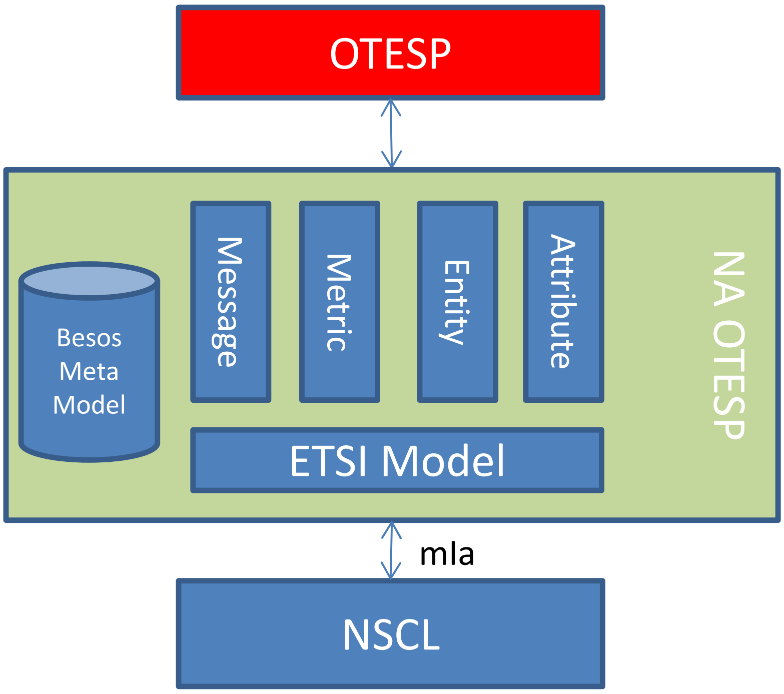


Figure 9 – NA OTESP Architecture

The NA OTESP follows the procedures defined by ETSI and adopts a RESTful architecture to communicate with NSCL. Therefore, it registers in the NSCL and subscribes for EMS information by means of CRUD primitives. Whenever new data become available, it is converted to the BESOS data model and the data is stored in the database.

NA OTESP accepts both synchronous and asynchronous requests from the OTESP. Depending on the communication paradigm, it notifies OTESP or answers to a respective request about a specific EMS measurement. The communication is done through Web Services using SOAP protocol.

3.2.4. Provided entities and services

The EMS provides the following entities to the platform.

Table 2 – ISA EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
ISA_EMS_ORG	ISA EMS SYSTEM ORGANIZATION	ORGANISATION	The complete ISA EMS as Super entity
ISA_EMS	ISA EMS SYSTEM	PUBLIC_BUILDING_PREMISES	Sub entity of ORGANIZATION
3400	besos-3400	NETWORK_ANALYSER	Sub entity
15128	besos-15128	NETWORK_ANALYSER	Sub entity
15129	besos-15129	NETWORK_ANALYSER	Sub entity
15130	besos-15130	NETWORK_ANALYSER	Sub entity
15131	besos-15131	NETWORK_ANALYSER	Sub entity
15132	besos-15132	NETWORK_ANALYSER	Sub entity
15133	besos-15133	NETWORK_ANALYSER	Sub entity
15150	besos-15150	NETWORK_ANALYSER	Sub entity

15151	besos-15151	NETWORK_ANALYSER	Sub entity
15152	besos-15152	NETWORK_ANALYSER	Sub entity
15153	besos-15153	NETWORK_ANALYSER	Sub entity
15154	besos-15154	NETWORK_ANALYSER	Sub entity
15155	besos-15155	NETWORK_ANALYSER	Sub entity
15164	besos-15164	NETWORK_ANALYSER	Sub entity
15173	besos-15173	NETWORK_ANALYSER	Sub entity
15182	besos-15182	NETWORK_ANALYSER	Sub entity
15191	besos-15191	NETWORK_ANALYSER	Sub entity
15200	besos-15200	NETWORK_ANALYSER	Sub entity
15209	besos-15209	NETWORK_ANALYSER	Sub entity
15218	besos-15218	NETWORK_ANALYSER	Sub entity
15227	besos-15227	NETWORK_ANALYSER	Sub entity
20383	besos-20383	NETWORK_ANALYSER	Sub entity
20384	besos-20384	NETWORK_ANALYSER	Sub entity
20385	besos-20385	NETWORK_ANALYSER	Sub entity
20386	besos-20386	NETWORK_ANALYSER	Sub entity
20387	besos-20387	NETWORK_ANALYSER	Sub entity
20388	besos-20388	NETWORK_ANALYSER	Sub entity
20405	besos-20405	NETWORK_ANALYSER	Sub entity
20406	besos-20406	NETWORK_ANALYSER	Sub entity
20407	besos-20407	NETWORK_ANALYSER	Sub entity
20408	besos-20408	NETWORK_ANALYSER	Sub entity
20409	besos-20409	NETWORK_ANALYSER	Sub entity
20410	besos-20410	NETWORK_ANALYSER	Sub entity
20419	besos-20419	NETWORK_ANALYSER	Sub entity
20428	besos-20428	NETWORK_ANALYSER	Sub entity
20437	besos-20437	NETWORK_ANALYSER	Sub entity
20446	besos-20446	NETWORK_ANALYSER	Sub entity
20455	besos-20455	NETWORK_ANALYSER	Sub entity
20464	besos-20464	NETWORK_ANALYSER	Sub entity
20473	besos-20473	NETWORK_ANALYSER	Sub entity
21707	besos-21707	NETWORK_ANALYSER	Sub entity
21708	besos-21708	NETWORK_ANALYSER	Sub entity
21712	besos-21712	NETWORK_ANALYSER	Sub entity
21713	besos-21713	NETWORK_ANALYSER	Sub entity

The adapted EMS provides the following services to the platform:

Table 3 – ISA EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ISA_EMS_ORG, All	ENTITY_INFORMATION ORGANISATION_INFORMATION POSITION_POINT
EntityService	ISA_EMS_ORG, All	ORGANISATION PUBLIC_BUILDING_PREMISES NETWORK_ANALYSER
MetricService	ISA_EMS_ORG, All	ENERGY_PRODUCTION ENERGY_CONSUMPTION

		POWER_FACTOR ENERGY_PRICE_PER_KWH CO2_EMISSIONS

3.2.5. Best integration practices and lessons learned

The integration of ISA EMS was done during the first phase of the project in a smoothly way. The mapping between ISA “logic” and BESOS framework was straightforwardly done due to the well documented API provided. It is critical to have well defined interfaces and a common understanding of the problems in order to easily perform the integration. The usage of web technologies also facilitated the incorporation of the three municipality buildings.

3.2.6. Summary: the “do’s and don’ts” of the integration

Do all the required meetings and readings until getting a complete understanding of the problem

Do studies to understand the field of activity

Do deep analyses of API description

Don’t start integrating until both interfaces and information models are crystal clear.

3.3. Municipality Social Services Building – LMIT-WiseMetering EMS

3.3.1. Introduction

In the Social Services building, two main activities are performed: the Internal Social Action of the City of Lisbon and the Municipality’s Staff Healthcare.

The building has an area of about 10,000 sqm. In architectural terms, the building is distinguished by having a fully glazed west facade, protected by external shading elements.

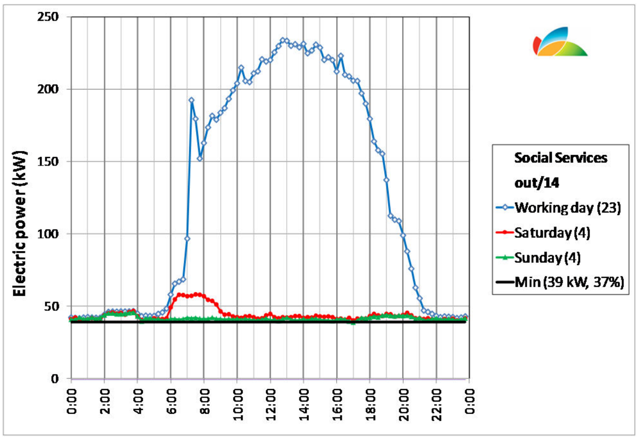


Figure 10 – Social Services Building

In energy terms, the building consumes electricity and natural gas .The building is supplied in medium voltage, with an installed capacity of 1,000 kVA in a single medium voltage transformation station. The largest consumer of the building is associated with the air conditioning and indoor air quality.

The building has got a yearly consumption of 0,9 GWh divided in the following consuming equipment: 1) Lighting (mainly fluorescent), 2) HVAC, 3) Lifts, 4) Gas Heating boilers, 5) Medical equipment.

The main consumption period is weekdays between 8 am and 8 pm with a power of 400 kW. Outside this period, the power is in the order of 50 kW (unless extraordinary situations).

Consumption disaggregation (smart metering):

1. HVAC Chillers.
2. HVAC Others.
3. Cafeteria.
4. 2nd floor Autoclave.
5. 2nd floor – other.
6. 3rd floor.
7. Canteen.
8. Autoclave.
9. Chiller 1.
10. Chiller 2.

3.3.2. System description

WiseMetering is an energy management platform based on the Internet, especially developed for networks of spaces. The WiseMetering automates equipment operation or electrical installations in a centralized manner, ensuring a continuous improvement of the energy performance, according to objectives. In addition, it allows monitoring water consumption and gas costs, overseeing all locations on a single platform.

The added value of an energy management system is the ability to transform data into reliable information, incorporating it in the definition of a best control strategy or human procedures. The WiseMetering defines a pragmatic and intuitive energy management approach, combining data acquisition technology for energy monitoring and simple-to-implement control models that provide the ability to, continually, optimize energy performance.

The WiseMetering is based on a web platform, easy to use, with a user friendly environment that meets the needs of a technical approach to control for each equipment, but also management concerns, such as analysing energy information of each space to make the right decisions. The WiseMetering allows you to automate and remotely monitor hundreds of points, in a centralized and simple approach, with simultaneous access to multiple spaces, offices, shops, restaurants, etc. It allows you to define rules and operating models for sets of common spaces (such as cleaning time, accounting, lunch time, etc.), establishing centralized and automated control equipment, or systems under each of these regimes. It can also create specific rules for each devices, for example, the HVAC control or lighting circuits.

Based on monitoring, WiseMetering energy management platform, offers a set of tools for benchmarking and monitoring of consumption (and costs) that let you set budget policies, based on reports. It also allows tariff validation, manage each of its components and understand where, when and why you are spending energy.

The WiseMetering also incorporates a complete model of alarms, raising energy consumption problems based on daily and weekly profiles. On the other hand, WiseMetering uses energy costs and forecasts to improve the efficiency implemented in each space. For that incorporates the geographical location of each space in order to better classify energy needs.

3.3.3. System Architecture

The Municipality Social Service Buiding is supported by LMIT devices used to collect sensor information. Since it has a specific data model, it requires adaptation to become compliant with BESOS common information model. The EMS GW runs on top of the LMIT EMS and enables the interconnection with OTESP platform using BESOS primitives. Additionally, the system is evolved with the NSCL IoT Enablement component making possible to have a loose couple relationship between applications and devices. Moreover, there is the need of a set of provisioning information, such as address or phone number, to fully charterize the system.

The global architecture is presented in Figure 11.

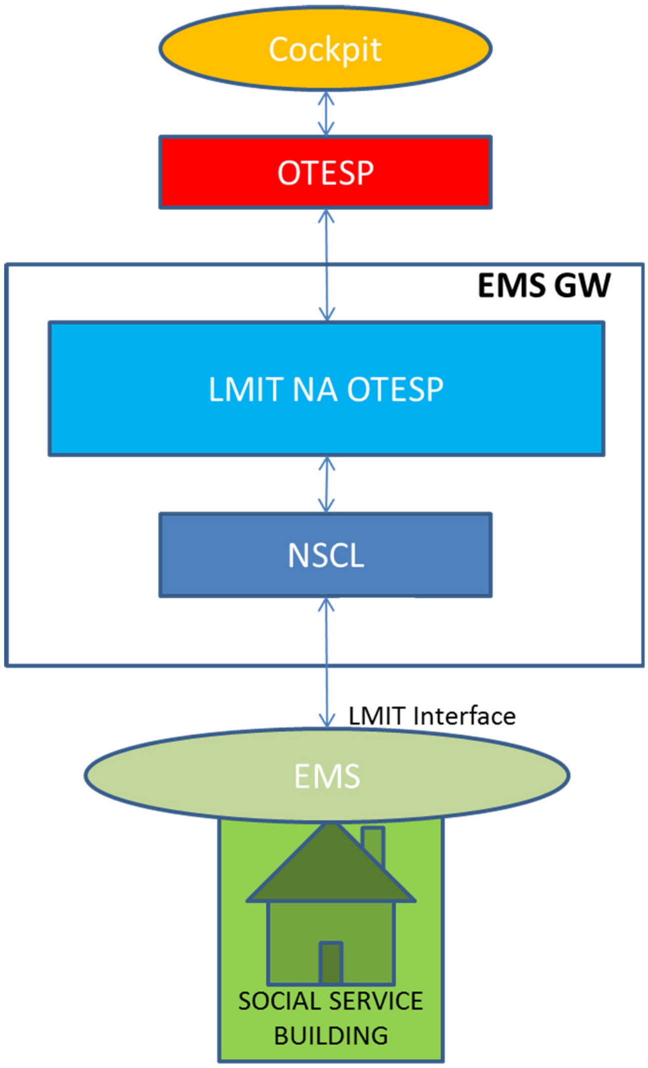


Figure 11 – Architecture for Lisboa LMIT EMS adaptation

The LMIT EMS includes a set of devices spread in the building used to measure specific metrics. It collects information from these specific sensors and publishes periodically the gathered information in the IoT Platform using REST operations. The NSCL acts as a broker between devices and applications. When it receives data coming from the LMIT EMS, it notifies the NA OTESP informing it about the new content received.

The NA OTESP is the core entity to perform EMS adaptation. It makes the bridge between the IoT Platform primitives and the ones used in OTESP. Furthermore, it implements the EMS GW by adjusting the EMS data model into the common information model defined in BESOS project. Figure 12 presents the generic architecture of NA OTESP.

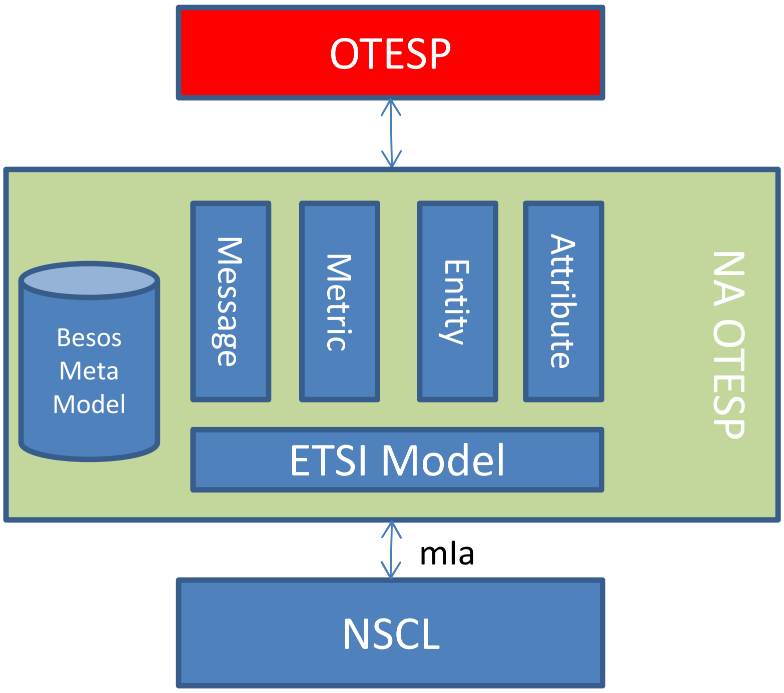


Figure 12 – NA OTESP Architecture

3.3.4. Provided entities and services

The EMS provides the following entities to the platform.

Table 4 –LMIT EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
LMIT_EMS_ORG	LMIT EMS SYSTEM ORGANIZATION	ORGANISATION	The complete LMIT EMS as Super entity
LMIT_EMS	LMIT EMS SYSTEM	PUBLIC_BUILDING_PREMISES	Sub entity of ORGANIZATION
Geral_Piso_2_(N)_QGBT_P_1	Geral Piso 2 (N) QGBT P-1	NETWORK_ANALYSER	Sub entity
Geral_Piso_ 3_(N)	Geral Piso 3 (N) QGBT P-1	NETWORK_ANALYSER	Sub entity
Refeitorio	Refeitorio	NETWORK_ANALYSER	Sub entity
Cafetaria	Cafetaria	NETWORK_ANALYSER	Sub entity
Autoclave	Autoclave	NETWORK_ANALYSER	Sub entity

Geral_Piso_3_(N)_QE bloco_Esq_P3	Geral Piso 3 (N) QE bloco Esq. P3	NETWORK_ANALYSER	Sub entity
Geral_Piso_3_(E)	Geral Piso 3 (E) QE bloco Esq. P3	NETWORK_ANALYSER	Sub entity
Geral_Q_AVAC	Geral Q. AVAC	NETWORK_ANALYSER	Sub entity
Chiller_1	Chiller 1	NETWORK_ANALYSER	Sub entity
Chiller_2	Chiller 2	NETWORK_ANALYSER	Sub entity

The adapted EMS provides the following services to the platform:

Table 5 – LMIT EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	LMIT_EMS_ORG, All	ENTITY_INFORMATION ORGANISATION_INFORMATION POSITION_POINT
EntityService	LMIT_EMS_ORG, All	ORGANISATION PUBLIC_BUILDING_PREMISES NETWORK_ANALYSER
MetricService	LMIT_EMS_ORG, LMIT_EMS, All	ACTIVE_ENERGY_CONSUMPTION REACTIVE_ENERGY_CONSUMPTION ENERGY_PRICE_PER_KWH CO2_EMISSIONS POWER_FACTOR

3.3.5. Best integration practices and lessons learned

The LMIT interface uses the servies provided by the EMS GW to “POST” the energy-related information. This mandates the storage of the all data in the EMS GW side, which forces the usage of large data storages to keep the information available. This approach transfers the costs of both the equipment and the system maintenance to the EMS GW owners.

3.3.6. Summary: the “do’s and don’ts” of the integration

Do deep architectural decisions pondering well all decisions.

Do save the original data gathered and make the filters on top of it.

Don’t be in charge of data maintenance unless you are more than a proxy of it.

3.4. Power Production Forecast Engine

3.4.1. Introduction

Research in techniques for regenerative power forecasting has been a major area of interest during the last decade, as more and more regenerative generators get integrated into the power grid. Regenerative generators have volatile energy characteristics, which means that they cannot be controlled such as conventional power plants.

The integration of these novel forms of power plants into the power grid is one of the big challenges that the industry currently faces. Due to the increasing portion of regenerative energy in the power mix, sophisticated algorithms have to predict the future energy generation in a reliable manner.

3.4.2. System description

All the mentioned actors need reliable forecasts of the future power generation of renewable energy sources in the power grid. As the power generation of these energy sources naturally heavily depends on the weather, virtually all forecasting techniques are based on numerical weather prediction (NWP).

A forecast is typically performed in a two-stage process:

1. An NWP is generated for a certain time period at a certain location (the location of the renewable energy power plant).
2. The NWP is used to forecast the power generation using a forecasting algorithm. This typically is either a physical model, a statistical-, or a machine learning technique.

Physical models have the advantage of being very accurate when having precise knowledge of both, the weather situation and the regenerative power plant parameters. Furthermore, they are very well understandable models and the impact of each parameter can be described in detail. However, this also happens to be a disadvantage if not all influence factors are taken into account, which can turn out to be relatively problematic in practice if the data are inaccurate.

Machine learning forecasting models are so-called “black box” models, meaning they use historic data of both weather situation and respective generated power to learn a model which performs a mapping which models the relationship between the input (e.g., weather) and the output (power generation).

Thereby, factors which do have a systematic influence on the forecast are taken into account in the model. The first proposed technique is an artificial neural network which is based on a deep learning technique to learn the association between a weather situation and power production. The second proposed technique is an analog ensemble which is based on finding similar historic segments to create a forecast.

The Auto-LSTM

The Auto-LSTM algorithm is based on an artificial neural network. It combines the feature learning of an AutoEncoder (AE) with the temporal context usage of a Long Short-Term Memory Network (LSTM) in a two-step approach to generate a power forecast of a photovoltaic facility:

1. An AE will be used to realize a feature learning of the input data, the NWP features.
2. An LSTM network is attached to the encoding part of the AE. Hence, it uses temporal information in form of sequences of the extracted NWP features of the AE.

For each photovoltaic facility we trained an own Auto-LSTM to maximize the forecasting performance of the power generation.

AutoEncoder

The AE is based on two main parts: the Encoder and Decoder.

In our use case we provide the encoding part of the AE all available NWP features without filtering them by expert knowledge. The Encoder reduces the given NWP features on its own to provide only the relevant features for the further forecast generation. For example is the relevance of a snow coverage feature much more relevant for a power forecast of a photovoltaic facility in northern Europe than in southern Europe. This method is called feature learning.

To realise the feature learning of the AE, the network topology has a so called bottleneck in the centre of it. Within the ongoing training process the bottleneck will be downscaled as shown in Figure 13. The Encoder receives the given NWP feature set and removes the irrelevant and redundant information to create a dimensionality reduced ensemble of the input data. The encoding part of the AE, the Decoder, takes the reduced feature subset to reconstruct the original input data. On the basis of the error between the original input data and the reconstructed input data of the Decoder the network topology of the AE will be optimized.

After the training phase the AE will be cut after the bottleneck to use the Encoder for the further architecture. The main advantage of the AE is the feature extraction of the Encoder. The Encoder takes the total NWP features and extracts the only relevant ensembles of features to serve it to the LSTM for the final power forecast generation.

Long Short-Term Memory

In the second step a LSTM network is attached to the previously trained Encoder to generate the final power forecast. Unlike a normal artificial neural network, the LSTM network uses temporal information of the input data. The LSTM realizes this ability by a special neuron structure called memory cell. These memory cells have the ability to store information over an arbitrary time. For the prediction of the power forecast to a certain timestamp the LSTM network uses the weather information of the previously timestamps.

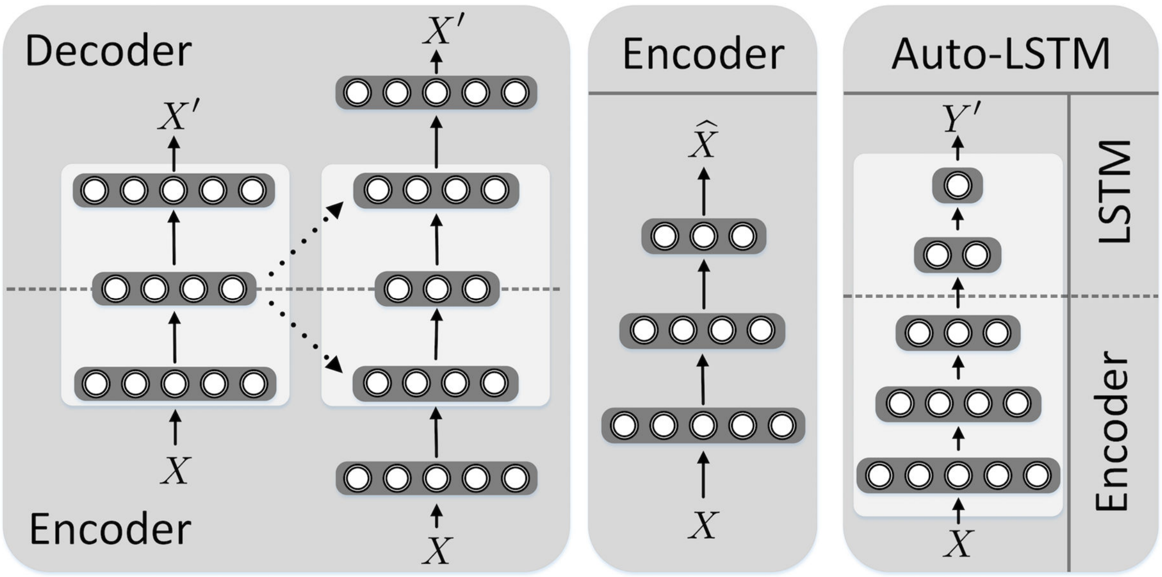


Figure 13 – The Auto-LSTM Architecture

Main advantages of the Auto-LSTM

In contrast to other power forecasting systems like a physical model has the Auto-LSTM two main benefits. The Auto-LSTM decides dependent on the location of a photovoltaic facility by its own which NWP features are the most important ones to generate a high quality power forecast. Furthermore, the LSTM network in the Auto-LSTM takes the temporal weather information into account. On the basis of the temporal weather information has the Auto-LSTM the ability to recognize time-dependent weather phenomena. This information will be used too to generate the high quality power forecast.

