Collaborative Project of the 7th Framework Programme

WP 2:

D2.1.1 Reference Architecture and principles v1

Partner: Thales Italia Spa (THALIT)

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Authors (Partner)	Thales Italia Spa (THALIT)			
Responsible Authors	Gianpiero Francavilla Andrea Nasuti		**Email**	gianpiero.francavilla@thalesgroup.com andrea.nasuti@thalesgroup.com
	Partner	THALIT	**Phone**	+393356999664

Abstract (for dissemination)	BEAMS’ strategic goal is the development of an advanced, integrated management system which enables energy efficiency in buildings and special infrastructures based on a holistic perspective. The project includes an open interoperability gateway and the management of diverse, heterogeneous sources and loads. The goal of WP2 is to define the principle and the reference architecture for BEAMS, starting from the inputs (requirement, use-cases and scenarios) defined in WP1. In particular, the deliverable D2.1 focuses on the principles and technologies that facilitate industry deployment and adoption of ICT solutions for energy efficiency by the various stakeholders (end-user, operators, designers, system integrators). Also, it provides design information concerning BEAMS and its demonstrators: the overall context, the architectural model, the use cases and functionalities, the main engineering and integration aspects.
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1 Introduction and reference data

1.1 Purpose and scope of the Document

This document focuses on the principles and technologies that facilitate the deployment and adoption of ICT solutions for energy efficiency by various stakeholders including end-users, operators, designers and system integrators.

Two document versions will be released: D2.1.1 at M9 (the current version) and D2.1.2 at M26. In particular, D2.1.2 will include updates and results from the mid-term demonstrators, and feedbacks from the workgroups activities.

D2.1.1 starts from the results (requirement, use-cases and scenarios) of the WP1 activities and provides inputs to the following work-packages. It describes the overall architecture of BEAMS focusing on its main features: decentralization, scalability, flexibility, configurability and openness to the third parties willing to interact with the system.

The scope of the deliverable can be summarized as follows:

- Provide a high level specification of the system components and their interaction.
- Ensure fulfillment of requirements, providing also a good flexibility for future reusability of components and modules.
- Identify an interoperability architecture that complies with the European FP7 initiatives in the energy sector and may contribute to the standardization efforts.
- Use standard communication protocols and interfaces.

To offer a preliminary and overall view of the topic, a short introduction to the BEAMS components and references to other Work Packages is provided in the following paragraphs.

1.2 BEAMS Approach

The BEAMS system is an enhanced Building Management System (BMS) with a decentralized architecture.
It is composed by one or more open interoperability gateways which allow the control of heterogeneous subsystems in a facility. The control is local and therefore distributed in the specific areas where the subsystems of the facility are deployed. The open gateway implements a granular monitoring and control of the energy subsystems and an improved management of their power consumption or generation.
Central control and monitoring is possible through the Facility Management Environment, which will provide high level optimization of energy usage through specific algorithms and recognition of scenarios. Furthermore, it provides user interaction with the Facility Manager.

Figure 1 – BEAMS approach

1.3 BEAMS Components and Modules

The BEAMS components, as introduced before, are:

- Interoperability Gateway (OGEMA): it is an existing open source framework that allows the development of software applications (and the integration of existing ones) to manage the energy subsystems through specific drivers; it includes services for the smart grid interoperability and weather data forecasts integration.
- Facility Management Environment (FAME): it is an environment providing smart algorithms for energy process optimization and a man-machine interface (MMI) for user interaction.
- Third Party Interface: standard interfaces used to let the system interact with the smart grid services; this interface is realized through direct access to OGEMA. As specified in the DoW, this interface is not the main focus of the project and its functionality will be tested by simulation scripts that will be run by FAME.
- Energy Subsystems:
  - Lighting
  - HVAC (Heating Ventilation and Air Conditioning)
  - Photovoltaic generation
  - Electrical Vehicles
  - Metering
  - Environment Sensors

1.3.1 OGEMA - Interoperability Gateway

OGEMA is an existing open source framework developed by Fraunhofer IWES. In its current version, the OGEMA architecture is based on the OSGi Java-based framework that allows development and integration of new application bundles. Its main modules are:

- Management Agent: the management agent is a collection of bundles that offer several functionalities to the application and communication drivers (i.e. administration of resources, system time control, and database management) thus providing a base set of interoperability.
- Applications: an application is a piece of software that is able to run in the environment of the gateway framework. They represent specific use cases or services related to the business logic.
- Resources: a resource is a representation of a field device or data with its own parameters, states and related data. It can represent also data information.
- Communication Drivers: the driver layer enables the communication with field devices using standard and widely used protocols for building management systems like KNX, modbus, etc.