Analog Ensemble-base Similarity Search Technique for Solar Power Forecast

The idea of the Analog Ensemble-base Similarity Search Technique is to search in historical weather data for a number of historic situations (analog situations) which are similar to a novel situation for which a forecast has to be created. The power generation time series during the found similar historic situations are then aggregated to an overall forecast (ensemble step), e.g., by averaging the different similar situations. The historic data are typically regarded separately for each facility. These models have the property of being virtually training-free, as the information regarding the model output are directly extracted from a combination of a-priori observed historical weather situations with their respective power generation time series. Models of the class of analog ensembles also have the advantage of being universally applicable, and making little assumption about the model complexity. However, until now these models often only have a very simple representation of the historic weather situation, simple search patterns, or the properties of the particular weather situation are weighted equally. This may hinder the quality of the similarity assessment, which in turn may lead to worse forecasting results.

In the following, the Analog Ensemble Algorithm (AEA) and variants of (novel) search strategies is described. Prerequisite is a data set of historical NWP, corresponding power measurements and a weather forecast for the desired forecast-window. It is assumed that a set of power data depend on the corresponding NWP. With the knowledge of the NWP in the forecast-window, the goal is to find similar segments of the historical NWP (analog situations) to create a forecast.

The AEA mainly composed of three steps:

1. In a first step, the similarity of the current weather situation to each situation in the historical data is assessed using a comparison strategy. The result are so-called analogs, containing element-wise similarity scores.
2. Next, the analogs are filtered using a filter strategy to only contain the appropriate analogs for ensembling.
3. Last, the filtered analogs are used to extract the appropriate segments from the historical power measurements using an ensemble method to create the final forecast.

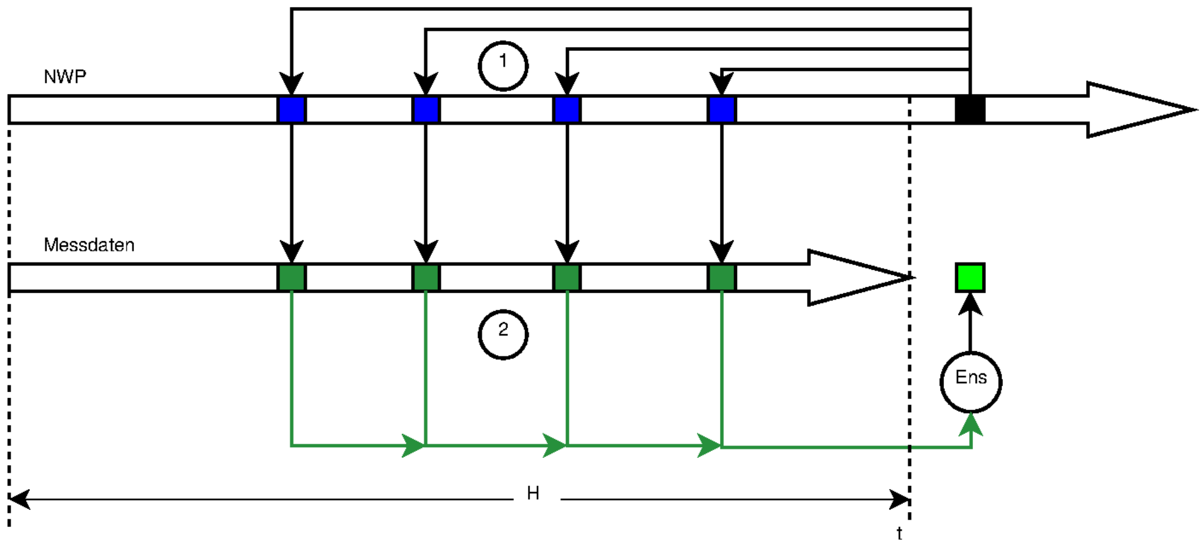


Figure 14 – The basic procedure of the AEA

For comparing segments, i.e., time series of multivariate data, we choose a suitable score, which is able to quantify the similarity of an analog in the way of an extended Euclidean distance. This measurement compares two multi-variate time series: for example a segment which represents a weather situation of the forecast-window and a segments of a historical weather situation. The main feature of this measurement is an adaptive weighting of different NWP-types. These weights provide an adaption of the local weather-characteristica.

The main principle of the comparison-technique is as follows: The forecast-window with current NWP measurements is slid over a historic data set. In each step, the window content of the forecast-window is compared with the respective element of the historical NWP, and a similarity score is computed using the described measurement.

Filtering of Analogs

The comparison strategies provide the similarities of analogs, where a small value means a high similarity of the search window and the respective historic situation. The amount of analogs is usually as big as the amount of time-stamps in the historical data, the goal is to filter the most similar situations for further processing. The intention of the filtering is to find the threshold in the data where the similarity drastically increases. The number of relevant analog situations is determined dynamically depending on the values of the most similar analogs. After sorting by the distance, the analogs are present in monotonically increasing order. The slope of these data points is calculated for the first few best analogs and the highest slope value is stored as a threshold. As a last step, the slope value of each analog is used to compare with the threshold. As soon as the slope of the sorted analogs exceed the threshold, the process terminates. The result is a set of optimal analogs.

Weighted Ensemble Creation

Given an optimal set of analogs as described before, the goal is to calculate a forecast based on the respective energy measurements. We introduce an adaptive weighting of the respective analog based on the similarity values. The idea is to exponentially weigh the analogs based on their similarity. We use a function to calculate a sort of an inversion of the distance values of the analogs.

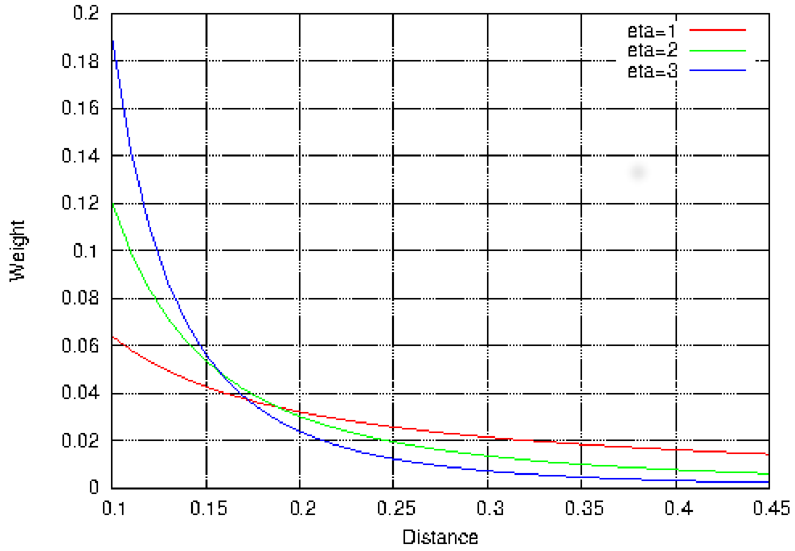


Figure 15 – The example of the inverse function

The parameter eta determines the amount of exponentially weighting, i.e., a high value of eta leads to disproportionately high weighting of the most similar analogs. Note that a low similarity value means a good analog and high value means a less similar analog. After calculating weights for each analog, the forecasting ensemble can be created using the weighted sum of corresponding power measurements.

Experimental Results

In this section we compare the forecasting power of the Auto-LSTM and Analog Ensemble Algorithm (AEA) with a basic physical model forecasting system. Each model predicted the future power generation of one solar facility in Lisbon for the time range of January 2016 till May 2016. All models had to predict the day-ahead forecast horizon of 24h to 48h. The predicted energy generation is compared to the measured power generation by three error measures: the root mean squared error (RMSE), mean absolute error (MAE) and BIAS. These Error Measures can be used to assess the power forecast. If RMSE > MAE the forecast has high deviations to the measured power output. If RMSE ≈ MAE the forecast has only small deviations to the measured power output. The BIAS allows assessing whether power forecast is predicting higher or lower values than the measured power output.

Table 6 – Experimental results of the forecasting engines

	RMSE	MAE	BIAS
Auto-LSTM	6,66 %	3,81 %	-0,95 %
AEA	6,97 %	3,91 %	0,56 %
Physical Model	7,93 %	4,17 %	1,93 %

The previous table shows the error scores of the different models during the experiment. The analysed Auto-LSTM as the AEA outperforms the physical forecasting model. The RMSE and MAE values of the Auto-LSTM are slightly better as of the AEA. In contrast the physical model has a much higher RMSE and MAE value. In conclusion the forecast of the physical model has a higher deviation to the target power generation as the Auto-LSTM and the AEA. According to the BIAS values the Auto-LSTM underestimates the power generation whereby the AEA slightly overestimates the power generation of the solar plant. The physical model heavily overestimates the power generation.

Figure 15 shows a forecast example of the three different models and the measured power as violet curve. As mentioned before the overestimating of the physical model is noticeable. On the other hand there are days where no forecast model performs very well, for example the days around time stamp 172 and 188.

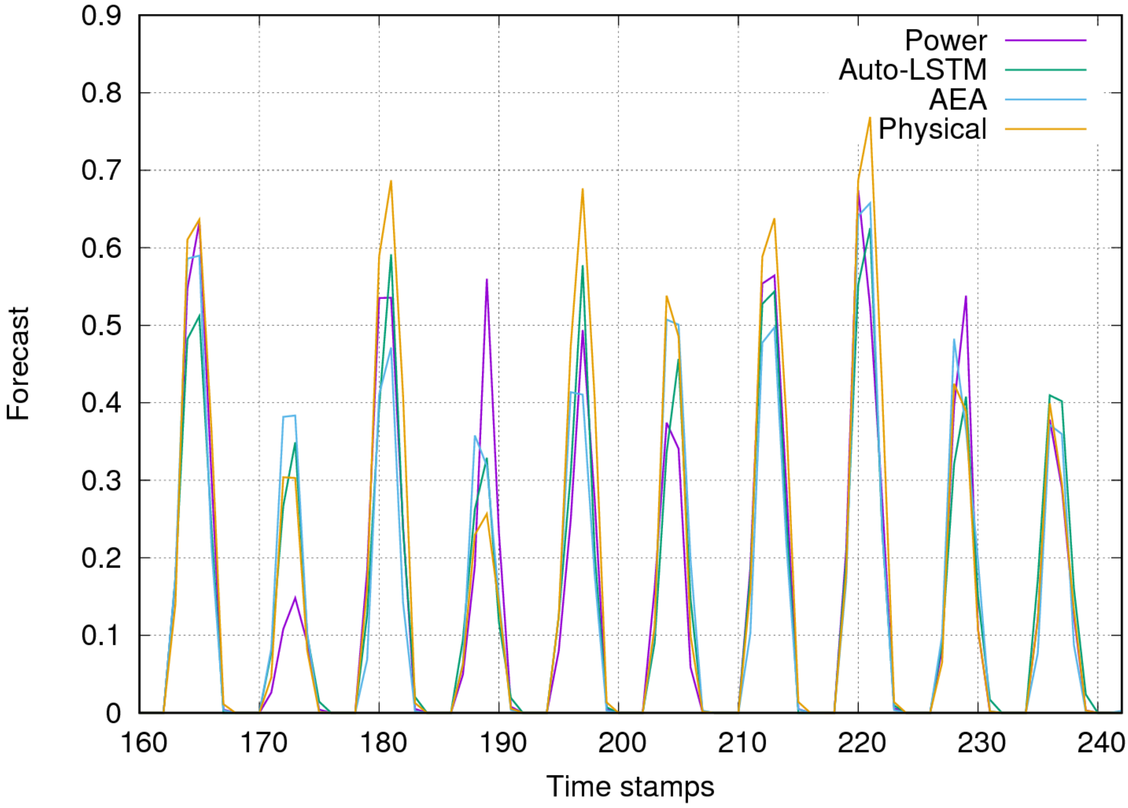


Figure 16 – Example days of March 2016

Conclusion and Outlook

The results showed that the Auto-LSTM has a slightly better performance as the AEA whereby both models outperform the physical forecasting model. In future work, we plan to ensemble the forecasts of each model to improve the forecasting error further. During our work, we trained multiple models but only used the best performing model. By combining the different models depending on their individual strength, we might be able to increase the forecasting quality further.

3.4.3. System Architecture

For configuration of both forecast systems, the AEA and the Auto-LSTM, historical power measurements of the target solar facility are needed. The target solar facility should be controlled as an energy supplier by the OTESP. Both forecast models are embedded and managed in a BESOS top-level application like a BBSC or DSSC. The top level application requests the OTESP for needed power measurements. For the creation of a forecast both models need weather data for the target solar facility and target time. The weather data is requested by the top level application and delivered by an EMS Gateway through a uniform interface. After calculating the desired forecast by one or both forecast models, the top-level application can process the forecast.

3.4.4. Provided Entities

Table 7 – Power production forecast entities

Provided Service	Supported EMS ID	Supported Types
MetricService	TU_LISBON_PV_PRD 1001440003805 1001440003821 1001440003835 1001440003812 1001440001774 1001440001861 1001440003824 1001440003890 COBRA CECOVI Center Viudo I Montegordo Ficosa PV Generation Site	POWER_PRODUCTION_FORECAST

3.4.5. Best integration practices

The Auto-LSTM and AEA forecasting system should be integrated as a micro service architecture as a RESTful service. To generate a power forecast for a photovoltaic facility, the user should provide the power generation of the facility via the RESTful service. The architecture trains by itself an Auto-LSTM network. The AEA forecasting systems should be configured via a website to the specific photovoltaic facility. Following the system generates by itself the power forecasts by the Auto-LSTM and AEA model which can be requested by the user via the RESTful service.

3.4.6. Summary “the do’s and dont’s”

- Do only use filtered power generation data for the Auto-LSTM and AEA forecasting system to ensure a high quality power forecast.
- Do include maintenance or outtake information of the production into the power generation time series.
- Do provide the information of the currently available capacity for each measurement data. Background: a string or a wind turbine could be offline. So the currently measurement value is not reflecting the current situation. This will lead to a lower forecast accuracy.
- The power generation time series should be equidistant and sorted by time.

- The power generation time series should contain not less than one year of data to cover all seasonal effects.

3.5. Power Consumption Forecast for Buildings

3.5.1. Introduction

The Power Consumption forecast for buildings was one of the R&D goals of this project of enercast. Enercast has developed methods for providing power production forecasts for RE since several years. The power production algorithms are based on self-learning algorithms such as Artificial Neuron Networks (ANN) or Support Vector Machines (SVM). The idea was to apply similar methods to field of power consumption forecast for HVAC systems. The energy amount which is used for heating and cooling (Air Condition and/or Ventilation) is heavenly influenced by the weather. Similar to production forecast, it should be possible to create a method for providing consumption forecasts for buildings.

3.5.2. System description

Using a similar approach than in the production forecasts, the self-learning algorithms where trained with historical power consumption data and numerical weather predictions from different Weather services, such as the European Weather Services ECMWF, located in Reading, UK, the German Weather Service DWD, located in Offenbach, the UK Weather Service MetOffice, located in Exeter, UK and the US Weather Service NOOA, located in Boulder CO, USA.

The historical and real time consumption data of the buildings where accessed via the OTESP gateway and transferred to the enercast SKY platform. The enercast SKY platform provides the necessary tools for filtering, training and developing the forecast algorithms. It's connected as the power consumption forecast EMS to BESOS platform via the OTESP gateway.

3.5.3. System architecture

The historical consumption data where retrieved via the OTESP platform. After retrieving the data is validated by some simple validation patterns. Afterwards the cleansed data is normalized by the usage. The most of the buildings where public buildings. Public buildings got a different power consumption profile than residential buildings. So the data have to be normalized by different factors, such as "day of week", "hour of day", etc. Ensuing the normalization, the data is used the target goal for the self-learning algorithms. The cleansed and normalized consumption data is used in the training process with the different NWPs of the different weather services.

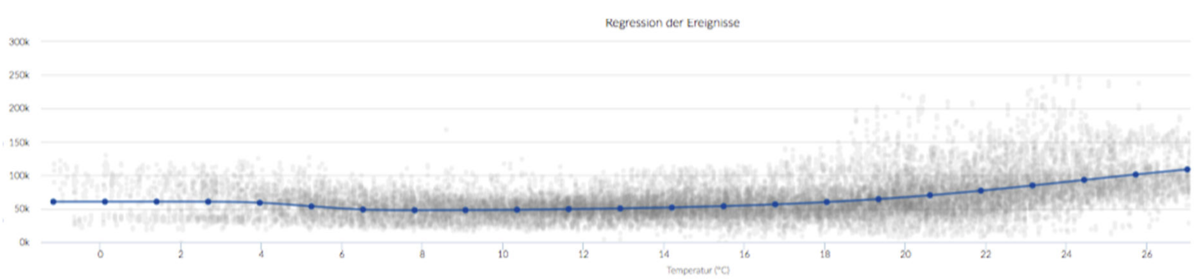


Figure 17 - Consumption forecast

3.5.4. Provided entities

Table 8 – Power consumption forecast entities

Provided Service	Supported EMS ID	Supported Types
MetricService	Campo Grande, Lisabon Barcelona BcnBuildings/0160/C3 BcnBuildings/0160/C4 BcnSodexoBuildings/CapCervello/Hvac BcnSodexoBuildings/CapGracia/Hvac BcnSodexoBuildings/EoiSabadell/Hvac BcnSodexoBuildings/Filmoteca/Hvac	POWER_CONSUMPTION_FORECAST

3.5.5. Best integration practices

The power consumption forecast is similar as the production forecast provided by micro service architecture. The forecast is integrated to OTESP platform by a small REST services which integrates the forecast from the enercast SKY platform to the BESOS platform.

Similar to production forecasts, the validation of the historical time series data is very important. The self-learning algorithms are very sensitive for fault data. In addition to the production forecast, the usage profile of the building, e.g. public building versus residential building, has to be taken in account for the normalization.

3.5.6. Summary: the "Do's and don'ts"

- Do a data validation before using the data.
- Do a data normalization of the data according to the usage profile of the building.

3.6. Public Lighting EMS – Philips City Touch

3.6.1. Introduction

The EMS to be adapted in Lisbon is a proprietary solutions by PHILIPS that is being deployed in the city. BESOS demonstrate how it is possible to interact with close solutions from different vendors.

3.6.2. System description

CityTouch connect application

The CityTouch connect application allows to control each light individually or in custom groups.

It is possible to set custom lighting and dimming schedules, so that, for example, there is more light in the centre on Friday evenings and less light in the business district on week-ends.

Straightforward remote management makes city lighting fully flexible, so citizens will always have the illumination they need. And with improved visibility over individual lights, it is possible to monitor energy use and identify outages immediately.

Manage street lights remotely

The EMS in Lisbon is capable of responding to changing needs by activating, deactivating or adjusting the brightness of street lights. Remote control lets the operator to boost light levels to improve safety and visibility, or dim levels to save energy and preserve the night sky.

The CityTouch connect application makes it easy to:

- Adapt light levels with a simple click.
- Set flexible lighting schedules in advance using the calendar function.
- Store specific dimming profiles for every individual luminaire.
- Monitor luminaire status.

CityTouch lets the city operator to monitor the health of the entire lighting infrastructure without costly, time-consuming night scouting.

The CityTouch connect application allows to:

- Get automatic failure notifications from street lights in a city.
- Have access to the latest status updates on lighting infrastructure.
- Send repair crews only when and where needed, improving operational efficiency.
- Measure energy use.

Data graphs help you see when and where savings have been made. To optimize energy efficiency, it can easily measure and compare the energy usage of single light points, groups of light points, or entire city districts.

With the CityTouch connect application, it is possible to:

- See full breakdowns of energy usage, including historical data.
- Quantify the effect of energy-saving initiatives.

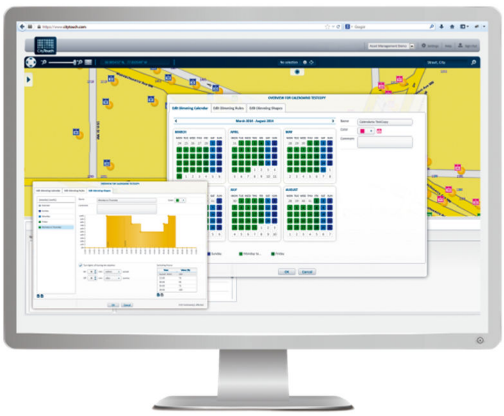


Figure 18 – Philips City touch platform

CityTouch workflow application

The CityTouch workflow application makes managing assets straightforward with:

- Map-based visualizations.
- Simple charts and diagrams.
- Workflows for maintenance work.

With clear insights about the lighting system, the operator is able to easily identify areas with energy saving potential, reduce operational and maintenance costs, and make fact-based investment decisions.

IntelligentCity is a total integrated solution that connects light points, controls and cabinets with advanced lighting software and dedicated services.

- Dynamic, intelligent and flexible to any situation.
- Detailed, real-time insight into status of lighting assets.
- Seamlessly balances city ambiance with sustainability and safety.

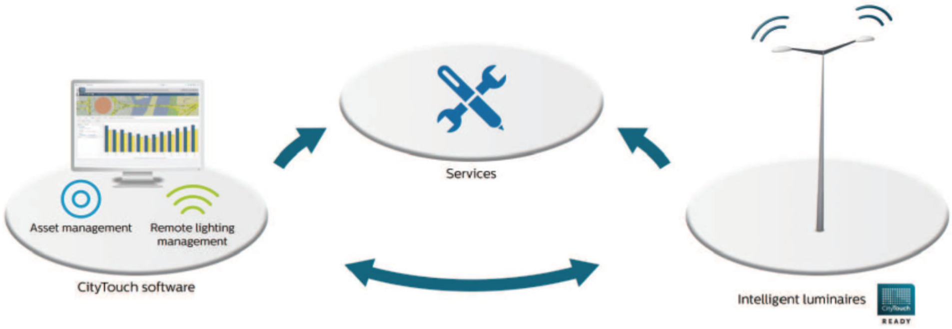


Figure 19 – Philips CityTouch workflow application

3.6.3. System Architecture

The public lighting provided by Philips have integrated systems skilled to monitor the luminaire status. This information is made available by the CityTouch platform that offers an open service enabling external applications to gather alarm information related with each specific lamp. Philips uses proprietary API and data models, therefore there is the need of an EMS GW do adapt both the primitives and the representation of information to BESOS system, hiding therefore the specificities of the EMS. The EMS GW will therefore make possible the exchange of information between OTESP and the Philips EMS allowing the cockpit application to be aware of the luminaires status. Moreover, during development phase, there is the need to customize the EMS GW with a set of provisioning data in order to fully describe the Philips system. Figure 20 presents the architecture for Lisboa E-Nova Philips EMS adaptation.

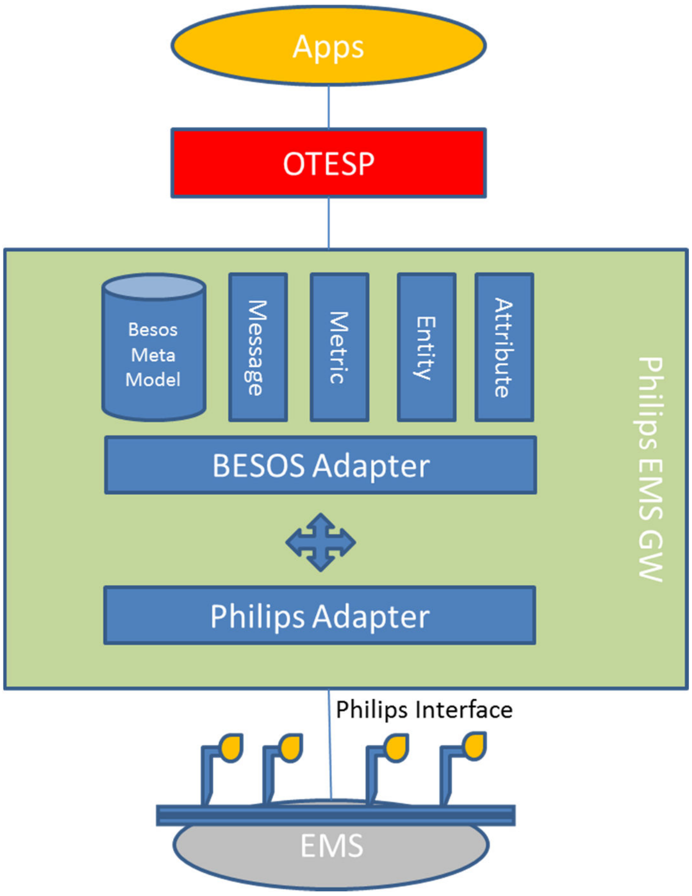


Figure 20 – Architecture for Lisboa-E-Nova Philips EMS adaptation

3.6.4. Provided entities and services

The EMS provides the following entities to the platform.

Table 9 – Philips EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
PHILIPS_EMS	PHILIPS EMS SYSTEM	ORGANISATION	The complete Philips EMS as Super entity
SEGMENT_CONTROLLER_1	Segment Controller 1	SEGMENT_CONTROLLER	Sub entity of ORGANISATION which children are of type POINT_OF_LIGHTLIGHT
POINT_OF_LIGHT_1-1	Point of Light 1-1	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-2	Point of Light 1-2	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLL

			ER
POINT_OF_LIGHT_1-3	Point of Light 1-3	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-4	Point of Light 1-4	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-5	Point of Light 1-5	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-6	Point of Light 1-6	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-7	Point of Light 1-7	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-8	Point of Light 1-8	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-9	Point of Light 1-9	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER
POINT_OF_LIGHT_1-10	Point of Light 1-10	POINT_OF_LIGHT	Sub entity of SEGMENT_CONTROLLER

The adapted EMS provides the following services to the platform:

Table 10 – Philips EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	PHILIPS_EMS, All	ENTITY_INFORMATION ORGANISATION_INFORMATION POSITION_POINT ALARM
EntityService	PHILIPS_EMS, All	ORGANISATION SEGMENT_CONTROLLER POINT_OF_LIGHT

3.6.5. Best integration practices and lessons learned

Each EMS has its own set of capabilities. The EMS owner is the entity in charge of the equipment roadmap. For straightforward integration use the functionalities deployed in order to mitigate dependencies.