The following figure shows the OGEMA System Architecture including a few application examples, devices and communication drivers. These modules are exchangeable and some of them will be replaced by the ones used for the BEAMS implementations at the demonstrator sites. However the Management Agent modules are fixed and will not be subject to further development within BEAMS.

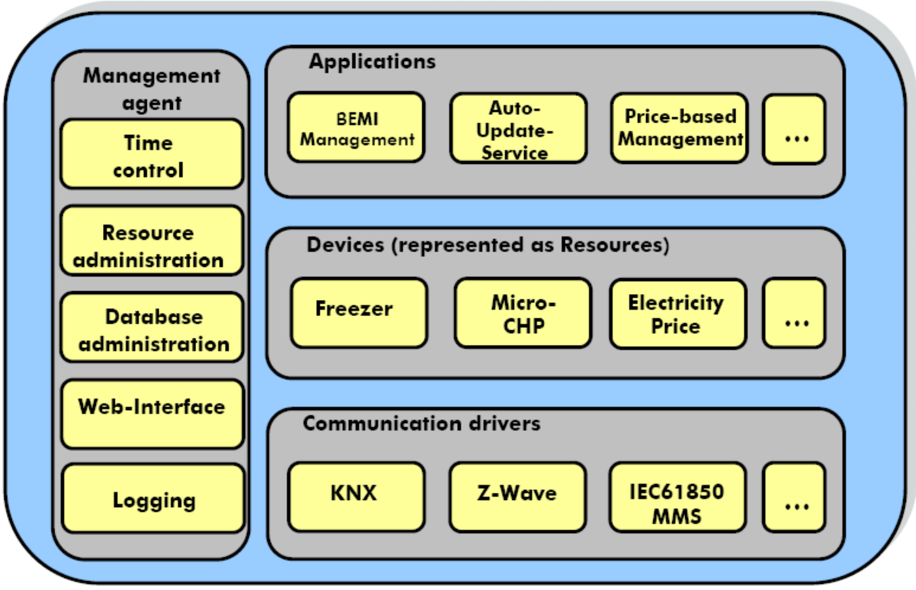


Figure 2 – OGEMA System Architecture (example)

One of the objectives of BEAMS is to develop an open gateway which could easily interact with ICT solutions from different vendors. The gateway provides an interface to low voltage (LV) energy management systems (EMS), allowing the control of a large number of distributed loads or generators. In particular, OGEMA provides a bidirectional interface to FAME or other EMS connected to an energy supplier and the distribution system operator (DSO).

In order to achieve these objectives, the external interface of OGEMA shall be standardized both at inter-networking level (e.g. using standard Web Services protocols) and at information model level. The definition of the final information model is an ongoing activity at this stage of the project and the results will be presented in the deliverable D2.2.1 (Information Model and Interoperability).

The project activity related to OGEMA design and development will be done in WP4.

1.3.2 FAME – Facility Management Environment

FAME is the management system which is composed by the following modules:

- Smart Control Algorithm with Learning Capabilities (SCALC): it is responsible for identifying and classifying the situations that will trigger the execution of corrective actions and commands. The algorithm is able to learn from the information gathered through the interoperability gateway (these data are stored in a centralized database). This mechanism allows an automatic optimization of the controlled energy systems. When the situation is not recognized, a human decision will be necessary (through the DAS module) for modeling new situations.
- Decision Support and Simulation (DAS): this module provides MMI functionalities to the end users of the system, and the simulation and decision tools that assess and deploy control scenarios to the involved gateways.
- Energy Efficiency Balanced Score Card (EBS): a balanced scorecard is a strategic performance management tool applied to the energy efficiency domain. It provides indicators on how the system is using energy, temperature changing, energy produced, etc. and presents them in an aggregated high level view for assessment of energy optimization strategies.

1.4 Synthesis of requirements specified in WP1

This chapter describes the list of use cases and requirements (from the deliverable D1.1) having impact on the architecture.