3.6.6. Summary: the “do’s and don’ts” of the integration

Do care about product roadmaps in order to mitigate dependencies.

Do regular meetings with manufactors to understand the evolution of EMS equipment.

3.7. Electrical Charging System at Campo Grande 25 Municipal Building: ISA Kisense EMS

3.7.1. Introduction

Campo Grande 25 is a 5 block building, where most administrative part of the Municipality work is performed (see 1st round of trials). It has got around 2000 people working every day and many other are visiting the building, as it hosts some important public services, open to the citizen.

The building, has a total area of 55.000 sqm and is supplied with medium-voltage and has an average yearly consumption of 3,2 GWh, and is owned and managed by the Municipality.

A fleet of around 25 electrical vehicles (mainly Peugeot iOn) is charged in this building in 2 charging stations, in different basement levels, level -1 and level -2.

Each charging station has 15 plugs.

Today the charging process is manual. The driver, after parking the EV near the charging station, just connect the plug to the EV. The plug has a 5 meter flexible wire to facilitate this process.

There is no control of the charging process, neither the duration of it.

The tool for power management, able to identify sources of savings and monitor the evolution of consumption in use is KiSense.

KiSense - Key Features:

- Analysis of energy consumption;
- Definition , visualization and automatic sending of alarms;
- Definition and implementation reports;
- Possibility of remote control devices and circuits;
- Analysis and tariff management;
- Integration with other systems and equipment - GTC , BMS , PLC , etc ;

In general terms, the technical solution presented is based on platform centralized architecture that receives information directly from local equipment installed.

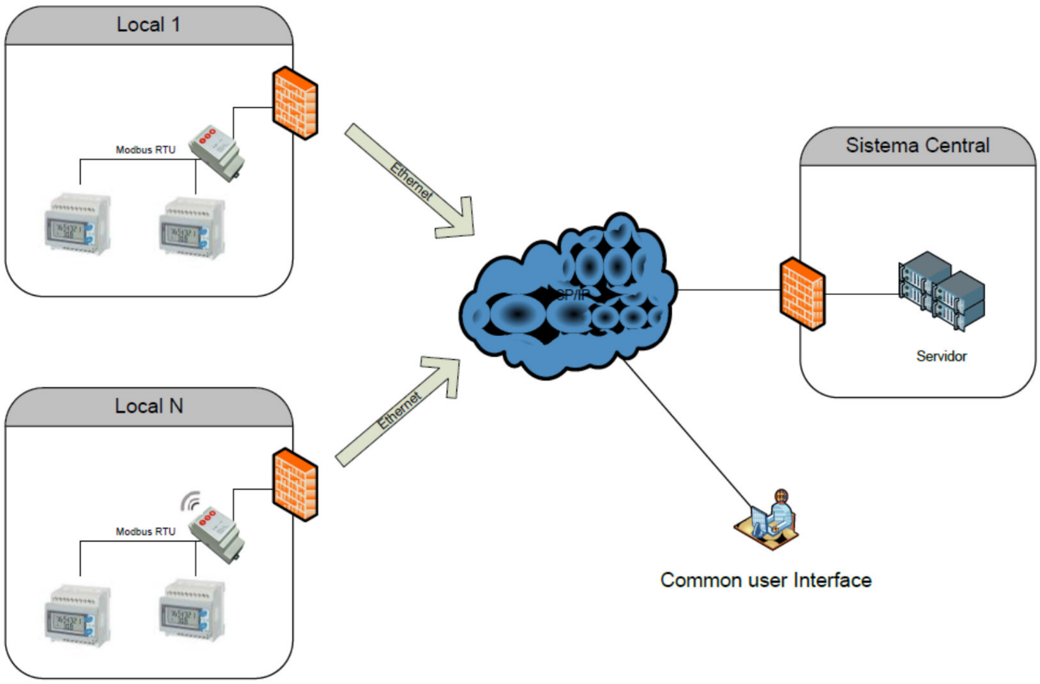


Figure 21 – ISA Kisense EMS technical solution

The previous figure of architecture is the logical form, simplified the interaction with various systems installed. In this, the consumption of network monitoring is data acquisition of new equipment to be installed. In terms of operation, there is a local data collection equipment in each location which collects the information and sends it to the host using where possible the existing network infrastructure. The equipment for this purpose that will be installed for measuring the consumption local and remote transmission of information is designated by IHUB and ensures the collection of information with a certain frequency (typically 15 minutes) for sending directly to the central server. The information collected in local is then sent to the central system, waiting for an acknowledgement of the successful transmission of information. In case of failure, the IHUB also ensures storage capacity of the data in local memory of each of the monitored locations for later delivery to the central system. The central system has the ability to receive, consolidate and centrally store the information collected from various locations, as well as the ability to provide access to data via web browser, using for this purpose to a web server.

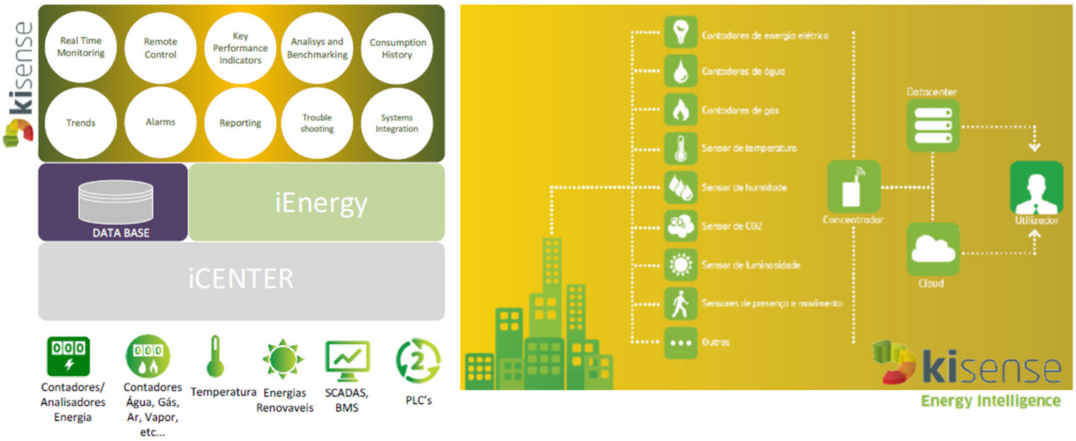


Figure 22 – ISA Kisense EMS visulaization tool

Figure 23 – EV charging stations use

Figure 24 – Muncipal EV fleet

The new charging system will be installed in the level -2 charging station. Each plugs will be monitored, providing on-line data of electrical consumption in a 15 minutes period.

The driver after parking the EV and connect the plug to the EV, must give the following information to the new system, creating an event:

a) The number of the plug (from 1 to 15).
b) The number of the EV (from 1 to 100).
c) The urgency of charging:
    c1) Charge the EV immediately.
    c2) Charge the EV avoiding the peak hours.
    c3) Charge the EV at the best time.

While question a) and b) are systematic, the answer to question c) will oblige a lot of work with the drivers in order to give them information about charging speed, peak hours, electric costs avoid, CO2 avoid in electricity production, etc... This task will be done by the Municipality Mobility staff. This means that ISA System will have in memory 3 profiles of 24 hours, one for each type of urgency of charging.

When an event occurs, ISA System sends the event information to BESOS platform and starts following the selected profile of charging. BESOS platform can change at any moment the 3 profiles, with immediate update in the ISA System, with effects even in profiles that are running at that time.

Interface

The data interfacing process starts when the system informs BESOS platform of the following 3 data values:
a) Driver data introduction time.
b) The number of the plug (from 1 to 15).
c) The number of the EV (from 1 to 100).
d) The urgency of charging (A, B or C).

BESOS platform informs ISA System of the 3 profiles to follow. A profile is defined by:
a) Number of events.
b) For each event:
    b1) Time of the event.
    b2) Charging action: 0 means not charge, 1 means charge.

The profile generation

The profile will be defined accordingly to the Portuguese schedule of electricity daily price.

In Portugal the electricity price is charging with different 4 prices (VAT included):
- Peak hours (in Portuguese "ponta"), around 0,28 €/kWh.
- Daily hours (in Portuguese "cheia"), around 0,13 €/kWh.
- Low hours (in Portuguese "vazio normal"), around 0,09 €/kWh.
- Super low hours (in Portuguese "super vazio"), around 0,09 €/kWh.

The cost of electricity change every year due to the contract as Portugal electrical market are liberalized. The Portuguese companies can choose between a daily metering, where all days (working and week end days) have the same schedule, and weekly metering (where there is 3 schedules: working day, Saturday and Sunday).

The Campo Grande 25 electrical contract is under weekly metering so this will be the schedule to use in the profile generation.

In the profile generation it will be assumed that 10 hours is enough to charge the EV. This number of hours will be tested during the project.

The profile generations strongly depends of the "urgency" requested by the driver:

a) Urgency 1: The charging in immediately on.
b) Urgency 2: The charging is off only during "Peak hours".
c) Urgency 3: The charging is on only at the start at the start of "Low hours" (as "Super low hours" is very similar to "Low hours" price).

3.7.2. System architecture

The EV EMS uses an enhanced version of the ISA system described in D4.2.1, which in terms of data access, is very similar to the version used during the first phase of the implementation.

In the EV scenario, there is the need to exchange non-energy related information between the ISA EMS and the cockpit, such as the number of the plug, the identification of the EV and the urgency of charging. To that end, the EMS GW makes available capabilities to enable the communication with the Cockpit whenever a new car is to be charged. Moreover, there is also the need to receive commands from the application side informing the ISA system to actuate on the plug, which means to switch on or switch off the electrical plug. Finally, the ISA EMS allows to collect energy consumption information that shall be used by OTESP and applications to derive energy related information. So, whenever a driver intends to charge the car, information is sent to application with the full profile. A decision is made at application level allowing the charging at a specific period of the day. The consumption of the plugs are also exchanged between ISA EMS and the cockpit through the OTESP.

The EMS GW will therefore adapt the primitives from ISA EMS towards the BESOS ones. Moreover the data model are also converted within the EMS GW. Finally, specific functionalities are added in order to allow “posting” user information directly in the cockpit applications.

Figure 25 below presents the architecture for Lisboa-E-Nova ISA EV EMS adaptation.

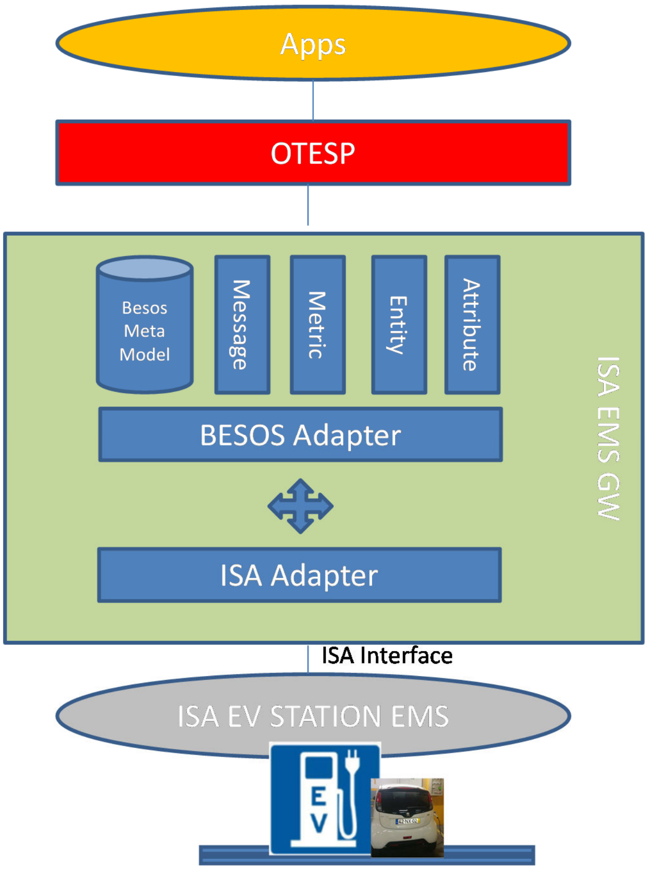


Figure 25 – Architecture for ISA EV EMS adaptation

3.7.3. Provided entities and services

The ISA EMS provides the following entities to the platform.

Table 11 – ISA EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
EV_ISA_EMS	EV ISA EMS SYSTEM	ORGANISATION	The complete EV ISA EMS as Super entity
CHARGING_STATION_1	Charging Station 1	ELECTRIC_VEHICLE_CHARGING_POINT	Sub entity of ORGANISATION which children are of type ELECTRIC_VEHICLE_PLUG
EV_PLUG_1-1	EV PLUG 1-1	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-2	EV PLUG 1-2	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-3	EV PLUG	ELECTRIC_VEHICLE_PLUG	Sub entity of

	1-3		CHARGING_STATION
EV_PLUG_1-4	EV PLUG 1-4	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-5	EV PLUG 1-5	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-6	EV PLUG 1-6	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-7	EV PLUG 1-7	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-8	EV PLUG 1-8	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-9	EV PLUG 1-9	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-10	EV PLUG 1-10	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-11	EV PLUG 1-11	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-12	EV PLUG 1-12	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-13	EV PLUG 1-13	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-14	EV PLUG 1-14	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
EV_PLUG_1-15	EV PLUG 1-15	ELECTRIC_VEHICLE_PLUG	Sub entity of CHARGING_STATION
ISA_EMS_BUILDING	Public Building	PUBLIC_BUILDING_PREMISES	Sub entity of ORGANIZATION
CONTADOR_1	Energy Consumption Plug 1	NETWORK_ANALYSER	Sub entity
CONTADOR_2	Energy Consumption Plug 2	NETWORK_ANALYSER	Sub entity
CONTADOR_3	Energy Consumption Plug 3	NETWORK_ANALYSER	Sub entity

CONTADOR_4	Energy Consumption Plug 4	NETWORK_ANALYSER	Sub entity
CONTADOR_5	Energy Consumption Plug 5	NETWORK_ANALYSER	Sub entity
CONTADOR_6	Energy Consumption Plug 6	NETWORK_ANALYSER	Sub entity
CONTADOR_7	Energy Consumption Plug 7	NETWORK_ANALYSER	Sub entity
CONTADOR_8	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_9	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_10	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_11	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_12	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_13	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_14	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity
CONTADOR_15	Energy Consumption Plug 8	NETWORK_ANALYSER	Sub entity

The adapted EMS provides the following services to the platform:

Table 12 – ISA EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	EV_ISA_EMS, All	ENTITY_INFORMATION ORGANISATION_INFORMATION POSITION_POINT
EntityService	EV_ISA_EMS, All	ORGANISATION CHARGING_STATION NETWORK_ANALYSER ELECTRIC_VEHICLE_PLUG
MetricService	EV_ISA_EMS, ISA_EMS_BUILDING, All	CURRENT VOLTAGE ACTIVE_ENERGY_CONSUMPTION REACTIVE_ENERGY_CONSUMPTION ENERGY_PRICE_PER_KWH CO2_EMISSIONS
MessageService	EV_ISA_EMS, CHARGING_STATION, All	COMMAND

3.7.4. Best integration practices and lessons learned

The EV integration was complex but it worked quite well. The regular meetings between partners and ISA experts were crucial for the regular integration of the EMS. The usage of internet based protocols made the conversations much simpler and productive.

3.7.5. Summary: the "do's and don'ts" of the integration

Do deep architectural analyses in order to take the most appropriate decisions.

Do messages sequence charts to deep understand the required parameters.

Do continuous integration meetings to ensure that all stakeholders have the same view.

Don't delay your doubts, try to clarify them as soon as possible to decrease the impact in the deployment.

Use standard protocols to enable a smooth integration.

3.8. Traffic Consumption System, Lisbon

3.8.1. Introduction

EDP Serviços The Consumption Management System (GC) – WEBSERVICE - is an online tool that allows the customer to monitor their energy consumption data in a simple and comprehensive way, providing it with information for effective management of the energy consumed either in a perspective of cost optimization, or resource allocation. This tool is used to monitor the traffic consumption in Entrecampos roundabout, in Lisbon, whose data was integrated into BESOS in the 2nd phase of development.

3.8.2. System Architecture

The management of consumption aims to answer three growing needs of our customers:

- Control and access structured information about their consumption;
- Simplify compliance with regulatory requirements relating to energy consumption;

- To assure the best operating conditions and safety of their electrical installations.

Thus, the Consumption Management System is an integrated, simple and effective solution.

The objective of this web service is to provide a customer API aggregate consumption analysis of its facilities for a given day. The request to the web service will return a vector with various objects, one for each analyser specified in the request to the web service. Each object has information as the analyser consumption, the period for which occurred and the parser who registered. The own parser object is supplemented with relevant information such as the type of analyser and energy type for which the parser registers consumption.

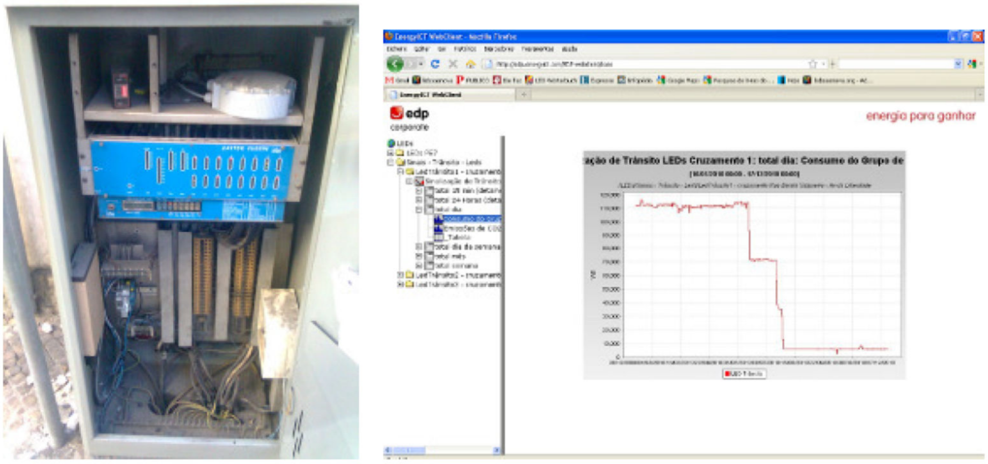


Figure 26 – Smart meter from the energy provider installed on a CASTOR 8000 traffic light controller; Visualization of the EMS

Via this web service, an API is provided to be able to get 15-minute granularity consumption data of the system. This web service is queried once a day by a dedicated service from BESOS, which stores the records in a local data base. This information is then accessed by the EMS GW to serve it to the OTESP.

3.8.3. Provided entities and services

The EMS provides the following entities to the platform.

Table 13 – Lisbon Traffic Consumption EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
LbnTrafficService	Lisbon Traffic Consumption	ORGANISATION	The complete EMS
Entrecampos	Entrecampos roundabout segment controller	SEGMENT_CONTROLLER	Child of LbnTrafficService.
TrafficConsumption	Network analyser	NETWORK_ANALYZER	Child of Entrecampos.

The adapted EMS provides the following services to the platform:

Table 14 – Lisbon Traffic Consumption EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION POSITION_POINT
EntityService	ALL	ORGANISATION SEGMENT_CONTROLLER NETWORK_ANALYZER
MetricService	ALL	ENTITY_COUNT ENTITY_USED ENERGY_PRICE_PER_KWH ENERGY_CONSUMPTION CO2_EMISSIONS ENERGY_COST

3.8.4. Best integration practices and lessons learned

The API presented some access limitations to avoid the overload of the service. For this reason, the decision had to be taken to query the web service periodically and store the results for further usage instead of integrating the API directly into the EMS GW.

3.8.5. Summary: the "do's and don'ts" of the integration

Do be aware of the limitations of the access means you have been provided with: early-detected problems avoid extra work.

3.9. Energy Production of Ficosa Renewables Plant site, Barcelona

3.9.1. Introduction

The energy micro-generators plant in Sant Guim de Freixenet (Barcelona) is provided and maintained by Ficosa, a multinational corporation which main activity consists in the research, development and production of systems and parts for the automotive industry. The company dedicates an annual percentage of its activity to R&D, in which this project is included.

3.9.2. System Architecture

The architecture of the energy generation system includes measuring devices, device controllers, an integrated local server, and a remote server. A series of different communications between these components are defined and scheduled in order to measure, store and send the different sorts of data managed by the plant's system.

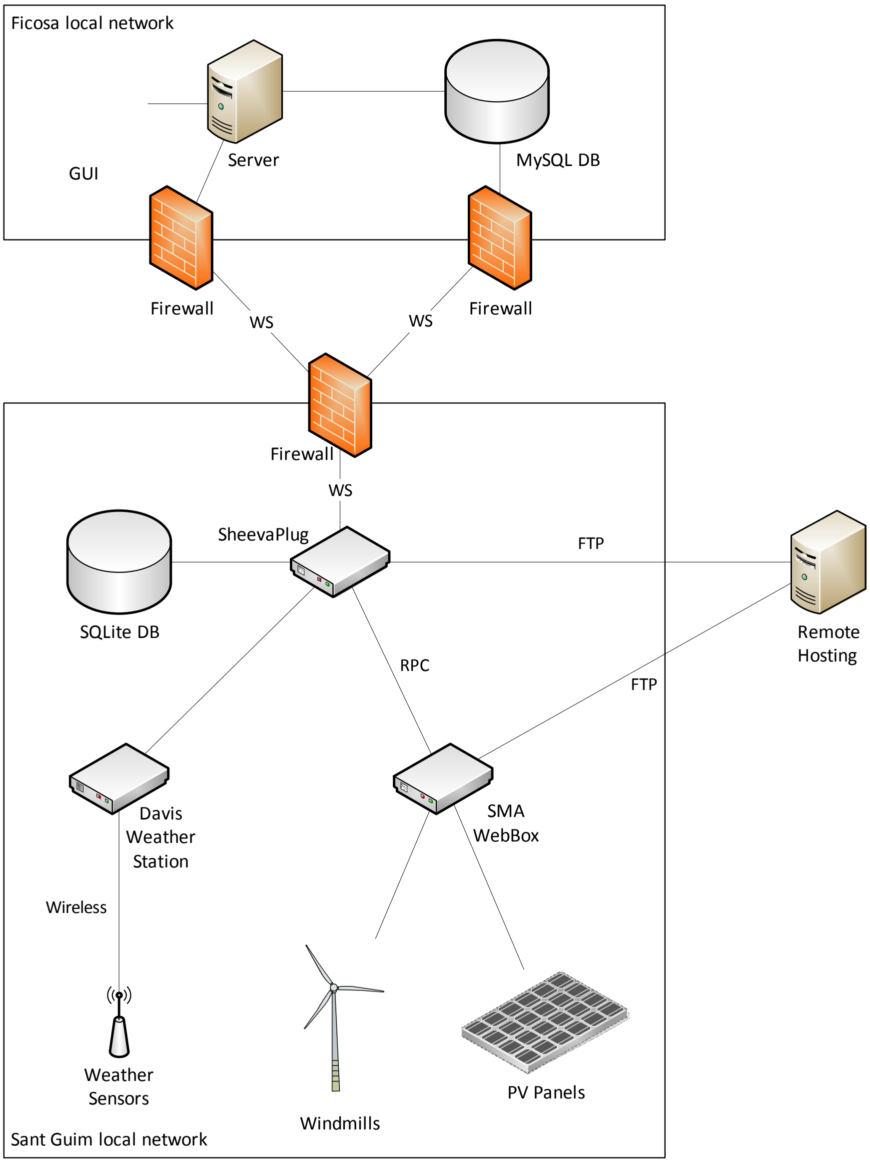


Figure 27 – Ficosa Power Plant EMS system architecture

3.9.3. Provided entities and services

The EMS provides the following entities to the platform.

Table 15 – Ficosa Power Plant EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
BcnPowerPlant	Ficosa Power Plant	ORGANISATION	The complete EMS
WeatherStation	Weather station	WEATHER_STATION_UNIT	Child of BcnPowerPlant.
Windmill1	Windmill 1	WIND_GENERATING_UNIT	Child of BcnPowerPlant.
PvPanel1	PV Panel 1	PV_GENERATIN	Child of

		G_UNIT	BcnPowerPlant.

The adapted EMS provides the following services to the platform:

Table 16 – Ficosa Power Plant EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	BcnPowerPlant WeatherStation Windmill1 PvPanel1	ORGANISATION_INFORMATION WIND_GENERATING_UNIT_INFORMATION PV_GENERATING_UNIT_INFORMATION EQUIPMENT_INFORMATION POSITION_POINT
EntityService	BcnPowerPlant WeatherStation Windmill1 PvPanel1	ORGANISATION WIND_GENERATING_UNIT PV_GENERATING_UNIT WEATHER_STATION_UNIT
MetricService	BcnPowerPlant WeatherStation Windmill1 PvPanel1	ENTITY_COUNT ENTITIES_USED WIND_DIRECTION WIND_SPEED WIND_GUST INSIDE_TEMPERATURE OUTSIDE_TEMPERATURE ATMOSPHERIC_PRESSURE ENERGY_PRODUCTION POTENTIAL_ENERGY_PRODUCTION ACTIVE_POWER ACTIVE_POWER_MIN ACTIVE_POWER_MAX

3.9.4. Best integration practices and lessons learned

The integration of the Ficosa power plant EMS was completed at early stages of the development phase. A RESTful API was provided to access the different measurements taken from the plant, whose integration into BESOS was straightforward.

The main concerns in the overall process did not lie in the integration of the system, but in the data generated in the plant. As small set of assets was integrated, this led to frequent periods with zero generation data. During the first months after the integration, it had to be determined whether they were caused by some problem or if this was the nature of the underlying system.

3.9.5. Summary: the “do’s and don’ts” of the integration

Do request a well-documented API to access the data.

Do ask for any clarifications when needed, as assuming and guessing could lead to incorrect data and extra work.

3.10. Public Buildings controlled by the Barcelona Municipality, Barcelona

3.10.1. Introduction

The Barcelona Municipality has the responsibility of maintaining and providing many different services, including the management of public buildings (medical centres, schools, libraries, etc.). In the scope of the BESOS project, the partnership with the Barcelona Municipality led to the integration of some of these buildings into the system, including the monitoring of their properties.

3.10.2. System Architecture

The information gathered from each public building managed by the Barcelona Municipality was available through a common service platform called Sentilo.

Sentilo is open source software developed by the Municipal Institute of Informatics (IMI), an entity that depends on the Barcelona Municipality, starting in November 2012. The platform is conceived as a central hub of all the information generated by the city, including assets not managed by the municipality. For this purpose, a public API was made available in February 2014 for anyone to connect to the platform and provide data from his facilities.

The following figure shows the architecture of the information managed by the Barcelona Municipality through the Sentilo platform:

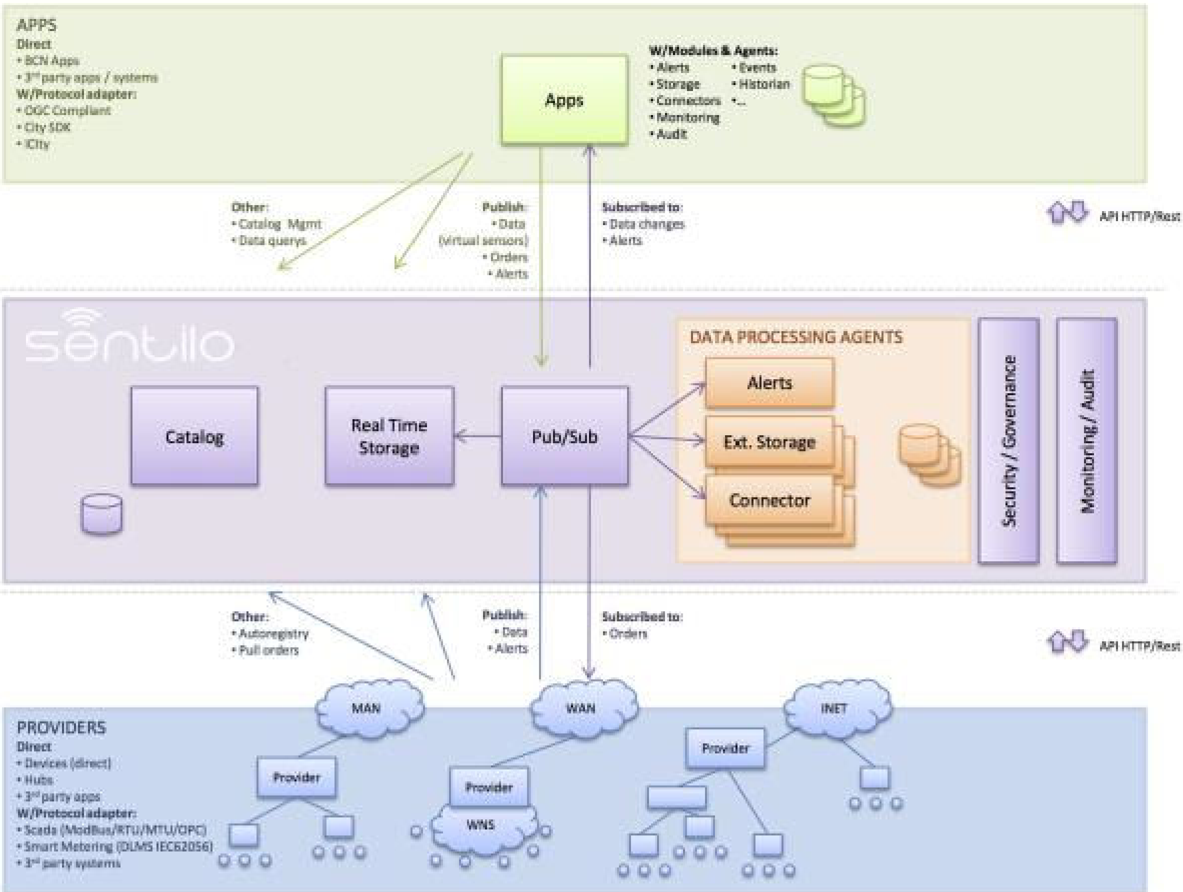


Figure 28 – BCN Public Buildings EMS system architecture

3.10.3. Provided entities and services

The list of integrated buildings from this EMS is provided below. The number of network analysers (N.A.), weather stations (W.S.), and PV panels (PV) is provided for each of them.

Table 17 – BCN Public Buildings EMS Provided Entities

Unique Name or ID	Readable name	Entity type	N.A.	W.S.	PV
BcnPublicBuildings	Barcelona public buildings system	ORGANISATION			
0061	Biblioteca Mercé Rodoreda	PUBLIC_BUILDING_PREMISES			1
0100	Edifici Nou i Novíssim	PUBLIC_BUILDING_PREMISES			1
0107	Pergola de Vallbona	PUBLIC_BUILDING_PREMISES			1
0108	CEIP Taber	PUBLIC_BUILDING_PREMISES			1
0109	CEIP Font den Fargas	PUBLIC_BUILDING_PREMISES			1
0110	IE Costa i Llobera	PUBLIC_BUILDING_PREMISES			1
0111	Biblioteca Can Fabra	PUBLIC_BUILDING_PREMISES			1
0112	IES M Joan Manuel Zafra	PUBLIC_BUILDING_PREMISES			1
0113	IES M A G Mundet	PUBLIC_BUILDING_PREMISES			1
0114	CEE Pont del Drago	PUBLIC_BUILDING_PREMISES			1
0115	IES Bosc de Montjuic	PUBLIC_BUILDING_PREMISES			1
0116	INS Narcis Monturiol	PUBLIC_BUILDING_PREMISES			1
0117	IES Serrat i Bonastre	PUBLIC_BUILDING_PREMISES			1
0118	IES Ferran Tallada	PUBLIC_BUILDING_PREMISES			1
0119	CEIP Escola del Mar	PUBLIC_BUILDING_PREMISES			1
0121	Biblioteca Juan Marse	PUBLIC_BUILDING_PREMISES			1
0122	CC Sandaru	PUBLIC_BUILDING_PREMISES			1
0123	Masia de Can Cadena	PUBLIC_BUILDING_PREMISES			1
0124	CC Carmel	PUBLIC_BUILDING_PREMISES			1
0125	Pergola de Bon Pastor	PUBLIC_BUILDING_PREMISES			1
0126	Centre OSI Escola Bressol Sant Medir	PUBLIC_BUILDING_PREMISES			1

0127	CC Annibal CC el Sortidor	PUBLIC_BUILDING_PREMISES			1
0129	Biblioteca Francesc Candel	PUBLIC_BUILDING_PREMISES			1
0130	Casal GG Vall d'Hebron	PUBLIC_BUILDING_PREMISES			1
0131	Casal de Navas	PUBLIC_BUILDING_PREMISES			1
0132	Seu districte les Corts	PUBLIC_BUILDING_PREMISES			1
0133	Edifici Suma	PUBLIC_BUILDING_PREMISES			1
0134	Escola Adults Barceloneta	PUBLIC_BUILDING_PREMISES			1
0135	Casa Elizalde	PUBLIC_BUILDING_PREMISES			1
0136	Biblioteca Vapor Vell	PUBLIC_BUILDING_PREMISES			1
0137	CC Vazquez Montalban	PUBLIC_BUILDING_PREMISES			1
0138	Biblioteca les Roquetes	PUBLIC_BUILDING_PREMISES			1
0140	Fòrum Fase 1	PUBLIC_BUILDING_PREMISES			1
0141	Biblioteca Joan Miro	PUBLIC_BUILDING_PREMISES			1
0142	CC Trinitat Vella	PUBLIC_BUILDING_PREMISES			1
0143	CEIP Gaudi	PUBLIC_BUILDING_PREMISES			1
0149	Palau Alos	PUBLIC_BUILDING_PREMISES			1
0156	Biblioteca Collserola	PUBLIC_BUILDING_PREMISES	8	3	
0158	Biblioteca Francesc Candel	PUBLIC_BUILDING_PREMISES	6	3	
0160	Seu Districte Sants	PUBLIC_BUILDING_PREMISES	11	3	
0161	Seu Districte Sarrià	PUBLIC_BUILDING_PREMISES	2	2	
0162	Seu Districte Sant Andreu	PUBLIC_BUILDING_PREMISES	2	1	
0163	Seu Districte Gracia	PUBLIC_BUILDING_PREMISES	10	4	1
0174	Palau de Foronda	PUBLIC_BUILDING_PREMISES	1		
0175	CEIP Pau Vila	PUBLIC_BUILDING_PREMISES	2	1	

The adapted EMS provides the following services to the platform:

Table 18 – BCN Public Buildings EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION POSITION_POINT
EntityService	ALL	ORGANISATION PUBLIC_BUILDING_PREMISES NETWORK_ANALYSER WEATHER_STATION_UNIT PV_GENERATING_UNIT
MetricService	ALL	ENTITY_COUNT ENTITY_USED ENERGY_PRICE_PER_KWH ENERGY_CONSUMPTION ENERGY_PRODUCTION POWER_FACTOR PHASE_POWER_FACTOR_A PHASE_POWER_FACTOR_B PHASE_POWER_FACTOR_C CURRENT PHASE_CURRENT_A PHASE_CURRENT_B PHASE_CURRENT_C ACTIVE_POWER PHASE_ACTIVE_POWER_A PHASE_ACTIVE_POWER_B PHASE_ACTIVE_POWER_C REACTIVE_POWER PHASE_REACTIVE_POWER_A PHASE_REACTIVE_POWER_B PHASE_REACTIVE_POWER_C PHASE_VOLTAGE_A PHASE_VOLTAGE_B PHASE_VOLTAGE_C TEMPERATURE RELATIVE_HUMIDITY AC_FREQUENCY MAX_PEAK_POWER_DEMAND

3.10.4. Best integration practices and lessons learned

The integration of this EMS was completed during the 1st phase of development. It supposed a change in relation to other EMSs integrated by ETRA, as it was the first one where data was not initially available, but kept arriving periodically by means of subscription services. This meant the development of not only the GW between the EMS and BESOS, but also the service in charge of receiving messages from Sentilo and storing them locally.

During this second process, several test were made before setting up the communication with the platform in Barcelona. These efforts –and the problems that arose during the process– eventually provided the experience to work with Sentilo in the integration of subsequent EMSs.

3.10.5. Summary: the “do’s and don’ts” of the integration

When data is not available in a remote repository but you have to store it instead, do shape the way to do it –technology chosen, format of the records, data adaptation, etc.– so it best fits its future usage.

Whenever possible, do work with platforms or other open software that could potentially make easier the integration of future EMSs.

3.11. Public Buildings managed by Sodexo, Barcelona

3.11.1. Introduction

Besides other activities, which range from construction works to food services, Sodexo maintenance activities support the everyday functioning of more than 200 educational centers just in the area of Catalonia. Maintenance tasks include monitoring and control over elemental systems such as lighting or air conditioning.

3.11.2. System description

While specific details of each building may differ slightly, the following figure represents the general architecture of a building management systems controlled by Sodexo in Barcelona:

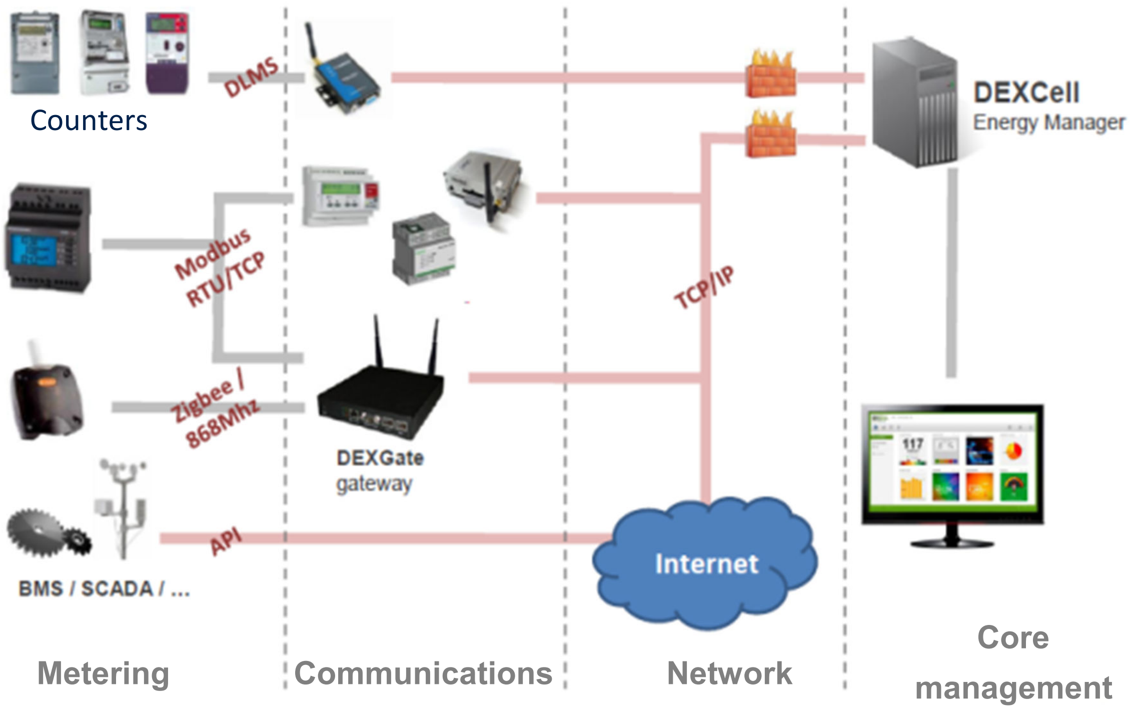


Figure 29 – BCN Sodexo Buildings EMS typical building architecture

Four different logical layers can be distinguished:

- **Metering layer:** Consists of all the hardware measuring the different values in the building (voltage, luminosity, temperature, energy consumption/production, etc.) and the SCADA-like system controlling all of them.
- **Communications layer:** While some of the devices in the metering layer (e.g., the

SCADA system) already have communication functionalities, many other basic devices cannot send their metrics outside the LAN. For this purpose, different assets (GPRS modems, Ethernet gateways, etc.) are deployed in the communications layer, acting as intermediaries between the meters and the central information repository.

- **Network layer:** Devices from lower layers periodically send their information to the Energy Manager through the Internet. It includes the appropriate security measures (firewalls, encryption, etc.).
- **Core management layer:** A central manager constantly receives measurements and information from every building managed by Sodexo. The stored information can be browsed using an existing web UI with statistical functionalities.

3.11.3. System Architecture

During the 1st phase of EMS adaptation, only historical data from the buildings could be added due to the lack of direct communication with their monitoring systems. For this reason, the main purpose during the 2nd adaptation phase was to acquire real-time data from those buildings. This goal was successfully achieved by installing a circuit board especially developed and produced for BESOS, which permits reading and sending measurements from the analyser.

The BETRA circuit board includes the necessary hardware and software to read data from a set of equipment using the MODBUS protocol. The main interfaces the circuit board exposes to interact with it are explained below:

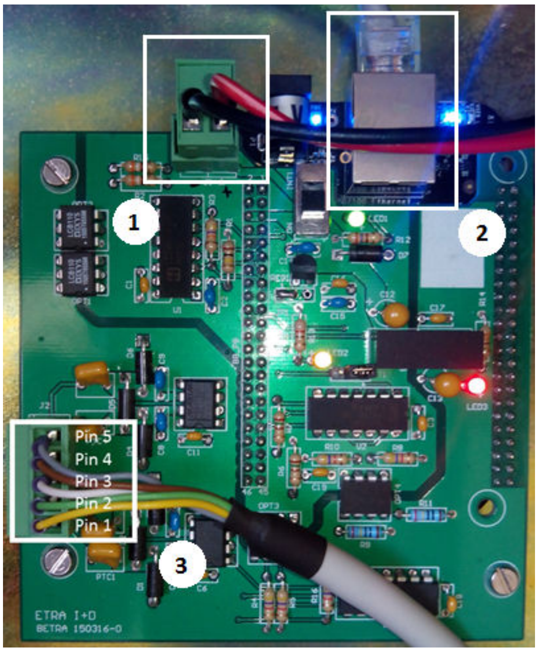


Figure 30 – BETRA components diagram

1. **Power:** The BETRA circuit board needs a 5V@1A power source that must be connected as shown in the last figure.
2. **Internet connection:** The board needs to be connected to the Internet using its Ethernet connector. This connection can be configured via SSH and is used by the board to send the measurements read from the local network.

3. **MODBUS connection:** The connection to the local network is established through a 5-pin connector included in the board.

In the case of Sodexo buildings EMS, the bus was already in use by the equipment already in place, so the BETRA had to coexist with it assuring that both devices could read data without conflicts accessing the bus. In this case, two RS-485 two-wire buses were used for connection, one of them between the BETRA board and the existing network analysers, and the other between the BETRA board and the master device:

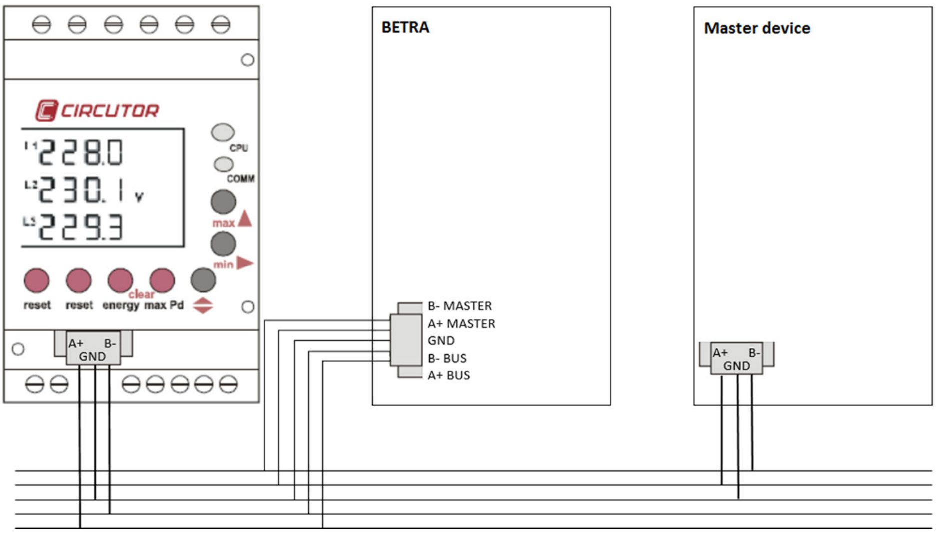


Figure 31 – BETRA circuit board connection schema (with a master device)

The normal operation process of the board in this case is the following:

- The BETRA board is continuously listening to the requests from the master device through a dedicated serial port.
- When the BETRA board starts, it waits for the master device to make two consecutive requests. By analyzing the times, the time window the master device uses to read data is estimated. This time window – with an added 10 second margin before and after – will be observed and taken into account during the normal functioning of the board. The BETRA board only starts requesting data once it has the necessary information to estimate these time windows.
- When functioning normally, the software in the BETRA board requests data to the bus during the periods it is not being used by the master device. If the bus is busy, the board waits for the master device to finish and sends it request after at least 10 seconds of bus silence.
- In every moment the hardware of the BETRA board checks that both devices can access the bus without conflicting each other.

3.11.4. Provided entities and services

The list of integrated buildings from this EMS is provided below. The ones where a BETRA board was installed, and subsequently provide real-time data, are marked as such.

Table 19 – BCN Sodexo Buildings EMS Provided Entities

Unique Name or ID	Readable name	Entity type	BETRA
BcnSodexoBuildings	Sodexo buildings EMS	ORGANISATION	-

CapCervello	Cervelló primary health care center	PUBLIC_BUILDING_PREMISES	Yes
CapGracia	Gràcia primary health care center	PUBLIC_BUILDING_PREMISES	No
EoiSabadell	Official language school in Sabadell (Barcelona)	PUBLIC_BUILDING_PREMISES	No
Filmoteca	Film institute of Catalonia	PUBLIC_BUILDING_PREMISES	Yes
IesCanMargarit	Can Margarit secondary school	PUBLIC_BUILDING_PREMISES	Yes
IesSantEsteve	Sant Esteve Sesrovires secondary school	PUBLIC_BUILDING_PREMISES	No
IesTuro	Turó d'en Baldiri secondary school	PUBLIC_BUILDING_PREMISES	No
Infraestructures	Headquarters of Infraestructures de Catalunya	PUBLIC_BUILDING_PREMISES	Yes
UpcCampusNord	North Campus of Polytechnic University of Catalonia	PUBLIC_BUILDING_PREMISES	Yes
ArxiuMunicipal	Archive of Government Documentation of Barcelona	PUBLIC_BUILDING_PREMISES	Yes
Orlandai	Casa Orlandai culture and leisure center	PUBLIC_BUILDING_PREMISES	Yes
BibliotecaRoquetes	Les Roquetes library	PUBLIC_BUILDING_PREMISES	Yes
BibliotecaAgustiCentelles	Agustí Centelles library	PUBLIC_BUILDING_PREMISES	Yes
TomasaCuevas	Tomasa Cuevas - Les Corts culture and leisure center	PUBLIC_BUILDING_PREMISES	Yes
CanDeu	Can Déu culture and leisure center	PUBLIC_BUILDING_PREMISES	Yes

The adapted EMS provides the following services to the platform:

Table 20 – BCN Sodexo Buildings EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION POSITION_POINT
EntityService	ALL	ORGANISATION PUBLIC_BUILDING_PREMISES NETWORK_ANALYSER WEATHER_STATION_UNIT HVAC
MetricService	ALL	ENTITY_COUNT ENTITIES_USED ENERGY_PRICE_PER_KWH ENERGY_CONSUMPTION CO2_EMISSIONS ENERGY_COST POWER_FACTOR PHASE_POWER_FACTOR_A

		PHASE_POWER_FACTOR_B PHASE_POWER_FACTOR_C CURRENT PHASE_CURRENT_A PHASE_CURRENT_B PHASE_CURRENT_C ACTIVE_POWER PHASE_ACTIVE_POWER_A PHASE_ACTIVE_POWER_B PHASE_ACTIVE_POWER_C REACTIVE_POWER PHASE_REACTIVE_POWER_A PHASE_REACTIVE_POWER_B PHASE_REACTIVE_POWER_C VOLTAGE PHASE_VOLTAGE_A PHASE_VOLTAGE_B PHASE_VOLTAGE_C AC_FREQUENCY INSIDE_TEMPERATURE OUTSIDE_TEMPERATURE INSIDE_RELATIVE_HUMIDITY OUTSIDE_RELATIVE_HUMIDITY INFLOW_TEMPERATURE OUTFLOW_TEMPERATURE POWER_ON_LEVEL INFLOW_RELATIVE_HUMIDITY OUTFLOW_RELATIVE_HUMIDITY

3.11.5. Best integration practices and lessons learned

Sodexo buildings was for ETRA one of the most challenging and rewarding EMSs to integrate in terms of lessons learned, as not only software but also hardware development was involved in the process.

Having that the equipment already installed in the buildings could differ among themselves, the BETRA board was designed to have the flexibility to interact with different vendors and allow an easy configuration to add new models. Moreover, its installation –as explained in previous sections– was kept as simple as possible, as it is able to configure itself once it is connected.

Finally, the measurements read by the board are sent to a remote configurable queue, thus allowing its subsequent read and/or storage open to multiple possibilities.

3.11.6. Summary: the “do’s and don’ts” of the integration

Do work together with the facility manager to reach the better solution to accomplish the integration of their system.

Don’t allow hindrances in the process block the integration of the EMS. Try any alternative solution to achieve the acquisition of data.

Do design your prototypes with flexibility in mind. Anticipate the possibility of interacting with different vendors and prepare your system to easily accept new configurations.