The “Architectural Principles” in BEAMS refer to requirements related to the system components, the interfaces between them, and so on. In D1.1, these requirements have been organized based on the following sub-categories:

- OGEMA-based architectural principles
- FAME-based architectural principles
- Green Energy Positive (GPE) architectural principles
- Communication interfaces between BEAMS components
- Communication interfaces between BEAMS and external systems
- Particular pilot sites requirements
- Functional and systems constraints.

Here we further classify requirements based on their priority level (1 to 5). Requirements with priority 5 are considered mandatory, while lower priority requirements like 1, 2, 3 and 4 are considered optional.

1.4.1.1 High priority requirements

ID	Description
ARC_006	Communication between OGEMA and the subsystems under its control SHOULD be based in a bidirectional interface based on one uniform publicly available standard/technology.
ARC_010	OGEMA SHOULD be able to generate artificial short term DER generation forecasts from weather information obtained locally, seasonal and historical data
ARC_072	Communication interface between one OGEMA instance and all subsystems under its control should be based on bi-directional standardized protocols that allow data transmission as well as control commands requests/responses exchange.
ARC_076	OGEMA SHOULD provide proper mechanisms for core Sw update
ARC_001	FAME SHOULD communicate with all OGEMA instances deployed within a facility through an Enterprise Service Bus (ESB).
ARC_070	FAME SHOULD support a publish-subscribe communication mechanism with all OGEMA instances in facility, allowing reception of alarms, events, etc from OGEMAs
ARC_071	FAME SHOULD support a request-response data communication mechanism that allow it to request measurements data from all OGEMA instances in a facility
ARC_039	Events and alerts (high priority data) detection and notification mechanism SHOULD be provided for the interface OGEMA-FAME
ARC_062	Communication to all subsystem measurements
ARC_032	FAME to OGEMA (and vice versa) communication messages shall be delivered within 5 seconds
ARC_074	Third-party "high priority data" such as alarms, DR messages, etc should be sent from OGEMA to FAME before local optimizations are performed in OGEMA (facility manager authorization is required for this type of data)
ARC_007	OGEMA and FAME SHOULD have a modular architecture design that assures scalability and adaptability to different deployment sites.
ARC_030	FAME and BEAMS components system clock shall be aligned to a clock reference
ARC_034	In case of BEAMS system unavailability all site energy subsystems shall not be affected (it shall be possible for the subsystems to operate independently). Subsystems MUST be self-secure.
ARC_036	One subsystem within a facility (e.g., HVAC, lighting, etc) COULD be controlled entirely by one single instance of OGEMA.
ARC_040	Data privacy issues should be taken into account when designing BEAMS system (based on an analysis and verification of Use-cases sensible to privacy)
ARC_042	BEAMS shall use open source products for implementation of the ESB

ARC_043	BEAMS Architecture shall be based on Enterprise Service Bus (ESB) approach and Enterprise Integration Patterns (EIP)
ARC_044	A BEAMS protocol shall be defined and implemented using Web Services and defined with WSDL and XML Schema standards.
ARC_046	BEAMS Architecture design
ARC_065	The system SHOULD allow having more than one situation detected as active at the same time
ARC_067	There SHOULD be a simulation-run mode on FAME and the OGEMA+'s
ARC_075	Different parts of one subsystem COULD be controlled by several different OGEMA instances while optimizations of the whole "logical subsystem" are performed at a higher level by FAME.
ARC_078	Install two different types of off-the-shelf solutions in each pilot site. On one hand they should allow monitoring "only", and on the other hand they COULD allow control and manual connection/disconnection of this control capability