3.12. Public Lighting energy consumption, Barcelona

3.12.1. Introduction

The Municipality of Barcelona is responsible for the correct functioning and maintenance of the public lighting system of the city. The functionalities of the public lighting system implemented in Barcelona are:

- Monitoring the actual status of the existing segments and point of light controllers: status of communication, alarms, intensity levels, electrical parameters, consumption and status.
- Defining timetables associated to segments and/or point of light controllers. These calendars set intervals of time and the associated levels of power or light intensity.
- Collecting data of the electrical measurements of the segments controllers and points of light and storing it in a database for statistical purposes.
- Reporting the consumption by point of light and segment controller. In the case of segments controllers, the reports are based on aggregated data of each point of light managed by the segment controller.
- Maintaining a hierarchical structure of the strategic activation units.
- Implementing strategies for the reduction of consumption of the segment controllers or the point of light controllers in response to a demand by the operator.
- Implementing strategies to maintain the intensity of the light depending on the weather conditions and other external factors.

3.12.2. System Architecture

The information from this EMS is accessed through Sentilo, the smart open-source platform from the Municipal Institute of Informatics (IMI). It had already been used in BESOS to obtain data from other EMSs, e.g. Municipality Buildings in Barcelona.

The gateway for the public lighting system acts as a top-level application in the Sentilo architecture. By means of subscription services, the gateway receives measurements from the different sensors that were agreed with the IMI to be included in the project. These sensors send new measurements periodically to a dedicated service that stores them locally to create a repository from which fulfill the requests coming from the OTESP and the applications on top of it..

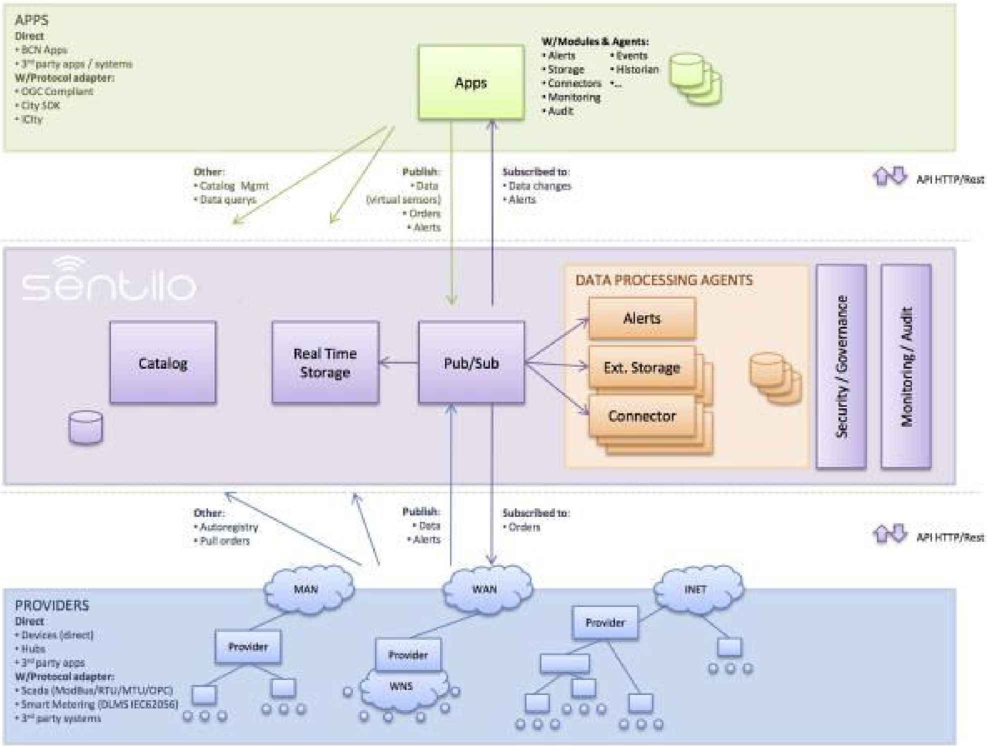


Figure 32 – Sentilo architecture

3.12.3. Provided entities and services

The EMS provides the following entities to the platform.

Table 21 – BCN Public Lighting EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
BcnPublicLighting	Barcelona public lighting system	ORGANISATION	The complete EMS.
1192	Gran Via Corts Catalanes, s/n (near Llacuna)	SEGMENT_CONTROLLER	Segment controller, controls 90 points of light
1996	València, 592	SEGMENT_CONTROLLER	Segment controller, controls 32 points of light
2032	Selva de Mar, 186	SEGMENT_CONTROLLER	Segment controller, controls 100 points of light
2304	Av. Meridiana, 592	SEGMENT_CONTROLLER	Segment controller, controls 63 points of light
6568	Llull, 190	SEGMENT_CONTROLLER	Segment controller, controls 71 points of

			light
6870	Pl. Diamant, 1 (between València and Mallorca)	SEGMENT_CONTROLLER	Segment controller, controls 91 points of light
7894	Pg. Gràcia, 68 (between Provença and Mallorca)	SEGMENT_CONTROLLER	Segment controller, controls 47 points of light
7895	Pg. Gràcia, 87 (between València and Mallorca)	SEGMENT_CONTROLLER	Segment controller, controls 70 points of light
7896	Pg. Gràcia, 61 (between Provença and Mallorca)	SEGMENT_CONTROLLER	Segment controller, controls 45 points of light
7897	Pg. Gràcia, 90 (between Aragó and Corts Catalanes)	SEGMENT_CONTROLLER	Segment controller, controls 64 points of light
7913	Pg. Gràcia, 33 (between Aragó and Corts Catalanes)	SEGMENT_CONTROLLER	Segment controller, controls 69 points of light
7914	Pg. Gràcia, 42 (between Aragó and Corts Catalanes)	SEGMENT_CONTROLLER	Segment controller, controls 71 points of light
7927	Pg. Sant Joan, 78 (between Aragó and Consell de Cent)	SEGMENT_CONTROLLER	Segment controller, controls 54 points of light
7937	Sa Tuna, s/n (between S'Agaro and Meridiana)	SEGMENT_CONTROLLER	Segment controller, controls 60 points of light
7960	Gran Via Corts Catalanes, s/n (between Diagonal and Ciutat de Granada)	SEGMENT_CONTROLLER	Segment controller, controls 112 points of light

The adapted EMS provides the following services to the platform:

Table 22 – BCN Public Lighting EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION

		POSITION_POINT
EntityService	ALL	ORGANISATION SEGMENT_CONTROLLER NETWORK_ANALYSER
MetricService	ALL	ENERGY_CONSUMPTION ACTIVE_POWER POWER_FACTOR ENERGY_CONSUMPTION_REACTIVE REACTIVE_POWER VOLTAGE CO2_EMISSIONS ENERGY_COST

3.12.4. Best integration practices and lessons learned

Originally, the collaboration with the Municipality of Barcelona was the connecting point for the integration of the public lighting system of the city as a data source in the project during phase 1 of the EMS adaption. However, as this collaboration faced some difficulties that delayed the required steps for the system to be adapted, a decision was taken to integrate instead a simulated system that temporarily provided the necessary information to the rest of the BESOS environment.

During phase 2 of the EMS adaption, the Municipal Institute of Informatics (IMI) took the responsibility of providing the access to the real public lighting system in Barcelona. The information from this EMS was agreed to be accessed through Sentilo, as it was better for both parties: ETRA already had the know-how to integrate with the platform, and the IMI added a new partner –the manager of the public lighting system– to join their system.

3.12.5. Summary: the “do’s and don’ts” of the integration

Don’t let bottlenecks to delay dependent developments. Try to find a temporary solution (e.g. simulation) and be ready to change it when the real system is available.

Do work with known systems when possible, provided that you can assess they are a suitable solution for your problem.

3.13. Electric Vehicle charging points energy consumption, Barcelona

3.13.1. Introduction

The electric vehicle infrastructure implemented in Barcelona consists on a platform that enables the monitoring and management of the electric vehicles charging points located on the thoroughfare. This platform is designed not only for the management of a small group of charging stations, but for the management of a large system, covering the whole city.

3.13.2. System Architecture

This is the internal architecture of the electric vehicle management system as it is currently deployed.

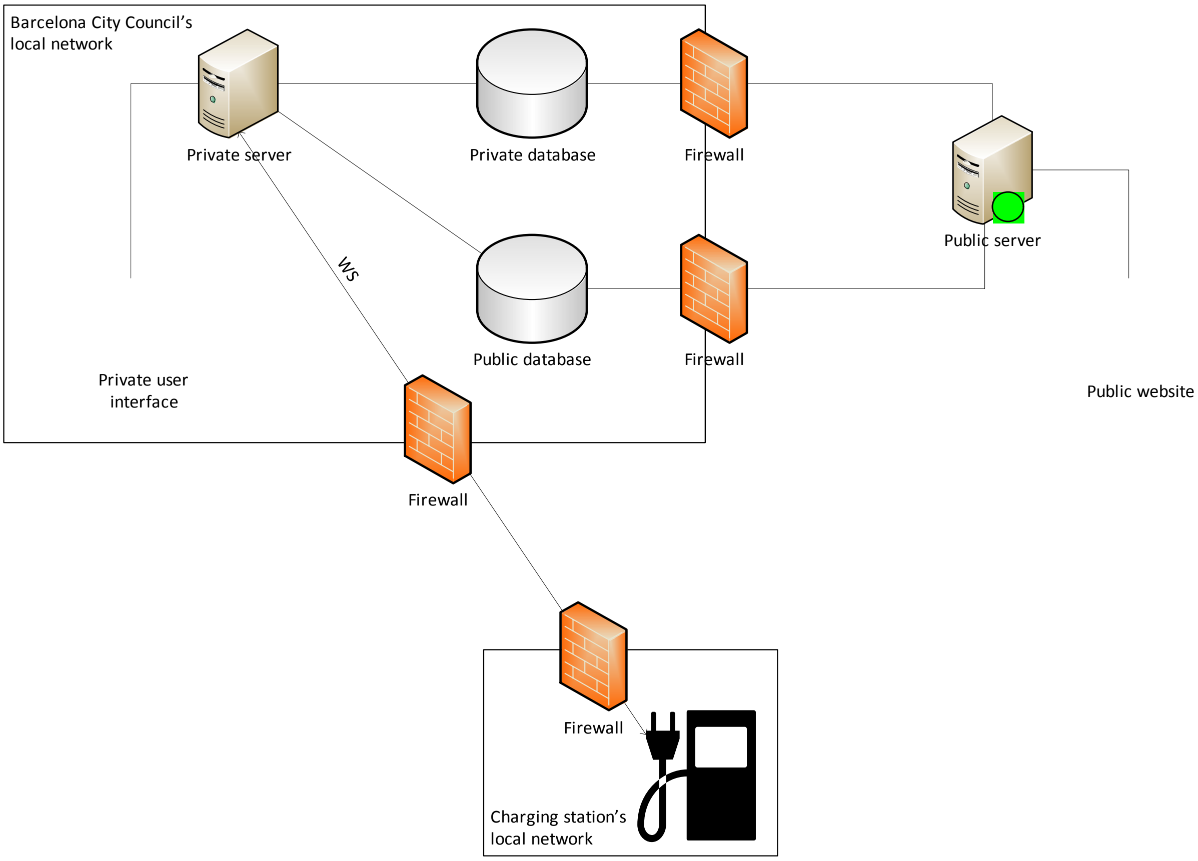


Figure 33 – BCN Electric Vehicle EMS system architecture

The EMS GW interacts with a SOAP service that provides the measurements of the different charging stations integrated in the system.

3.13.3. Provided entities and services

The EMS provides the following EV charging points to the platform. The number of plugs on each point is indicated as well.

Table 23 – BCN Electric Vehicle EMS Provided Entities

Unique Name or ID	Readable name	Entity type	Plugs
BcnElectric Vehicle	Barcelona electric vehicle management system	ORGANISATION	-
PRC1	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC10	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1011	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1012	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1013	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1021	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1022	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2

PRC1023	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1031	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1032	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1033	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1041	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1042	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1043	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1051	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1052	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1053	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1054	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1055	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	1
PRC1061	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1062	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1063	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1064	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1065	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	1
PRC1071	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1072	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1073	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1074	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1075	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	1
PRC1081	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1082	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1083	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1084	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC1085	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	1
PRC11	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2011	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2021	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2031	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2041	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2051	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2061	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2071	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2081	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2091	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2101	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2111	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2121	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2131	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2141	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2151	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2161	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2171	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2181	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2191	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2201	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2211	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2221	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2

PRC2231	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2241	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2251	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2261	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2271	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC2281	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC3	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC3001	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC4	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC5	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC5001	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC6	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC8	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2
PRC9	Charging point	ELECTRIC_VEHICLE_CHARGING_POINT	2

The adapted EMS provides the following services to the platform:

Table 24 – BCN Electric Vehicle EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION POSITION_POINT EQUIPMENT_INFORMATION
EntityService	ALL	ORGANISATION ELECTRIC_VEHICLE_CHARGING_POINT ELECTRIC_VEHICLE_PLUG
MetricService	ALL	ENTITY_COUNT ENTITY_USED ENERGY_PRICE_PER_KWH ENERGY_CONSUMPTION CO2_EMISSIONS ENERGY_COST

3.13.4. Best integration practices and lessons learned

The adaption of the electric vehicle system in Barcelona was among the first ones to be completed and the integration of its services into BESOS was easy and did not led to major problems. The main concern with this EMS was the small amount of data generated in the system, which unfortunately has been constant throughout the project.

3.13.5. Summary: the “do’s and don’ts” of the integration

Do integrate first those EMSs that are straightforward, as the experience gathered would help you with more complex ones.

Do inquire into the source of your data to find out whether the values you are receiving are correct or come as a result of any problem.

3.14. Traffic Information System, Barcelona

3.14.1. Introduction

Among many other areas of the city, the Municipality of Barcelona manages the multiple services, tasks and infrastructures that surround the traffic system in Barcelona. Information from this service was adapted and incorporated into BESOS, including both the traffic status and the consumption of the system in a set of streets within the Barcelona pilot site.

3.14.2. System Architecture

The adaptation of the traffic system in Barcelona takes two different directions according to the two types of information that want to be gathered from the system: traffic status information on the one hand, consumption and electrical measurements of the traffic system on the other.

For the traffic status information, the BESOS system – and specifically the Traffic System Gateway implemented for this adaptation – is agnostic about the vast infrastructure that is in place along the Catalan road system in order to acquire the necessary data to monitor the traffic in this area.

Information about the current status of the traffic in the streets of Barcelona included in the project is periodically sent to a FTP in the form of an XML file. A dedicated service reads from this FTP and stores the updated information in a local data base, which is then used as the main repository of data to be provided to the OTESP via its different web services. An intermediate module is responsible for managing requests coming from the OTESP and forwarding responses in the adequate form.

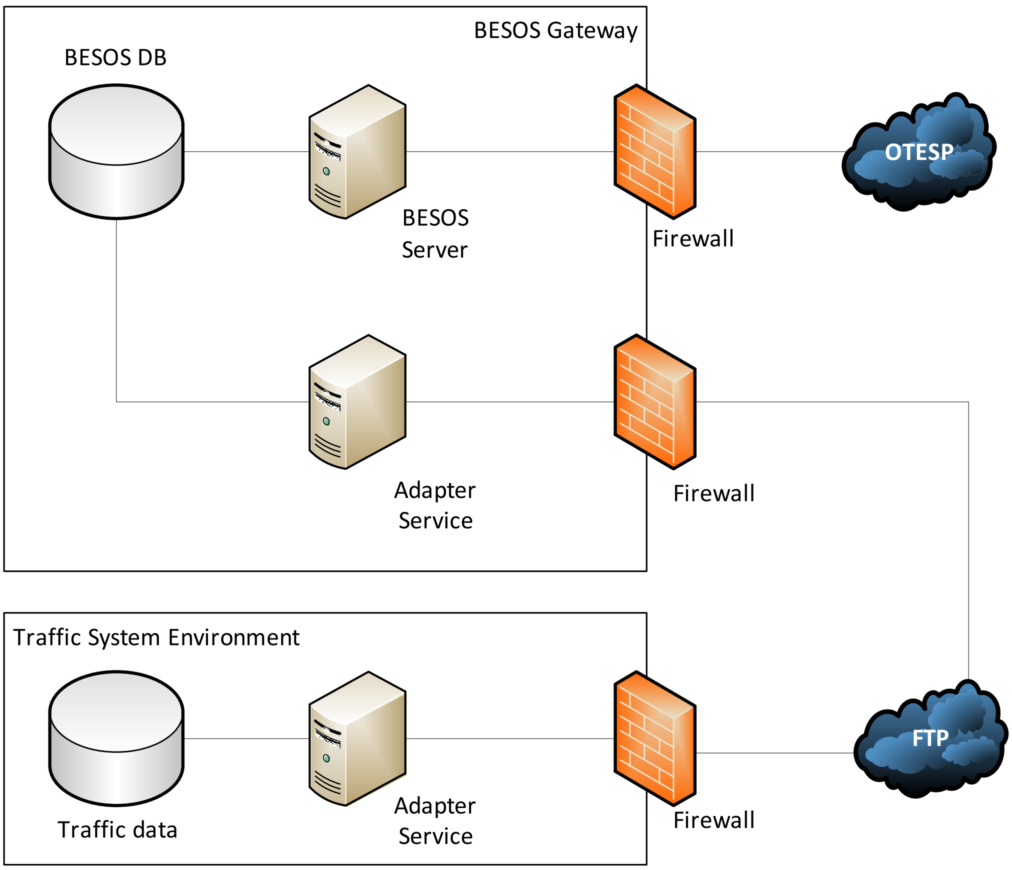


Figure 34 – BCN Traffic Information System architecture

In the case of the consumption and electrical information, a bigger effort had to be made in order to gather the measurements, as the data was not available from the Catalan traffic service.

The main goal was not to obtain measurements from every single traffic light – as they are not operated individually, such level of detail was not required. Instead, the approach taken for this adaption was to install the equipment at the cabinets where the traffic controller systems are located. In particular on each cabinet, a network analyser was installed to measure the different parameters of the system, and a BETRA circuit board, whose details were previously explained in section 3.9.3.

3.14.3. Provided entities and services

The EMS provides to the platform consumption information from 16 traffic light cabinets (162 traffic lights) and traffic density information from 491 road lanes. Due to this number of entities and to improve the structure of the present document, the full list of entities can be found in Annex I.

The adapted EMS provides the following services to the platform:

Table 25 – BCN Traffic Information System Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	ALL	ORGANISATION_INFORMATION POSITION_POINT PATHWAY
EntityService	ALL	ORGANISATION SEGMENT_CONTROLLER NETWORK_ANALYSER ROAD_SYSTEM ROAD_LANE
MetricService	ALL	ENTITY_COUNT ENTITY_USED ENERGY_PRICE_PER_KWH ENERGY_CONSUMPTION CO2_EMISSIONS ENERGY_COST TRAFFIC_DENSITY

3.14.4. Best integration practices and lessons learned

The integration of the traffic information service in Barcelona took two different paths in order to acquire two different types of data. While one of them –traffic density data through FTP communications– was a proposed by the manager of the system, the reuse of the BETRA board –originally designed for a different EMS– was a proffer from ETRA to both put into practice the lessons learned in previous integration processes and provide added value to its hardware. Thanks to the ease in the configuration of new equipment models to the board, the integration with the street cabinets was straightforward and proved to be a suitable solution.

3.14.5. Summary: the "do's and don'ts" of the integration

Do work with the manager of the system to decide the best solution to integrate their data. Propose working with technologies you know can be suitable and will make things easier.

3.15. Cobra CECOVI Center, wind energy production, Barcelona & Lisbon

3.15.1. Introduction

Both wind farms, P. E. Viudo I (Valencia) and P. E. Montegordo (Huelva), are operated by CECOVI, belonging to COBRA.

In Phase 1, the system (EMS) developed by COBRA did not support real-time data, only historical data. This objective (real-time data) is achieved in Phase 2.

In Phase 2, the COBRA's EMS already support real-time data and it's totally integrated with OTESP. Besides, in this second phase, EMS is able to supply more electrical metrics, such as reactive power, current, voltage and power factor. At this time, the COBRA's EMS is operative 24/7. The historical data is available from 01/01/2012.

3.15.2. System description

CECOVI (which means "Villadiego Control Center") is the control center that operates and monitors the renewable plants of the COBRA group. The main target of CECOVI, is to comply with the Spanish state regulation, which requires that all installations of renewable power with more than 10 MW of installed capacity must be associated with a control centre of generation, which act as an interlocutor with the system operator (REE: RED ELÉCTRICA OF SPAIN), sending real-time information on the facilities and running their instructions in order to ensure at all times the stability of electrical system.

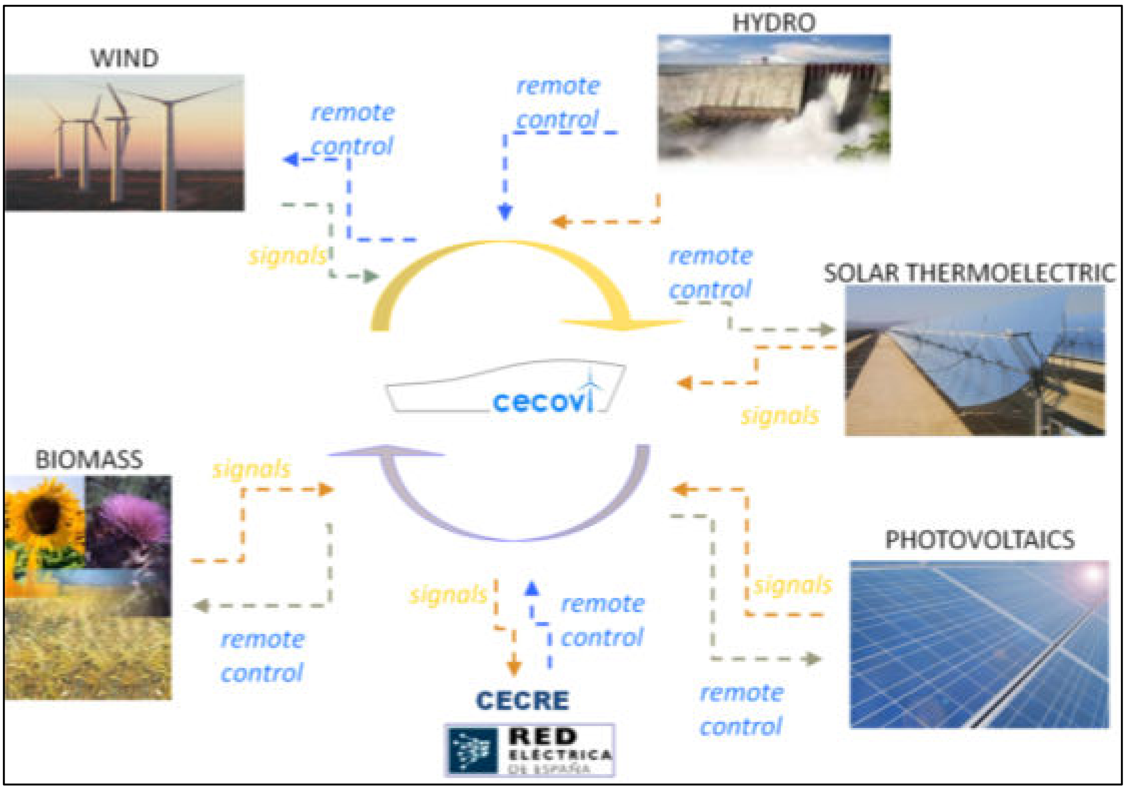


Figure 35 – View of Real Time Control of Power Units from CECOVI

With this purpose, CECOVI send in real time, with a periodicity of 12 seconds, to the Control Centre of the System Operator (CECRE), at least, the following information for each installation:

- Active Power
- Reactive Power
- Connection Status of the generator with the electric network.
- Voltage measurement.

In addition, in the case of the wind farms, is also sending with the periodicity already indicated, the following measure information as a representative point of the Wind Farm:

- Wind Speed (intensity and direction)
- Temperature

For that purpose, the control system of the CECOVI, called CECOGER performs the following functions:

- Captures the information from each generator which is part of the wind facility. This information will be sent in an aggregate manner by facility to an external supervisor.
- Ensure consistency in the topology information and measures of a generator what is being supplied.

In addition, the CECOGER is able to execute the marching orders in an automated way, over generating facilities, ensuring, all time, the compliance and keeping of these requests.

The database of CECOVI, stores not only the data from the generation facilities, but also the orders of external action. The CECOGER displays at all times, through its interface, the instantaneous values of the main data of the generation facilities, as well as the information or instructions you receive from the outside, keeping this information visible, while the orders are active.

With system descripted before, COBRA has all necessary resources to maintain, exploit and support the complete metrics requested from OTESP, by using computers on which is running the EMS of COBRA, formed by electronic communications, and servers, both data-bases and applications.

3.15.3. System Architecture

The COBRA resources consist of:

- Wind Farm Viudo I with 40MW of power installed, located in Valencia.
- Wind Farm Montegordo with 48MW, located in Huelva.
- Remote Control Centre, CECOVI, located in Burgos.

Both wind farms are equipped with data collectors and systems to store and send them to CECOGER (information system of CECOVI).

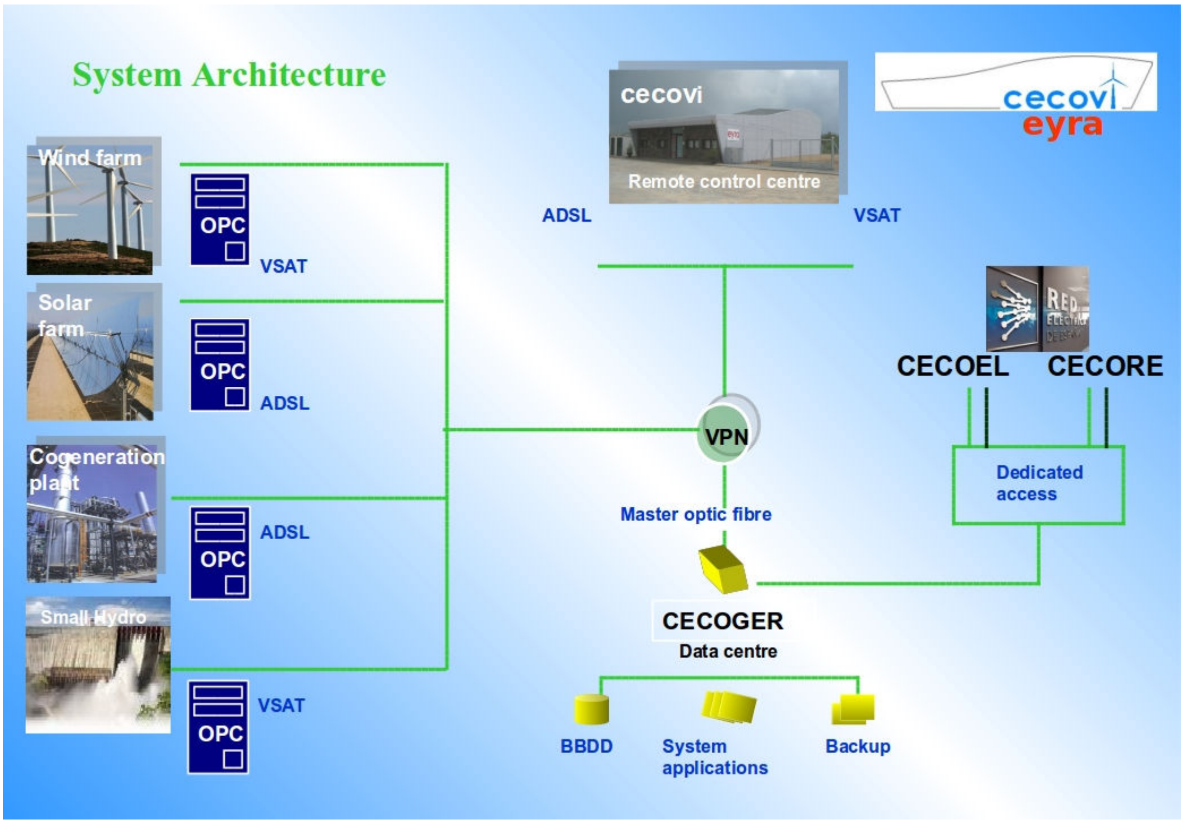


Figure 36 – COBRA Power Plants EMS system architecture

3.15.4. Provided entities and services

The EMS provides the following entities to the platform.

Table 26 – COBRA Power Plants EMS Provided Entities

Unique Entity ID	Readable name	Entity type	Notes
COBRA	COBRA	ORGANISATION	Root Entity
VIUDO	ENERGY_PLANT_VIUDO	GENERATION_UNIT	Child Entity
MONTEGORDO	ENERGY_PLANT_MONTEGORDO	GENERATION_UNIT	Child Entity
WF_VIUDO	WIND_FARM_VIUDO_I	WIND_GENERATING_UNIT	Sub Entity
WS_VIUDO	WEATHER_STATION_VIUDO_I	WEATHER_STATION	Sub Entity
WF_MONTEGORDO	WIND_FARM_MONTEGORDO	WIND_GENERATING_UNIT	Sub Entity
WS_MONTEGORDO	WEATHER_STATION_MONTEGORDO	WEATHER_STATION	Sub Entity

The adapted EMS provides the following services to the platform:

Table 27 – COBRA Power Plants EMS Provided Services

Provided Service	Supported EMS ID	Supported Types
AttributeService	COBRA VIUDO MONTEGORDO WF_VIUDO WS_VIUDO WF_MONTEGORDO WS_MONTEGORDO	ORGANISATION_INFORMATION ENTITY_INFORMATION WIND_GENERATION_UNIT_INFORMA TION
EntityService	COBRA VIUDO MONTEGORDO WF_VIUDO WS_VIUDO WF_MONTEGORDO WS_MONTEGORDO	ORGANISATION WIND_GENERATION_UNIT WEATHER_STATION_UNIT
MetricService	COBRA VIUDO MONTEGORDO WF_VIUDO WS_VIUDO WF_MONTEGORDO WS_MONTEGORDO	ENTITY_COUNT ENTITY_USED ENERGY_PRICE_PER_KWH ACTIVE_POWER ACTIVE_POWER_MAX ACTIVE_POWER_MIN ENERGY_PRODUCTION REACTIVE_POWER CURRENT VOLTAGE POWER_FACTOR WIND_DIRECTION WIND_SPEED WIND_GUST OUTSIDE_TEMPERATURE ATMOSPHERIC_PRESSURE

3.15.5. Best integration practices and lessons learned

Ease of development thanks to the detailed documentation of use cases and the use of open technologies with a huge public documents, such as web technologies. These, along with a deep and worked API documentation used, allows the integration of all parts of the system.

Furthermore, with the agreement of distributed databases, each owner of EMS is responsible for security, maintenance and backup of such information, and provide any necessary equipment to do their part. This ensures a sharing of expenses.

3.15.6. Summary: the "do's and don'ts" of the integration

Do perform all necessary meetings to evaluate and design a solution.

Do a good analysis of requirements to understand which activities are necessary to develop.

Do an extensive and detailed list of use cases to make the right decisions about system architecture and task sharing.

Do not perform integration until all individual tests are correct, both over the system on which runs the environment, such as the development work.

Do not perform tests of global integration without the participation of all the parties involved

4. Strategies and recommendations of EMS integrations

This section describes the strategies and integration recommendations for such an amount of heterogeneous EMS system from a birds view. The spectrum of different EMS covered by this project is very wide. It covers the whole bandwidth from the integration of the RE power production of PV and wind production EMS, over a lot of different power consumption EMS such as HVAC of public buildings, public lightning and public power charging points of Electric Vehicles (EV) in two big metropolitan regions of two countries.

The key factors for the successful implementation of such a challenging project are:

- Crystal clear goals and use cases
  The project goals and use cases where developed in the phase 1 and 2. During the runtime of the project, it was very useful in each phase to check that the current work is according to the project goals and use goals.

- Regular project meetings and phone conferences
  During the project life time it was important to held face to face meetings, visit the demo sites and holding regular phone conferences.

- Design simple data formats and simple business rules
  One success factor is a simple but efficient design for business rules and data formats. The rules should be so simple that everybody can understand them easily. A simple design has the benefit that there is less room for interpretations and this makes the assembling much easier. The BESOS project has integrated a wide spectrum of different EMS – some were legacy EMS, which needed an extra hardware to be integrated. So the ensemble task to integrate all this different EMS is much easier with a simple but efficient design.

- Be prepared for the unexpected
  The project should be prepared to manage some unexpected events, e.g. the change or the bankruptcy of a supplier. The bankruptcy of the supplier Conergy was an unexpected issue that had to be managed. This kind of issues should be taken into account for further projects.
  One possible solution could be to provide the necessary hardware within the consortium. Another option might be to establish a service agreement with an independent third party or solution provider as a backup.
  To lower the project risks, at least one of the options should be taken into account.

- Data validation / data quality
  Perform or establish a process which takes care about the data validation or data quality. Scope of the process is to monitor or to get information of the data quality. The data received by data loggers are sometimes faulty. It is important to establish this process and get this information early as possible.

- QoS of the data provisioning / Monitoring
  Perform or establish a process which monitors the data provisioning. The idea is to detect a broken data route early. Complex systems like BESOS rely on the data flow. If one data route is disturbed (e.g. a data logger is broken or an upload route is damaged), this could have consequences to a lot of work flows and use cases. A possible counter measurement is to establish a monitoring process for the data provisioning.

- Data relevant topics

The following topics are more IT-related, but also relevant. They help to prevent some unpleasant and avoidable errors.

  - Time zone issues: Projects that are running in different time zones and/or using time series with daylight saving times are always sensitive for time zone problems. This could be avoided by using either UTC as default time zone or provide the time zone information in all-time series. The time zone information should be provided in a standard such as the IANA standard.

  - Entity management / Time series orientation: When dealing with time series, it is always helpful that entity management services provide information such as the unit or the orientation of the corresponding time series. With this kind of service a mix up between “kW” and “kWh” can be easily detected.

  - Versioned or time based master data: Sometimes a master data has temporary component, e.g. the amount of PV systems installed in Barcelona. The number and the nominal capacity of all PV systems installed in Barcelona varies during the runtime of project.
    It is necessary to identify such “time based” master data and provide an API to access the data for a specific time stamp.

5. Conclusion

The spectrum of different EMS covered by this project is very wide. It covers the whole bandwidth from the integration of the RE power production of PV and wind production EMS, over a lot of different power consumption EMSs, such as HVAC of public buildings, public lightning and public power charging points of Electric Vehicles (EV) in two big metropolitan regions of two countries.

The aspect of the power consumption forecast for the buildings is an interesting aspect. Together with the other aspects of this project, it provides a lot of opportunities and business cases for many stakeholders, e.g. if the power consumption and the production information is available in the cockpit, the stakeholder can generate many new use cases.

The methods developed in this project are the first step to create smart energy efficient regions. To achieve the goals of the climate protocols it is important to reduce to CO2 emissions. Projects such as BESOS provide the necessary information to the stakeholders to achieve this goal.

Annex I: List of entities provided by the Barcelona Traffic Information System

Table 28 – BCN Traffic Information System Provided Entities

Unique Name or ID	Readable name	Entity type	Notes
BcnTrafficStatus	Traffic information System	ORGANISATION	EMS providing traffic status information.
BcnTrafficConsumption	Traffic information System	ORGANISATION	EMS providing consumption and electrical information from the traffic system.
RoadSystem	Road system	ROAD_SYSTEM	Child of BcnTrafficStatus.
Almogavers1	Almogàvers (Badajoz to Marina)	ROAD_LANE	Child of RoadSystem
Almogavers2	Almogàvers (Marina to Passeig Lluís Companys)	ROAD_LANE	Child of RoadSystem
Arago1	Aragó (Balmes to Urgell)	ROAD_LANE	Child of RoadSystem
Arago2	Aragó (Cartagena to Diagonal)	ROAD_LANE	Child of RoadSystem
Arago3	Aragó (Diagonal to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Arago4	Aragó (Meridiana to Cartagena)	ROAD_LANE	Child of RoadSystem
Arago5	Aragó (Passeig de Sant Joan to Pau Claris)	ROAD_LANE	Child of RoadSystem
Arago6	Aragó (Pau Claris to Balmes)	ROAD_LANE	Child of RoadSystem
Arago7	Aragó (Urgell to Tarragona)	ROAD_LANE	Child of RoadSystem
Aribau1	Aribau (Aragó to Diagonal)	ROAD_LANE	Child of RoadSystem
Aribau2	Aribau (Diagonal - Via Augusta)	ROAD_LANE	Child of RoadSystem
Aribau3	Aribau (Pl. Universitat to Aragó)	ROAD_LANE	Child of RoadSystem
AristidesMaillol1	Aristides Maillol (Av. Doctor Marañón to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
AristidesMaillol2	Aristides Maillol (Travessera de les Corts to Av. Doctor Marañón)	ROAD_LANE	Child of RoadSystem
ArnauOms	Arnau d'Oms (Escòcia to Fabra i Puig)	ROAD_LANE	Child of RoadSystem

BacRoda1	Bac de Roda (Gran Via to Clot)	ROAD_LANE	Child of RoadSystem
BacRoda2	Bac de Roda (Gran Via to Pere IV)	ROAD_LANE	Child of RoadSystem
BacRoda3	Bac de Roda (Guipúscoa to Gran Via)	ROAD_LANE	Child of RoadSystem
BacRoda4	Bac de Roda (Pere IV to Gran Via)	ROAD_LANE	Child of RoadSystem
BacRoda5	Bac de Roda (Pere IV to Ronda del Litoral)	ROAD_LANE	Child of RoadSystem
BacRoda6	Bac de Roda (Ronda Litoral to Pere IV)	ROAD_LANE	Child of RoadSystem
Bailen1	Bailén (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
Bailen2	Bailén (Av. Diagonal to Aragó)	ROAD_LANE	Child of RoadSystem
Balmes1	Balmes (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
Balmes2	Balmes (Av. Tibidabo to Mitre)	ROAD_LANE	Child of RoadSystem
Balmes3	Balmes (Diagonal to Aragó)	ROAD_LANE	Child of RoadSystem
Balmes4	Balmes (Gran Via to Pl. Catalunya)	ROAD_LANE	Child of RoadSystem
Balmes5	Balmes (Mitre to Av. Tibidabo)	ROAD_LANE	Child of RoadSystem
Balmes6	Balmes (Mitre to Pl. Molina)	ROAD_LANE	Child of RoadSystem
Balmes7	Balmes (Pl. Molina to Mitre)	ROAD_LANE	Child of RoadSystem
Balmes8	Balmes (Pl. Molina to Travessera de Gràcia)	ROAD_LANE	Child of RoadSystem
Balmes9	Balmes (Travessera de Gràcia to Diagonal)	ROAD_LANE	Child of RoadSystem
BerenguerPalou	Berenguer de Palou (Clot to Pare Manyanet)	ROAD_LANE	Child of RoadSystem
Berlin	Berlín (Numància to Josep Tarradellas)	ROAD_LANE	Child of RoadSystem
Bilbao	Bilbao (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
Borbo	Av. Borbó (Pl. Virrei Amat to Passeig Maragall)	ROAD_LANE	Child of RoadSystem
Camelies	Camèlies (Escorial to Pl. de la Font Castellana)	ROAD_LANE	Child of RoadSystem
CanRabia1	Can Ràbia (Av. Sarrià to Mitre)	ROAD_LANE	Child of RoadSystem
CanRabia2	Can Ràbia (Rda. General Mitre to Av. Sarrià)	ROAD_LANE	Child of RoadSystem
Cantabria1	Cantàbria (Gran Via to Pont del Treball)	ROAD_LANE	Child of RoadSystem
Cantabria2	Cantàbria (Pont del Treball to Gran Via)	ROAD_LANE	Child of RoadSystem

CantabriaSantander	Cantàbria - Santander (Pont del Treball to Ronda Litoral)	ROAD_LANE	Child of RoadSystem
CapitaArenas	Capità Arenas (Passeig Manuel Girona to Pl. Maria Cristina)	ROAD_LANE	Child of RoadSystem
CarlesIII1	Carles III (Carrer de Sants to Pl. Cerdà)	ROAD_LANE	Child of RoadSystem
CarlesIII2	Carles III (Carrer de Sants to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
CarlesIII3	Carles III (Pl. Cerdà to Carrer de Sants)	ROAD_LANE	Child of RoadSystem
CarlesIII4	Carles III (Pl. Maria Cristina to Pl. Prat de la Riba)	ROAD_LANE	Child of RoadSystem
CarlesIII5	Carles III (Pl. Maria Cristina to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
CarlesIII6	Carles III (Pl. Prat de la Riba to Pl. Maria Cristina)	ROAD_LANE	Child of RoadSystem
CarlesIII7	Carles III (Travessera de les Corts to Carrer de Sans)	ROAD_LANE	Child of RoadSystem
CarlesIII8	Carles III (Travessera de les Corts to Pl. Maria Cristina)	ROAD_LANE	Child of RoadSystem
CarreteraCarmel	Ctra. del Carmel - Ramiro de Maeztu (Gran Vista to Pl. Sanllehy)	ROAD_LANE	Child of RoadSystem
Ciencies	Ciències (Túnel de la Rovira to Lisboa)	ROAD_LANE	Child of RoadSystem
Clot1	Clot (Sagrera to Mallorca)	ROAD_LANE	Child of RoadSystem
Clot2	Clot (València to Sagrera)	ROAD_LANE	Child of RoadSystem
CollAlentorn	Coll i Alentorn (Ronda de Dalt to Pl. de la Clota)	ROAD_LANE	Child of RoadSystem
Comerc	Comerç (Passeig Lluís Companys to Marquès de l'Argentera)	ROAD_LANE	Child of RoadSystem
ConsellCent	Consell de Cent (Av. Diagonal to Av. Meridiana)	ROAD_LANE	Child of RoadSystem
Corsega1	Còrsega (Padilla to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Corsega2	Còrsega (Passeig de Sant Joan to Pl. Joan Carles I)	ROAD_LANE	Child of RoadSystem
Corsega3	Còrsega (Passeig Maragall to Padilla)	ROAD_LANE	Child of RoadSystem
CraywinckelRepublicaArgentina	Craywinckel - República Argentina (Balmes to Pl. Alfonso Comín)	ROAD_LANE	Child of RoadSystem
CreuCobertaSants	Creu Coberta - Sants (Gran Via Carles III to Riera Blanca)	ROAD_LANE	Child of RoadSystem
Deia	Deià (Piferrer to Passeig Verdum)	ROAD_LANE	Child of RoadSystem
Diagonal1	Diagonal (Bac de Roda to Pl. Glòries)	ROAD_LANE	Child of RoadSystem
Diagonal10	Diagonal (Francesc Macià to Entença)	ROAD_LANE	Child of RoadSystem

Diagonal11	Diagonal (Marina to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Diagonal12	Diagonal (Marina to Pl. de les Glòries)	ROAD_LANE	Child of RoadSystem
Diagonal13	Diagonal (Numància to Pl. Maria Cristina)	ROAD_LANE	Child of RoadSystem
Diagonal14	Diagonal (Passeig de Sant Joan to Marina)	ROAD_LANE	Child of RoadSystem
Diagonal15	Diagonal (Passeig de Sant Joan to Pl. Joan Carles I)	ROAD_LANE	Child of RoadSystem
Diagonal16	Diagonal (Pl. de les Glòries to Marina)	ROAD_LANE	Child of RoadSystem
Diagonal17	Diagonal (Pl. Francesc Macià to Balmes)	ROAD_LANE	Child of RoadSystem
Diagonal18	Diagonal (Pl. Glòries to Bac de Roda)	ROAD_LANE	Child of RoadSystem
Diagonal19	Diagonal (Pl. Joan Carles I to Balmes)	ROAD_LANE	Child of RoadSystem
Diagonal2	Diagonal (Bac de Roda to Rambla de Prim)	ROAD_LANE	Child of RoadSystem
Diagonal20	Diagonal (Pl. Joan Carles I to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Diagonal21	Diagonal (Pl. Maria Cristina to Numància)	ROAD_LANE	Child of RoadSystem
Diagonal22	Diagonal (Pl. Maria Cristina to Pl. Pius XII)	ROAD_LANE	Child of RoadSystem
Diagonal23	Diagonal (Pl. Pius XII to Doctor Marañón)	ROAD_LANE	Child of RoadSystem
Diagonal24	Diagonal (Pl. Pius XII to Pl. Maria Cristina)	ROAD_LANE	Child of RoadSystem
Diagonal25	Diagonal (Rambla de Prim to Bac de Roda)	ROAD_LANE	Child of RoadSystem
Diagonal26	Diagonal (Ronda de Dalt to Doctor Marañón)	ROAD_LANE	Child of RoadSystem
Diagonal3	Diagonal (Balmes to Pl Joan Carles I)	ROAD_LANE	Child of RoadSystem
Diagonal4	Diagonal (Balmes to Pl. Francesc Macià)	ROAD_LANE	Child of RoadSystem
Diagonal5	Diagonal (Doctor Marañón to Pl. Pius XII)	ROAD_LANE	Child of RoadSystem
Diagonal6	Diagonal (Doctor Marañón to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
Diagonal7	Diagonal (Entença to Francesc Macià)	ROAD_LANE	Child of RoadSystem
Diagonal8	Diagonal (Entença to Numància)	ROAD_LANE	Child of RoadSystem
Diagonal9	Diagonal (Entença to Numància)	ROAD_LANE	Child of RoadSystem
DoctorAiguader1	Dr. Aiguader (Pl. Antonio López to Pl. Voluntaris)	ROAD_LANE	Child of RoadSystem
DoctorAiguader2	Dr. Aiguader (Pl. Voluntaris to Pl. Antonio López)	ROAD_LANE	Child of RoadSystem

DoctorMaranon1	Av. Doctor Marañón (Aristides Maillol to Av. Diagonal)	ROAD_LANE	Child of RoadSystem
DoctorMaranon2	Av. Doctor Marañón (Av. Diagonal to Aristides Maillol)	ROAD_LANE	Child of RoadSystem
DoctorPiMolist	Doctor Pi i Molist (Pl. Madres Mayo to Pl. Virrei Amat)	ROAD_LANE	Child of RoadSystem
DoctorRoux	Doctor Roux (Mitre to Via Augusta)	ROAD_LANE	Child of RoadSystem
EnricSanchis	P. Enric Sanchís (Sant Adrià to Santander)	ROAD_LANE	Child of RoadSystem
Entenca1	Entença (Aragó to Av. Roma)	ROAD_LANE	Child of RoadSystem
Entenca2	Entença (Av. Roma to Josep Tarradellas)	ROAD_LANE	Child of RoadSystem
Entenca3	Entença (Diagonal to Av Sarrià)	ROAD_LANE	Child of RoadSystem
Entenca4	Entença (Gran Via to Aragó)	ROAD_LANE	Child of RoadSystem
Entenca5	Entença (Josep Tarradellas to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
Entenca6	Entença (Paral.lel to Gran Via)	ROAD_LANE	Child of RoadSystem
Entenca7	Entença (Travessera de les Corts to Diagonal)	ROAD_LANE	Child of RoadSystem
Escocia	Escòcia (Felip II to Meridiana)	ROAD_LANE	Child of RoadSystem
Escorial	Escorial (Pl. Joanic to Camèlies)	ROAD_LANE	Child of RoadSystem
Esplugues1	Av. Esplugues (Av. Pedralbes to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
Esplugues2	Av. Esplugues (Ronda de Dalt to Av. Pedralbes)	ROAD_LANE	Child of RoadSystem
EstatutCatalunya1	Av. Estatut de Catalunya (Av. Can Marcet to Lisboa)	ROAD_LANE	Child of RoadSystem
EstatutCatalunya2	Av. Estatut de Catalunya (Av. Can Marcet to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
EstatutCatalunya3	Av. Estatut de Catalunya (Lisboa to Av. Can Marcet)	ROAD_LANE	Child of RoadSystem
EstatutCatalunya4	Av. Estatut de Catalunya (Ronda de Dalt to Av. Can Marcet)	ROAD_LANE	Child of RoadSystem
EsteveTerradas1	Esteve Terradas (Av. Hospital Militar to Pl. Alfonso Comín)	ROAD_LANE	Child of RoadSystem
EsteveTerradas2	Esteve Terradas (Pl. Alfonso Comín to Av. Hospital Militar)	ROAD_LANE	Child of RoadSystem
FabraPuig1	P. Fabra i Puig (Tajo to Pl. Virrei Amat)	ROAD_LANE	Child of RoadSystem
FabraPuig2	P. Fabra i Puig (Pl. Virrei Amat to Tajo)	ROAD_LANE	Child of RoadSystem
FabraPuig3	P. Fabra i Puig (Meridiana to Pl. Virrei Amat)	ROAD_LANE	Child of RoadSystem
FabraPuig4	P. Fabra i Puig (P. Urrutia to Tajo)	ROAD_LANE	Child of RoadSystem

FabraPuig5	P. Fabra i Puig (Tajo to P. Urrutia)	ROAD_LANE	Child of RoadSystem
FelipII1	Felip II (Clot to Meridiana)	ROAD_LANE	Child of RoadSystem
FelipII2	Felip II (Costa i Cuxart to Concepción Arenal)	ROAD_LANE	Child of RoadSystem
FelipII3	Felip II (Meridiana to Ramon Albó)	ROAD_LANE	Child of RoadSystem
FerranJunoy1	Ferran Junoy (Potosí to Passeig de Santa Coloma)	ROAD_LANE	Child of RoadSystem
FerranJunoy2	Ferran Junoy (Sant Adrià to Potosí)	ROAD_LANE	Child of RoadSystem
Foix1	Av. Foix (Passeig Manuel Girona to Passeig Reina Elisenda)	ROAD_LANE	Child of RoadSystem
Foix2	Av. Foix (Passeig Reina Elisenda to Passeig Manuel Girona)	ROAD_LANE	Child of RoadSystem
Foix3	Av. Foix (Passeig Reina Elisenda to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
Foix4	Av. Foix (Ronda de Dalt to Passeig Reina Elisenda)	ROAD_LANE	Child of RoadSystem
Fontanella	Fontanella (Pl. Catalunya to Pl. Urquinaona)	ROAD_LANE	Child of RoadSystem
FreserPasseig Maragall	Freser - Passeig Maragall (Rosselló to Indústria)	ROAD_LANE	Child of RoadSystem
Ganduxer1	Ganduxer (Diagonal to Pl. Gregori Tramaturg)	ROAD_LANE	Child of RoadSystem
Ganduxer2	Ganduxer (Pl. Gregori Tramaturg to Via Augusta)	ROAD_LANE	Child of RoadSystem
Ganduxer3	Ganduxer (Via Augusta to Passeig Bonanova)	ROAD_LANE	Child of RoadSystem
GonzalezTabl as	González Tablas (Av. Esplugues to Av. Diagonal)	ROAD_LANE	Child of RoadSystem
GranGracia1	Gran de Gràcia (Pl. Joan Carles I to Travessera de Gràcia)	ROAD_LANE	Child of RoadSystem
GranGracia2	Gran de Gràcia (Travessera de Gràcia to Pl. Lesseps)	ROAD_LANE	Child of RoadSystem
GranjaVella	Granja Vella (Pl. de la Clota to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
GranSantAndr euSagrera	Gran Sant Andreu - Sagrera (Onze de Setembre to Clot)	ROAD_LANE	Child of RoadSystem
GranVia1	Gran Via (Bac de Roda to Pl. de les Glòries)	ROAD_LANE	Child of RoadSystem
GranVia10	Gran Via (Pl. Cerdà to Moianés)	ROAD_LANE	Child of RoadSystem
GranVia11	Gran Via (Pl. de les Glòries to Bac de Roda)	ROAD_LANE	Child of RoadSystem
GranVia12	Gran Via (Pl. Espanya to Entença)	ROAD_LANE	Child of RoadSystem
GranVia13	Gran Via (Pl. Espanya to Moianés)	ROAD_LANE	Child of RoadSystem
GranVia14	Gran Via (Pl. Glòries to Marina)	ROAD_LANE	Child of RoadSystem

GranVia15	Gran Via (Pl. Tetuan to Marina)	ROAD_LANE	Child of RoadSystem
GranVia16	Gran Via (Pl. Universitat to Passeig de Gràcia)	ROAD_LANE	Child of RoadSystem
GranVia17	Gran Via (Rambla de Prim to Bac de Roda)	ROAD_LANE	Child of RoadSystem
GranVia18	Gran Via (Rambla de Prim to Ronda del Litoral)	ROAD_LANE	Child of RoadSystem
GranVia19	Gran Via (Roger de Llúria to Pl. Tetuan)	ROAD_LANE	Child of RoadSystem
GranVia2	Gran Via (Bac de Roda to Rambla de Prim)	ROAD_LANE	Child of RoadSystem
GranVia20	Gran Via (Ronda del Litoral to Rambla de Prim)	ROAD_LANE	Child of RoadSystem
GranVia21	Gran Via (Urgell to Pl. Universitat)	ROAD_LANE	Child of RoadSystem
GranVia3	Gran Via (Entença to Urgell)	ROAD_LANE	Child of RoadSystem
GranVia4	Gran Via (Hospitalet de Llobregat to Pl. Cerdà)	ROAD_LANE	Child of RoadSystem
GranVia5	Gran Via (Marina to Pl de les Glòries)	ROAD_LANE	Child of RoadSystem
GranVia6	Gran Via (Moianés to Pl. Cerdà)	ROAD_LANE	Child of RoadSystem
GranVia7	Gran Via (Moianés to Pl. Espanya)	ROAD_LANE	Child of RoadSystem
GranVia8	Gran Via (Passeig de Gràcia to Roger de Llúria)	ROAD_LANE	Child of RoadSystem
GranVia9	Gran Via (Pl. Cerdà to Hospitalet de Llobregat)	ROAD_LANE	Child of RoadSystem
Guipuscoa1	Guipúscoa (Bac de Roda to Cantàbria)	ROAD_LANE	Child of RoadSystem
Guipuscoa2	Guipúscoa (Bac de Roda to Meridiana)	ROAD_LANE	Child of RoadSystem
Guipuscoa3	Guipúscoa (Cantàbria to Bac de Roda)	ROAD_LANE	Child of RoadSystem
Guipuscoa4	Guipúscoa (Cantàbria to Ronda del Litoral)	ROAD_LANE	Child of RoadSystem
Guipuscoa5	Guipúscoa (Meridiana to Bac de Roda)	ROAD_LANE	Child of RoadSystem
Guipuscoa6	Guipúscoa (Ronda del Litoral to Cantàbria)	ROAD_LANE	Child of RoadSystem
HospitalMilitar 1	Hospital Militar (Esteve Terradas to Ballester)	ROAD_LANE	Child of RoadSystem
HospitalMilitar 2	Hospital Militar (Esteve Terradas to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
HospitalMilitar 3	Hospital Militar (Pl. Lesseps to Esteve Terradas)	ROAD_LANE	Child of RoadSystem
HospitalMilitar 4	Hospital Militar (Ronda de Dalt to Esteve Terradas)	ROAD_LANE	Child of RoadSystem
Industria1	Indústria (P. Sant Joan to Padilla)	ROAD_LANE	Child of RoadSystem

Industria2	Indústria (Padilla to P. Maragall)	ROAD_LANE	Child of RoadSystem
JoanXXIII1	Av. Joan XXIII (Av. Doctor Marañón to Pl. Pius XII)	ROAD_LANE	Child of RoadSystem
JoanXXIII2	Av. Joan XXIII (Pl. Pius XII to Av. Doctor Marañón)	ROAD_LANE	Child of RoadSystem
JosepCarner1	Josep Carner (Av. Paral.lel to Miramar)	ROAD_LANE	Child of RoadSystem
JosepCarner2	Josep Carner (Av. Paral.lel to Pl. Portal de la Pau)	ROAD_LANE	Child of RoadSystem
JosepCarner3	Josep Carner (Miramar to Av. Paral.lel)	ROAD_LANE	Child of RoadSystem
JosepCarner4	Josep Carner (Pl. Portal de la Pau to Av. Paral.lel)	ROAD_LANE	Child of RoadSystem
JosepPla1	Josep Pla (Gran Via to Pallars)	ROAD_LANE	Child of RoadSystem
JosepPla2	Josep Pla (Pallars to Gran Via)	ROAD_LANE	Child of RoadSystem
JosepSoldevila	Josep Soldevila (Onze de Setembre to Sant Adrià)	ROAD_LANE	Child of RoadSystem
Lepant1	Lepant (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
Lepant2	Lepant (Maria Claret to Aragó)	ROAD_LANE	Child of RoadSystem
Lepant3	Lepant (Ronda Guinardó to Maria Claret)	ROAD_LANE	Child of RoadSystem
Lisboa1	Lisboa (Av. Estatut Catalunya to Pl. de la Clota)	ROAD_LANE	Child of RoadSystem
Lisboa2	Lisboa (Pl. de la Clota to Av. Estatut Catalunya)	ROAD_LANE	Child of RoadSystem
Litoral	Av. del Litoral (Pl. Voluntaris to Llacuna)	ROAD_LANE	Child of RoadSystem
Madrid1	Av. Madrid (Carles III to Numància)	ROAD_LANE	Child of RoadSystem
Madrid2	Av. Madrid (Riera Blanca to Gran Via Carles III)	ROAD_LANE	Child of RoadSystem
Mallorca1	Mallorca (Aribau to Urgell)	ROAD_LANE	Child of RoadSystem
Mallorca2	Mallorca (Clot to Meridiana)	ROAD_LANE	Child of RoadSystem
Mallorca3	Mallorca (Meridiana to Padilla)	ROAD_LANE	Child of RoadSystem
Mallorca4	Mallorca (Padilla to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Mallorca5	Mallorca (Passeig de Gràcia to Aribau)	ROAD_LANE	Child of RoadSystem
Mallorca6	Mallorca (Passeig de Sant Joan to Passeig de Gràcia)	ROAD_LANE	Child of RoadSystem
Mallorca7	Mallorca (Urgell to Entença)	ROAD_LANE	Child of RoadSystem
ManuelGirona	Passeig Manuel Girona (Pl. Prat de la Riba to Av. Pedralbes)	ROAD_LANE	Child of RoadSystem

MareDeuColl1	P. Mare de Déu del Coll (Av. Rep. Argentina to Santuari)	ROAD_LANE	Child of RoadSystem
MareDeuColl2	P. Mare de Déu del Coll (Santuari to Av. Rep. Argentina)	ROAD_LANE	Child of RoadSystem
MareDeuMontserrat1	Av. Mare Déu Montserrat (Amílcar to Pl. de la Font Castellana)	ROAD_LANE	Child of RoadSystem
MareDeuMontserrat2	Av. Mare Déu Montserrat (Amílcar to Sagnier)	ROAD_LANE	Child of RoadSystem
MareDeuMontserrat3	Av. Mare Déu Montserrat (P. Maragall to Amílcar)	ROAD_LANE	Child of RoadSystem
MareDeuMontserrat4	Av. Mare Déu Montserrat (Pl. de la Font Castellana to Amílcar)	ROAD_LANE	Child of RoadSystem
MareDeuMontserrat5	Av. Mare Déu Montserrat (Pl. de la Font Castellana to Pl. Sanllehy)	ROAD_LANE	Child of RoadSystem
MariaClaret1	Maria Claret (Av. Meridiana to Passeig de Maragall)	ROAD_LANE	Child of RoadSystem
MariaClaret2	Maria Claret (Passeig de Maragall to Lepant)	ROAD_LANE	Child of RoadSystem
MariaClaret3	Maria Claret (Passeig de Maragall to Lepant)	ROAD_LANE	Child of RoadSystem
Marina1	Marina (Av. Icària to Av. Meridiana)	ROAD_LANE	Child of RoadSystem
Marina2	Marina (Av. Icària to Pl. Voluntaris)	ROAD_LANE	Child of RoadSystem
Marina3	Marina (Av. Meridiana to Gran Via)	ROAD_LANE	Child of RoadSystem
Marina4	Marina (Gran Via to Diagonal)	ROAD_LANE	Child of RoadSystem
Marina5	Marina (Gran Via to Meridiana)	ROAD_LANE	Child of RoadSystem
Marina6	Marina (Meridiana to Av. Icària)	ROAD_LANE	Child of RoadSystem
Marina7	Marina (Pl. Voluntaris to Av. Icària)	ROAD_LANE	Child of RoadSystem
MarquesArgentera1	Av. Marqués de l'Argentera (Passeig de Picasso to Pl. Antonio López)	ROAD_LANE	Child of RoadSystem
MarquesArgentera2	Av. Marqués de l'Argentera (Pl. Antonio López to Passeig de Picasso)	ROAD_LANE	Child of RoadSystem
Meridiana1	Meridiana (Aragó to Felip II)	ROAD_LANE	Child of RoadSystem
Meridiana10	Meridiana (Pl. de les Glòries to Aragó)	ROAD_LANE	Child of RoadSystem
Meridiana11	Meridiana (Pl. de les Glòries to Marina)	ROAD_LANE	Child of RoadSystem
Meridiana12	Meridiana (Ronda de Dalt to Passeig Valldaura)	ROAD_LANE	Child of RoadSystem
Meridiana2	Meridiana (Aragó to Pl. de les Glòries)	ROAD_LANE	Child of RoadSystem
Meridiana3	Meridiana (Fabra i Puig to Felip II)	ROAD_LANE	Child of

			RoadSystem
Meridiana4	Meridiana (Fabra i Puig to Passeig Valldaura)	ROAD_LANE	Child of RoadSystem
Meridiana5	Meridiana (Felip II to Aragó)	ROAD_LANE	Child of RoadSystem
Meridiana6	Meridiana (Felip II to Fabra i Puig)	ROAD_LANE	Child of RoadSystem
Meridiana7	Meridiana (Marina to Pl. de les Glòries)	ROAD_LANE	Child of RoadSystem
Meridiana8	Meridiana (Passeig Valldaura to Fabra i Puig)	ROAD_LANE	Child of RoadSystem
Meridiana9	Meridiana (Passeig Valldaura to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
MeridianaPasseigPujades	Meridiana - Passeig de Pujades (Marina to Passeig Picasso)	ROAD_LANE	Child of RoadSystem
Mitre1	Mitre (Balmes to Pl. Lesseps)	ROAD_LANE	Child of RoadSystem
Mitre2	Mitre (Balmes to Via Augusta)	ROAD_LANE	Child of RoadSystem
Mitre3	Mitre (Pl. Lesseps to Balmes)	ROAD_LANE	Child of RoadSystem
Mitre4	Mitre (Pl. Prat de la Riba to Via Augusta)	ROAD_LANE	Child of RoadSystem
Mitre5	Mitre (Via Augusta to Balmes)	ROAD_LANE	Child of RoadSystem
Mitre6	Mitre (Via Augusta to Pl. Prat de la Riba)	ROAD_LANE	Child of RoadSystem
Muntaner1	Muntaner (Aragó to Ronda de Sant Antoni)	ROAD_LANE	Child of RoadSystem
Muntaner2	Muntaner (Diagonal to Aragó)	ROAD_LANE	Child of RoadSystem
Muntaner3	Muntaner (Pl. Bonanova to Mitre)	ROAD_LANE	Child of RoadSystem
Muntaner4	Muntaner (Rda. General Mitre to Via Augusta)	ROAD_LANE	Child of RoadSystem
Muntaner5	Muntaner (Via Augusta to Diagonal)	ROAD_LANE	Child of RoadSystem
NavasTolosa1	Navas de Tolosa (Meridiana to Aragó)	ROAD_LANE	Child of RoadSystem
NavasTolosa2	Navas de Tolosa (Passeig Maragall to Meridiana)	ROAD_LANE	Child of RoadSystem
Numancia1	Numància (Berlin to Pl. Països Catalans)	ROAD_LANE	Child of RoadSystem
Numancia2	Numància (Diagonal to Pl. Prat de la Riba)	ROAD_LANE	Child of RoadSystem
Numancia3	Numància (Diagonal to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
Numancia4	Numància (Pl. Prat de la Riba to Diagonal)	ROAD_LANE	Child of RoadSystem
Numancia5	Numància (Travessera de les Corts to Berlin)	ROAD_LANE	Child of RoadSystem
OnzeSetembr	Onze de Setembre - Fabra i Puig	ROAD_LANE	Child of

eFabraPuig	(Josep Soldevila to Meridiana)		RoadSystem
Padilla1	Padilla (Aragó to Maria Claret)	ROAD_LANE	Child of RoadSystem
Padilla2	Padilla (Gran Via to Aragó)	ROAD_LANE	Child of RoadSystem
Padilla3	Padilla (Maria Claret to Ronda Guinardó)	ROAD_LANE	Child of RoadSystem
Pallars1	Pallars (Bac de Roda to Josep Pla)	ROAD_LANE	Child of RoadSystem
Pallars2	Pallars (Meridiana to Pere IV)	ROAD_LANE	Child of RoadSystem
Pallars3	Pallars (Pere IV to Bac de Roda)	ROAD_LANE	Child of RoadSystem
Parallel1	Paral.lel (Calàbria to Entença)	ROAD_LANE	Child of RoadSystem
Parallel2	Paral.lel (Calàbria to Ronda de Sant Pau)	ROAD_LANE	Child of RoadSystem
Parallel3	Paral.lel (Entença to Calàbria)	ROAD_LANE	Child of RoadSystem
Parallel4	Paral.lel (Entença to Pl. Espanya)	ROAD_LANE	Child of RoadSystem
Parallel5	Paral.lel (Josep Carner to Ronda de Sant Pau)	ROAD_LANE	Child of RoadSystem
Parallel6	Paral.lel (Pl. Espanya to Entença)	ROAD_LANE	Child of RoadSystem
Parallel7	Paral.lel (Ronda de Sant Pau to Calàbria)	ROAD_LANE	Child of RoadSystem
Parallel8	Paral.lel (Ronda de Sant Pau to Josep Carner)	ROAD_LANE	Child of RoadSystem
Paris1	París (Josep Tarradelles to Urgell)	ROAD_LANE	Child of RoadSystem
Paris2	París (Urgell to Balmes)	ROAD_LANE	Child of RoadSystem
PasseigBonanova1	Passeig de la Bonanova (Pl. Bonanova to Via Augusta)	ROAD_LANE	Child of RoadSystem
PasseigBonanova2	Passeig de la Bonanova (Via Augusta to Pl. Bonanova)	ROAD_LANE	Child of RoadSystem
PasseigCalvell1	Passeig de Calvell (Bac de Roda to Llacuna)	ROAD_LANE	Child of RoadSystem
PasseigCalvell2	Passeig de Calvell (Llacuna to Bac de Roda)	ROAD_LANE	Child of RoadSystem
PasseigCalvell3	Passeig Calvell (Llacuna to Bilbao)	ROAD_LANE	Child of RoadSystem
PasseigColom1	Passeig de Colom (Pl. Antonio López to Pl. Portal de la Pau)	ROAD_LANE	Child of RoadSystem
PasseigColom2	Passeig de Colom (Pl. Portal de la Pau to Pl. Antonio López)	ROAD_LANE	Child of RoadSystem
PasseigFabraPuig1	Passeig Fabra i Puig (Passeig Urrutia to Passeig Valldaura)	ROAD_LANE	Child of RoadSystem
PasseigFabraPuig2	Passeig Fabra i Puig (Passeig Valldaura to Passeig Urrutia)	ROAD_LANE	Child of RoadSystem
PasseigGarcia	Passeig de Garcia Faria (Bac de	ROAD_LANE	Child of

Faria1	Roda to Rambla de Prim)		RoadSystem
PasseigGarcia Faria2	Passeig de Garcia Faria (Rambla de Prim to Bac de Roda)	ROAD_LANE	Child of RoadSystem
PasseigGracia 1	Passeig de Gràcia (Aragó to Pl. Joan Carles I)	ROAD_LANE	Child of RoadSystem
PasseigGracia 2	Passeig de Gràcia (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
PasseigGracia 3	Passeig de Gràcia (Gran Via to Aragó)	ROAD_LANE	Child of RoadSystem
PasseigGracia 4	Passeig de Gràcia (Av. Diagonal to Aragó)	ROAD_LANE	Child of RoadSystem
PasseigGracia 5	Passeig de Gràcia (Pl. Catalunya to Gran Via)	ROAD_LANE	Child of RoadSystem
PasseigGracia 6	Passeig de Gràcia (Gran Via to Pl. Catalunya)	ROAD_LANE	Child of RoadSystem
PasseigLluisC ompanys1	Passeig Lluís Companys (Passeig de Pujades to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
PasseigLluisC ompanys2	Passeig Lluís Companys (Passeig de Sant Joan to Passeig de Pujades)	ROAD_LANE	Child of RoadSystem
PasseigMarag all1	Passeig Maragall (Av. Borbó to Tajo)	ROAD_LANE	Child of RoadSystem
PasseigMarag all2	Passeig Maragall (Av. Borbó to Pl. Maragall)	ROAD_LANE	Child of RoadSystem
PasseigMarag all3	Passeig Maragall (Tajo to Av. Borbó)	ROAD_LANE	Child of RoadSystem
PasseigMarag all4	Passeig Maragall (Indústria to Pl. Maragall)	ROAD_LANE	Child of RoadSystem
PasseigMarag all5	Passeig Maragall (Pl. Maragall to Av. Borbó)	ROAD_LANE	Child of RoadSystem
PasseigMarag all6	Passeig Maragall (Pl. Maragall to Indústria)	ROAD_LANE	Child of RoadSystem
PasseigPujad esMeridiana	Passeig de Pujades - Meridiana (Passeig Picasso to Marina)	ROAD_LANE	Child of RoadSystem
PasseigSanta Coloma	Passeig de Santa Coloma (Coronel Monasterio to Av. Meridiana)	ROAD_LANE	Child of RoadSystem
PasseigSantG ervasi1	Passeig de Sant Gervasi (Balmes to Pl. Bonanova)	ROAD_LANE	Child of RoadSystem
PasseigSantG ervasi2	Passeig de Sant Gervasi (Pl. Alfonso Comín to Balmes)	ROAD_LANE	Child of RoadSystem
PasseigSantG ervasi3	Passeig de Sant Gervasi (Pl. Bonanova to Balmes)	ROAD_LANE	Child of RoadSystem
PasseigSantJ oan1	Passeig de Sant Joan (Còrsega to Pl. Joanic)	ROAD_LANE	Child of RoadSystem
PasseigSantJ oan2	Passeig de Sant Joan (Còrsega to Pl. Verdaguer)	ROAD_LANE	Child of RoadSystem
PasseigSantJ oan3	Passeig de Sant Joan (Passeig Lluís Companys to Pl. Tetuan)	ROAD_LANE	Child of RoadSystem
PasseigSantJ oan4	Passeig de Sant Joan (Pl. Joanic to Còrsega)	ROAD_LANE	Child of RoadSystem

PasseigSantJoan5	Passeig de Sant Joan (Pl. Tetuan to Passeig Lluís Companys)	ROAD_LANE	Child of RoadSystem
PasseigSantJoan6	Passeig de Sant Joan (Pl. Tetuan to Pl. Verdaguer)	ROAD_LANE	Child of RoadSystem
PasseigSantJoan7	Passeig de Sant Joan (Pl. Verdaguer to Còrsega)	ROAD_LANE	Child of RoadSystem
PasseigSantJoan8	Passeig de Sant Joan (Pl. Verdaguer to Pl. Tetuan)	ROAD_LANE	Child of RoadSystem
PasseigTorrasBages1	Passeig de Torras i Bages (Passeig Santa Coloma to Sant Adrià)	ROAD_LANE	Child of RoadSystem
PasseigTorrasBages2	Passeig de Torras i Bages (Sant Adrià to Passeig Santa Coloma)	ROAD_LANE	Child of RoadSystem
PasseigValldaura1	Passeig de Valldaura (Pl. Karl Marx to Pl. Llucmajor)	ROAD_LANE	Child of RoadSystem
PasseigValldaura2	Passeig Valldaura (Meridiana to Pl.Llucmajor)	ROAD_LANE	Child of RoadSystem
PasseigValldaura3	Passeig de Valldaura (Pl. Llucmajor to Pl. Karl Marx)	ROAD_LANE	Child of RoadSystem
PasseigValldaura4	Passeig Valldaura (Pl. Lucmajor to Meridiana)	ROAD_LANE	Child of RoadSystem
PasseigZonaFranca1	Passeig de la Zona Franca (Foc to Pl. Cerdà)	ROAD_LANE	Child of RoadSystem
PasseigZonaFranca2	Passeig de la Zona Franca (Foc to Ronda del Litoral)	ROAD_LANE	Child of RoadSystem
PasseigZonaFranca3	Passeig de la Zona Franca (Pl. Cerdà to Foc)	ROAD_LANE	Child of RoadSystem
PasseigZonaFranca4	Passeig de la Zona Franca (Ronda del Litoral to Foc)	ROAD_LANE	Child of RoadSystem
PauClaris1	Pau Claris (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
PauClaris2	Pau Claris (Còrsega to Mallorca)	ROAD_LANE	Child of RoadSystem
PauClaris3	Pau Claris (Gran Via to Pl. Urquinaona)	ROAD_LANE	Child of RoadSystem
PauClaris4	Pau Claris (Mallorca to Aragó)	ROAD_LANE	Child of RoadSystem
Pedralbes1	Av. Pedralbes (Carretera Esplugues to Passeig Manuel Girona)	ROAD_LANE	Child of RoadSystem
Pedralbes2	Av. Pedralbes (Passeig Manuel Girona to Av. Esplugues)	ROAD_LANE	Child of RoadSystem
Pedralbes3	Av. Pedralbes (Passeig Manuel Girona to Pl. Pius XII)	ROAD_LANE	Child of RoadSystem
Pedralbes4	Av. Pedralbes (Pl. Pius XII to Passeig Manuel Girona)	ROAD_LANE	Child of RoadSystem
Pelai	Pelai (Pl. Universitat to Balmes)	ROAD_LANE	Child of RoadSystem
PereIV1	Pere IV (Bac de Roda to Gran Via)	ROAD_LANE	Child of RoadSystem
PereIV2	Pere IV (Gran Via to Bac de Roda)	ROAD_LANE	Child of RoadSystem

PereIV3	Pere IV (Pallars to Bac de Roda)	ROAD_LANE	Child of RoadSystem
PereIVAlmogavers	Pere IV - Almogàvers (Bac de Roda to Badajoz)	ROAD_LANE	Child of RoadSystem
Picasso1	P. Picasso (Av. Marquès de l'Argentera to P. Pujades)	ROAD_LANE	Child of RoadSystem
Picasso2	P. Picasso (P. Pujades to Av. Marquès de l'Argentera)	ROAD_LANE	Child of RoadSystem
PiMargall1	Pi i Margall (Pl. Alfons el Savi to Pl. Joanic)	ROAD_LANE	Child of RoadSystem
PiMargall2	Pi i Margall (Pl. Joanic to Pl. Alfons el Savi)	ROAD_LANE	Child of RoadSystem
PontTreball1	Pont del Treball (Berenguer de Palou to Cantàbria)	ROAD_LANE	Child of RoadSystem
PontTreball2	Pont del Treball (Cantàbria to Berenguer de Palou)	ROAD_LANE	Child of RoadSystem
Potosi1	Potosí (Ferran Junoy to Coronel Monasterio)	ROAD_LANE	Child of RoadSystem
Potosi2	Potosí (Ferran Junoy to Ronda Litoral)	ROAD_LANE	Child of RoadSystem
Potosi3	Potosí (Ronda Litoral to Ferran Junoy)	ROAD_LANE	Child of RoadSystem
Potosi4	Potosí (Torras i Bages to Ferran Junoy)	ROAD_LANE	Child of RoadSystem
PrincepAsturies1	Príncep d'Astúries (Pl. Lesseps to Via Augusta)	ROAD_LANE	Child of RoadSystem
PrincepAsturies2	Príncep d'Astúries (Via Augusta to Pl. Lesseps)	ROAD_LANE	Child of RoadSystem
RamblaCarmel	Rambla del Carmel (Lisboa to Túnel de la Rovira)	ROAD_LANE	Child of RoadSystem
RamblaPrim1	Rambla de Prim (Gran Via to Santander)	ROAD_LANE	Child of RoadSystem
RamblaPrim2	Rambla de Prim (Santander to Gran Via)	ROAD_LANE	Child of RoadSystem
RamblaPrim3	Rambla de Prim (Gran Via to Pl. Llevant)	ROAD_LANE	Child of RoadSystem
RamblaPrim4	Rambla de Prim (Pl. Llevant to Gran Via)	ROAD_LANE	Child of RoadSystem
RamiroMaeztuCarreteraCarmel	Ramiro de Maeztu - Ctra. del Carmel (Pl. Sanllehy to Gran Vista)	ROAD_LANE	Child of RoadSystem
RamonAlbo	Ramon Albó (Passeig Maragall to Escòcia)	ROAD_LANE	Child of RoadSystem
ReinaElisenda1	Passeig Reina Elisenda (Av. Pedralbes to Via Augusta)	ROAD_LANE	Child of RoadSystem
ReinaElisenda2	Passeig Reina Elisenda (Via Augusta to Av. Pedralbes)	ROAD_LANE	Child of RoadSystem
RepublicaArgentina1	República Argentina (Bolívar to Pl. Lesseps)	ROAD_LANE	Child of RoadSystem
RepublicaArgentina2	República Argentina (Simón Bolívar to Craywinckel)	ROAD_LANE	Child of RoadSystem
RepublicaArge	República Argentina (Craywinckel	ROAD_LANE	Child of

ntina3	to Bolívar)		RoadSystem
RieraBlanca1	Riera Blanca (Sants to Travessera de les Corts)	ROAD_LANE	Child of RoadSystem
RieraBlanca2	Riera Blanca (Travessera de les Corts to Sants)	ROAD_LANE	Child of RoadSystem
RioJaneiro1	Av. Rio de Janeiro (Fabra i Puig to Passeig de Valldaura)	ROAD_LANE	Child of RoadSystem
RioJaneiro2	Av. Rio de Janeiro (Meridiana to Passeig de Valldaura)	ROAD_LANE	Child of RoadSystem
RioJaneiro3	Av. Rio de Janeiro (Passeig de Valldaura to Meridiana)	ROAD_LANE	Child of RoadSystem
RogerLluria1	Roger de Llúria (Aragó to Diagonal)	ROAD_LANE	Child of RoadSystem
RogerLluria2	Roger de Llúria (Pl. Urquinaona to Aragó)	ROAD_LANE	Child of RoadSystem
Roma1	Av. Roma (Aragó to Urgell)	ROAD_LANE	Child of RoadSystem
Roma2	Av. Roma (Entença to Pl. Països Catalans)	ROAD_LANE	Child of RoadSystem
Roma3	Av. Roma (Urgell to Entença)	ROAD_LANE	Child of RoadSystem
RondaDalt1	Ronda de Dalt (Av. Estatut de Catalunya to Av. Jordà)	ROAD_LANE	Child of RoadSystem
RondaDalt10	Ronda de Dalt (Foix to Carretera d'Esplugues)	ROAD_LANE	Child of RoadSystem
RondaDalt11	Ronda de Dalt (Nus de la Trinitat to Via Júlia)	ROAD_LANE	Child of RoadSystem
RondaDalt12	Ronda de Dalt (Nus de la Trinitat to Via Júlia)	ROAD_LANE	Child of RoadSystem
RondaDalt13	Ronda de Dalt (Pl. d'Alfons Comín to Av. Jordà)	ROAD_LANE	Child of RoadSystem
RondaDalt14	Ronda de Dalt (Pl. d'Alfons Comín to Av. Jordà)	ROAD_LANE	Child of RoadSystem
RondaDalt15	Ronda de Dalt (Pl. Karl Marx to Av. Estatut de Catalunya)	ROAD_LANE	Child of RoadSystem
RondaDalt16	Ronda de Dalt (Pl. Karl Marx to Via Júlia)	ROAD_LANE	Child of RoadSystem
RondaDalt17	Ronda de Dalt (Via Júlia to Nus de la Trinitat)	ROAD_LANE	Child of RoadSystem
RondaDalt18	Ronda de Dalt (Via Júlia to Pl. Karl Marx)	ROAD_LANE	Child of RoadSystem
RondaDalt2	Ronda de Dalt (Av. Estatut de Catalunya to Pl. Karl Marx)	ROAD_LANE	Child of RoadSystem
RondaDalt3	Ronda de Dalt (Av. Jordà to Av. Estatut de Catalunya)	ROAD_LANE	Child of RoadSystem
RondaDalt4	Ronda de Dalt (Av. Jordà to Pl. d'Alfons Comín)	ROAD_LANE	Child of RoadSystem
RondaDalt5	Ronda de Dalt (Bellesguard to Pl. Alfons Comín)	ROAD_LANE	Child of RoadSystem
RondaDalt6	Ronda de Dalt (Carretera d'Esplugues to Diagonal)	ROAD_LANE	Child of RoadSystem
RondaDalt7	Ronda de Dalt (Carretera	ROAD_LANE	Child of

	d'Esplugues to Foix)		RoadSystem
RondaDalt8	Ronda de Dalt (Diagonal to Carretera d'Esplugues)	ROAD_LANE	Child of RoadSystem
RondaDalt9	Ronda de Dalt (Foix to Bellesguard)	ROAD_LANE	Child of RoadSystem
RondaGuinardo1	Ronda Guinardó (Escorial to Túnel de la Rovira)	ROAD_LANE	Child of RoadSystem
RondaGuinardo2	Ronda Guinardó (Flors de Maig to Túnel de la Rovira)	ROAD_LANE	Child of RoadSystem
RondaGuinardo3	Ronda Guinardó (Oblit to Passeig de Maragall)	ROAD_LANE	Child of RoadSystem
RondaGuinardo4	Ronda Guinardó (Túnel de la Rovira to Escorial)	ROAD_LANE	Child of RoadSystem
RondaGuinardo5	Ronda Guinardó (Túnel de la Rovira to Oblit)	ROAD_LANE	Child of RoadSystem
RondaLitoral1	Ronda del Litoral (Bac de Roda to Pl. dels Voluntaris)	ROAD_LANE	Child of RoadSystem
RondaLitoral10	Ronda del Litoral (Rambla de Prim to Gran Via)	ROAD_LANE	Child of RoadSystem
RondaLitoral11	Ronda Litoral (Estació de Can Tunis to Passeig de la Zona Franca)	ROAD_LANE	Child of RoadSystem
RondaLitoral12	Ronda Litoral (Gran Via to Potosí)	ROAD_LANE	Child of RoadSystem
RondaLitoral13	Ronda Litoral (Nus de la Trinitat to Potosí)	ROAD_LANE	Child of RoadSystem
RondaLitoral14	Ronda Litoral (Passeig de la Zona Franca to Estació de Can Tunis)	ROAD_LANE	Child of RoadSystem
RondaLitoral15	Ronda Litoral (Potosí to Gran Via)	ROAD_LANE	Child of RoadSystem
RondaLitoral16	Ronda Litoral (Potosí to Nus de la Trinitat)	ROAD_LANE	Child of RoadSystem
RondaLitoral2	Ronda del Litoral (Bac de Roda to Rambla de Prim)	ROAD_LANE	Child of RoadSystem
RondaLitoral3	Ronda del Litoral (Gran Via to Rambla de Prim)	ROAD_LANE	Child of RoadSystem
RondaLitoral4	Ronda del Litoral (Miramar to Passeig de la Zona Franca)	ROAD_LANE	Child of RoadSystem
RondaLitoral5	Ronda del Litoral (Miramar to Pl. dels Voluntaris)	ROAD_LANE	Child of RoadSystem
RondaLitoral6	Ronda del Litoral (Passeig de la Zona Franca to Miramar)	ROAD_LANE	Child of RoadSystem
RondaLitoral7	Ronda del Litoral (Pl. dels Voluntaris to Bac de Roda)	ROAD_LANE	Child of RoadSystem
RondaLitoral8	Ronda del Litoral (Pl. dels Voluntaris to Miramar)	ROAD_LANE	Child of RoadSystem
RondaLitoral9	Ronda del Litoral (Rambla de Prim to Bac de Roda)	ROAD_LANE	Child of RoadSystem
RondaSantAntoni1	Ronda de Sant Antoni (Pl. Universitat to Ronda de Sant Pau)	ROAD_LANE	Child of RoadSystem
RondaSantAnt	Ronda de Sant Antoni (Ronda de	ROAD_LANE	Child of

oni2	Sant Pau to Pl Universitat)		RoadSystem
RondaSantPau	Ronda de Sant Pau (Paral.lel to Ronda de Sant Antoni)	ROAD_LANE	Child of RoadSystem
RondaSantPere	Ronda de Sant Pere (Passeig de Sant Joan to Pl. Urquinaona)	ROAD_LANE	Child of RoadSystem
RondaUniversitat	Ronda Universitat (Pl. Urquinaona to Pl. Universitat)	ROAD_LANE	Child of RoadSystem
Rossello1	Rosselló (Balmes to Av. Diagonal)	ROAD_LANE	Child of RoadSystem
Rossello2	Rosselló (Casanova to Balmes)	ROAD_LANE	Child of RoadSystem
Rossello3	Rosselló (Diagonal to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Rossello4	Rosselló (Padilla to Freser)	ROAD_LANE	Child of RoadSystem
Rossello5	Rosselló (Passeig de Sant Joan to Padilla)	ROAD_LANE	Child of RoadSystem
SalvadorEspriu	Salvador Espriu (Llacuna to Pl. dels Voluntaris)	ROAD_LANE	Child of RoadSystem
SantaColoma1	P. Santa Coloma (Coronel Monasterio to Ronda Litoral)	ROAD_LANE	Child of RoadSystem
SantaColoma2	P. Santa Coloma (Meridiana to Coronel Monasterio)	ROAD_LANE	Child of RoadSystem
SantaColoma3	P. Santa Coloma (Ronda Litoral to Coronel Monasterio)	ROAD_LANE	Child of RoadSystem
SantAdria1	Sant Adrià (Enric Sanchís to P. Torras i Bages)	ROAD_LANE	Child of RoadSystem
SantAdria2	Sant Adrià (P. Torras i Bages to Enric Sanchís)	ROAD_LANE	Child of RoadSystem
SantanderCantabria	Santander - Cantàbria (Ronda Litoral to Pont del Treball)	ROAD_LANE	Child of RoadSystem
SantAntoni1	P. Sant Antoni (Pl. Països Catalans to Pl. Sants)	ROAD_LANE	Child of RoadSystem
SantAntoni2	P. Sant Antoni (Pl. Sants to Pl. Països Catalans)	ROAD_LANE	Child of RoadSystem
SantJoanBosco1	P. Sant Joan Bosco (Pl. Prat de la Riba to Pl. Artós)	ROAD_LANE	Child of RoadSystem
SantJoanBosco2	P. Sant Joan Bosco (Pl. Prat de la Riba to Pl. Artós)	ROAD_LANE	Child of RoadSystem
Sants1	Carrer de Sants (Carles III to Premià)	ROAD_LANE	Child of RoadSystem
Sants2	Carrer de Sants (Pl. Espanya to Premià)	ROAD_LANE	Child of RoadSystem
Sants3	Carrer de Sants (Premià to Carles III)	ROAD_LANE	Child of RoadSystem
Sants4	Carrer de Sants (Premià to Pl. Espanya)	ROAD_LANE	Child of RoadSystem
SantsCreuCoberta	Sants - Creu Coberta (Riera Blanca to Gran Via Carles III)	ROAD_LANE	Child of RoadSystem
Santuari1	Santuari (Gran Vista to P. Mare de Déu del Coll)	ROAD_LANE	Child of RoadSystem
Santuari2	Santuari (P. Mare de Déu del Coll	ROAD_LANE	Child of

	to Gran Vista)		RoadSystem
Sardenya1	Sardenya (Aragó to Gran Via)	ROAD_LANE	Child of RoadSystem
Sardenya2	Sardenya (Gran Via to Meridiana)	ROAD_LANE	Child of RoadSystem
Sardenya3	Sardenya (Maria Claret to Aragó)	ROAD_LANE	Child of RoadSystem
Sardenya4	Sardenya (Pi i Margall to Maria Claret)	ROAD_LANE	Child of RoadSystem
Sardenya5	Sardenya (Pl. Sanllehy to Pi i Margall)	ROAD_LANE	Child of RoadSystem
SardenyaTrias Fargas	Sardenya - Trias Fargas (Meridiana to Dr. Aiguader)	ROAD_LANE	Child of RoadSystem
Sarria1	Av. Sarrià (Diagonal to Pl. Prat de la Riba)	ROAD_LANE	Child of RoadSystem
Sarria2	Av. Sarrià (Urgell to Diagonal)	ROAD_LANE	Child of RoadSystem
Sepulveda1	Sepúlveda (Entença to Paral.lel)	ROAD_LANE	Child of RoadSystem
Sepulveda2	Sepúlveda (Ronda de Sant Antoni to Urgell)	ROAD_LANE	Child of RoadSystem
Sepulveda3	Sepúlveda (Urgell to Entença)	ROAD_LANE	Child of RoadSystem
Tajo1	Tajo (Lisboa to Passeig Maragall)	ROAD_LANE	Child of RoadSystem
Tajo2	Tajo (Passeig Maragall to Lisboa)	ROAD_LANE	Child of RoadSystem
Tarragona1	Tarragona (Aragó to Pl.Espanya)	ROAD_LANE	Child of RoadSystem
Tarragona2	Tarragona (Pl. Països Catalans to Aragó)	ROAD_LANE	Child of RoadSystem
Tibidabo1	Av. Tibidabo (Balmes to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
Tibidabo2	Av. Tibidabo (Ronda de Dalt to Balmes)	ROAD_LANE	Child of RoadSystem
Trafalgar	Trafalgar (Pl. Urquinaona to P. Lluís Companys)	ROAD_LANE	Child of RoadSystem
TravesseraCorts1	Travessera de les Corts (Av. Sarrià to Entença)	ROAD_LANE	Child of RoadSystem
TravesseraCorts2	Travessera de les Corts (Entença to Numància)	ROAD_LANE	Child of RoadSystem
TravesseraCorts3	Travessera de les Corts (Gran Via Carles III to Aristides Maillol)	ROAD_LANE	Child of RoadSystem
TravesseraCorts4	Travessera de les Corts (Numància to Carles III)	ROAD_LANE	Child of RoadSystem
TravesseraDalt1	Travessera de Dalt (Escorial to Pl. Lesseps)	ROAD_LANE	Child of RoadSystem
TravesseraDalt2	Travessera de Dalt (Pl. Lesseps to Escorial)	ROAD_LANE	Child of RoadSystem
TravesseraGracia1	Travessera de Gràcia (Gran de Gràcia to Escorial)	ROAD_LANE	Child of RoadSystem
TravesseraGr	Travessera de Gràcia (Aribau to	ROAD_LANE	Child of

acia2	Via Augusta)		RoadSystem
TravesseraGr acia3	Travessera de Gràcia (Pl. Francesc Macià to Aribau)	ROAD_LANE	Child of RoadSystem
TravesseraGr acia4	Travessera de Gràcia (Via Augusta to Gran de Gràcia)	ROAD_LANE	Child of RoadSystem
TunelRovira1	Túnel de la Rovira (Rambla del Carmel to Ronda Guinardó)	ROAD_LANE	Child of RoadSystem
TunelRovira2	Túnel de la Rovira (Ronda Guinardó to Rambla del Carmel)	ROAD_LANE	Child of RoadSystem
Urgell1	Urgell (Aragó to Av. Sarrià)	ROAD_LANE	Child of RoadSystem
Urgell2	Urgell (Gran Via to Aragó)	ROAD_LANE	Child of RoadSystem
Urgell3	Urgell (Pl. Francesc Macià to París)	ROAD_LANE	Child of RoadSystem
Urgell4	Urgell (Ronda de Sant Pau to Gran Via)	ROAD_LANE	Child of RoadSystem
Valencia1	València (Balmes to Pau Claris)	ROAD_LANE	Child of RoadSystem
Valencia2	València (Meridiana to Clot)	ROAD_LANE	Child of RoadSystem
Valencia3	València (Padilla to Meridiana)	ROAD_LANE	Child of RoadSystem
Valencia4	València (Passeig de Sant Joan to Padilla)	ROAD_LANE	Child of RoadSystem
Valencia5	València (Pau Claris to Passeig de Sant Joan)	ROAD_LANE	Child of RoadSystem
Valencia6	València (Urgell to Balmes)	ROAD_LANE	Child of RoadSystem
Verdum1	P. Verdum (Pl. Llucmajor to Pl. Madres Mayo)	ROAD_LANE	Child of RoadSystem
Verdum2	P. Verdum (Pl. Madres Mayo to Pl. Llucmajor)	ROAD_LANE	Child of RoadSystem
Vergos1	Vergós (Pl. Artós to Via Augusta)	ROAD_LANE	Child of RoadSystem
Vergos2	Vergós (Via Augusta to Pl. Artós)	ROAD_LANE	Child of RoadSystem
ViaAugusta1	Via Augusta (Diagonal to Travessera de Gràcia)	ROAD_LANE	Child of RoadSystem
ViaAugusta10	Via Augusta (Príncep d'Astúries to Travessera de Gràcia)	ROAD_LANE	Child of RoadSystem
ViaAugusta11	Via Augusta (Ronda de Dalt to Passeig Bonanova)	ROAD_LANE	Child of RoadSystem
ViaAugusta12	Via Augusta (Travessera de Gràcia to Diagonal)	ROAD_LANE	Child of RoadSystem
ViaAugusta13	Via Augusta (Travessera de Gràcia to Príncep d'Astúries)	ROAD_LANE	Child of RoadSystem
ViaAugusta14	Via Augusta (Vergós to Mitre)	ROAD_LANE	Child of RoadSystem
ViaAugusta15	Via Augusta (Vergós to Passeig Bonanova)	ROAD_LANE	Child of RoadSystem
ViaAugusta2	Via Augusta (Mitre to Muntaner)	ROAD_LANE	Child of

			RoadSystem
ViaAugusta3	Via Augusta (Mitre to Vergós)	ROAD_LANE	Child of RoadSystem
ViaAugusta4	Via Augusta (Muntaner to Mitre)	ROAD_LANE	Child of RoadSystem
ViaAugusta5	Via Augusta (Muntaner to Pl. Molina)	ROAD_LANE	Child of RoadSystem
ViaAugusta6	Via Augusta (Passeig Bonanova to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
ViaAugusta7	Via Augusta (Passeig Bonanova to Vergós)	ROAD_LANE	Child of RoadSystem
ViaAugusta8	Via Augusta (Pl. Molina to Muntaner)	ROAD_LANE	Child of RoadSystem
ViaAugusta9	Via Augusta (Príncep d'Astúries to Pl. Molina)	ROAD_LANE	Child of RoadSystem
ViaJulia1	Via Júlia (Pl. Llucmajor to Ronda de Dalt)	ROAD_LANE	Child of RoadSystem
ViaJulia2	Via Júlia (Ronda de Dalt to Pl. Llucmajor)	ROAD_LANE	Child of RoadSystem
ViaLaietana1	Via Laietana (Jaume I to Pl. Antonio López)	ROAD_LANE	Child of RoadSystem
ViaLaietana2	Via Laietana (Jaume I to Pl. Urquinaona)	ROAD_LANE	Child of RoadSystem
ViaLaietana3	Via Laietana (Pl. Antonio López to Jaume I)	ROAD_LANE	Child of RoadSystem
ViaLaietana4	Via Laietana (Pl. Uruiqnaona to Jaume I)	ROAD_LANE	Child of RoadSystem
Virgili	Virgili (Sant Adrià to Pare Manyanet)	ROAD_LANE	Child of RoadSystem
2805	Av. Diagonal - Castillejos - Diputació	SEGMENT_CONTROLLER	Traffic controller for streets Av. Diagonal - Castillejos - Diputació
2805/C1	Av. Diagonal - Castillejos - Diputació	NETWORK_ANALYZER	Consumption for 13 traffic lights
2829	Castillejos - Casp	SEGMENT_CONTROLLER	Traffic controller for streets Castillejos - Casp
2829/C1	Castillejos - Casp	NETWORK_ANALYZER	Consumption for 4 traffic lights
2839	Gran Via - Badajoz - Independència	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Badajoz - Independència
2839/C1	Gran Via - Badajoz -	NETWORK_ANA	Consumption

	Independència	LYZER	for 22 traffic lights
2827	Gran Via - Ciutat de Granada - Escultores Claperos	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Ciutat de Granada - Escultores Claperos
2827/C1	Gran Via - Ciutat de Granada - Escultores Claperos	NETWORK_ANALYZER	Consumption for 13 traffic lights
2830	Gran Via - Llacuna	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Llacuna
2830/C1	Gran Via - Llacuna	NETWORK_ANALYZER	Consumption for 11 traffic lights
2831	Gran Via - Rambla del Poblenou	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Rambla del Poblenou
2831/C1	Gran Via - Rambla del Poblenou	NETWORK_ANALYZER	Consumption for 10 traffic lights
2840	Gran Via - Roc Boronat	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Roc Boronat
2840/C1	Gran Via - Roc Boronat	NETWORK_ANALYZER	Consumption for 9 traffic lights
4911	Joan d'Àustria - Almogàvers	SEGMENT_CONTROLLER	Traffic controller for streets Joan d'Àustria - Almogàvers
4911/C1	Joan d'Àustria - Almogàvers	NETWORK_ANALYZER	Consumption for 7 traffic lights
4907	Lepant - Alí Bei	SEGMENT_CONTROLLER	Traffic controller for streets Lepant - Alí Bei
4907/C1	Lepant - Alí Bei	NETWORK_ANALYZER	Consumption for 6 traffic lights
4818	Marina - Alí Bei	SEGMENT_CONTROLLER	Traffic controller for streets Marina

			- Alí Bei
4818/C1	Marina - Alí Bei	NETWORK_ANALYZER	Consumption for 8 traffic lights
4919	Marina - Ausiàs Marc	SEGMENT_CONTROLLER	Traffic controller for streets Marina - Ausiàs Marc
4919/C1	Marina - Ausiàs Marc	NETWORK_ANALYZER	Consumption for 8 traffic lights
4917	Marina - Av. Meridiana	SEGMENT_CONTROLLER	Traffic controller for streets Marina - Av. Meridiana
4917/C1	Marina - Av. Meridiana	NETWORK_ANALYZER	Consumption for 5 traffic lights
2816	Pl. Glòries - Av. Diagonal - Badajoz	SEGMENT_CONTROLLER	Traffic controller for streets Pl. Glòries - Av. Diagonal - Badajoz
2816/C1	Pl. Glòries - Av. Diagonal - Badajoz	NETWORK_ANALYZER	Consumption for 13 traffic lights
2818	Pl. Glòries - Av. Meridiana	SEGMENT_CONTROLLER	Traffic controller for streets Pl. Glòries - Av. Meridiana
2818/C1	Pl. Glòries - Av. Meridiana	NETWORK_ANALYZER	Consumption for 14 traffic lights
2837	Pl. Glòries (Banda Mar)	SEGMENT_CONTROLLER	Traffic controller for streets Pl. Glòries (Banda Mar)
2837/C1	Pl. Glòries (Banda Mar)	NETWORK_ANALYZER	Consumption for 10 traffic lights
2838	Pl. Glòries (Banda Muntanya)	SEGMENT_CONTROLLER	Traffic controller for streets Pl. Glòries (Banda Muntanya)
2838/C1	Pl. Glòries (Banda Muntanya)	NETWORK_ANALYZER	Consumption for 9 traffic lights
2805	Av. Diagonal - Castillejos -	SEGMENT_CON	Traffic

	Diputació	TROLLER	controller for streets Av. Diagonal - Castillejos - Diputació
2805/C1	Av. Diagonal - Castillejos - Diputació	NETWORK_ANALYZER	Consumption for 13 traffic lights
2829	Castillejos - Casp	SEGMENT_CONTROLLER	Traffic controller for streets Castillejos - Casp
2829/C1	Castillejos - Casp	NETWORK_ANALYZER	Consumption for 4 traffic lights
2839	Gran Via - Badajoz - Independència	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Badajoz - Independència
2839/C1	Gran Via - Badajoz - Independència	NETWORK_ANALYZER	Consumption for 22 traffic lights
2827	Gran Via - Ciutat de Granada - Escultores Claperos	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Ciutat de Granada - Escultores Claperos
2827/C1	Gran Via - Ciutat de Granada - Escultores Claperos	NETWORK_ANALYZER	Consumption for 13 traffic lights
2830	Gran Via - Llacuna	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Llacuna
2830/C1	Gran Via - Llacuna	NETWORK_ANALYZER	Consumption for 11 traffic lights
2831	Gran Via - Rambla del Poblenou	SEGMENT_CONTROLLER	Traffic controller for streets Gran Via - Rambla del Poblenou