Table 1 – High Priority Requirements

1.4.1.2 Low priority requirements (optional)

ID	Description
ARC_005	OGEMA SHOULD be able to generate artificial long term DER generation forecast from accurate weather information obtained from third parties
ARC_041	OGEMA SHOULD provide proper update/maintenance mechanisms that inform FAME of current running OGEMA Sw version.
ARC_077	OGEMA SHOULD provide proper mechanisms for Sw components installation/update
ARC_002	Bidirectional and standardized communication between BEAMS system and third parties (e.g., utility, ESCO, etc) SHOULD be performed through OGEMA instances of a facility.
ARC_009	Bidirectional data exchange interfaces between BEAMS and a third-party SHOULD support existing or under development communication protocols and data models
ARC_073	OGEMA should support a bi-directional and standardized interface to third parties, allowing reception of data as well as command requests from these external actors
ARC_004	In those cases where RES systems are available, it should be clear whether or not these systems can be used to provide energy to the grid.
ARC_059	FCB pilot-site main components
ARC_060	Energy Systems at FCB Pilot Site
ARC_080	UNISAL pilot-site main components
ARC_081	Energy Systems at UNISAL Pilot Site
ARC_050	Easy update in the database of the technical characteristics of the Field Devices
ARC_051	The database SHOULD have advanced historical capabilities
ARC_052	Forecasting Error Estimation
ARC_053	The database SHOULD support the capability to manage scenarios
ARC_066	Some messages sent from the utility or from third parties COULD be automatically accepted without the requirement of an operator validation
ARC_068	The OGEMA adaptation after receiving messages from utility and third party SHOULD be delayed
ARC_035	BEAMS project should consider safety aspects
ARC_048	System Time Step 15min
ARC_049	Max Data Resolution 1 min
ARC_055	The system SHOULD have an error handling mechanism
ARC_056	The system SHOULD have a deadlock/bottleneck management mechanism
ARC_057	The system SHOULD have the ability of fixing missing data in the database
ARC_058	The system should cope with summer time change
ARC_064	The system SHOULD allow defining calendars
ARC_069	The ESB should support many MEP (Message Exchange Pattern), specifically it should support at least Request-Response, Publish-Subscribe, One-Way messages

Table 2 – Low Priority Requirements

2 Architectural and engineering model

This section focuses on good practices and guidelines for a correct architectural design and development flow, given the BEAMS objectives and the experience brought by the industrial partners of the BEAMS consortium. Also, it includes references to the most valuable architectural and interoperability initiatives in the field of the ICT for the energy sector.

2.1 Best practices and development model

An important objective for the architectural modeling in BEAMS (and in general in the field of ICT for energy efficiency systems) is to develop an **open architecture** that is **reusable** in various application areas and across different domains.
BEAMS' architecture aims at achieving strong **interoperability** and **scalability** for **future expansion** or **integration with other external systems**.
The architecture must enable **centralized**, **decentralized** or **combined operational policies**, and must assure **interoperability**, e.g. by using self-describing services and protocols. This means considering a **common ontology and information model** to seamlessly manage a wide variety of architecture components and actors. Finally it must ensure **scalability** and maintain appropriate **security and privacy** levels.
Nevertheless, the BEAMS architecture must **facilitate building prototypes** to use **in different contexts**, as it is in the case of the two planned demonstrators.

The architectural design in BEAMS targets the conception, design and specification of an infrastructure that uses the hybrid design principles of a Service Oriented Architecture (SOA) and an Event-Driven Architecture (EDA).
Furthermore the concepts and methodologies to deploy an Enterprise Service Bus (ESB) middleware are used to create an integrated and loosely coupled system.

The BEAMS services oriented architecture will be based on Web-Services, which is one of the most diffused SOA development model. To this purpose, the results from the Organization for the Advancement of Structured Information Standards (OASIS) consortium (see the activities of its various WS-x workgroups) are taken in consideration.

The definition of the system architecture is based on the use of Architectural Framework (AF) methodologies (Ref. **ARC_046**), and in particular TOGAF (The Open Group AF) and NAF (Nato AF). These AFs provide a structured way to manage system complexity.
TOGAF is based on an iterative process model supported by best practices and a re-usable set of existing architecture assets. NAF allows developing and presenting architecture descriptions that ensure a common denominator for understanding, comparing, and integrating architectures.
While TOGAF is the most comprehensive method currently available, it does not include a detailed description framework and therefore it is conveniently coupled with NAF.

The framework has been "tailored" to the size and scope of BEAMS, and in particular for what concerns process (defined by TOGAF) and artifacts (defined by NAF). This is in order to:

- Minimize the effort and the number of deliverables
- Extend the architecture description with additional views (as an option).

For further information on these methodologies see [4] and [5].

2.2 Service Oriented Architecture (SOA)

BEAMS System leverages the Service-Oriented Architecture (SOA) paradigm with the definition of modular service interfaces. This solution enables the system to scale and adapt easily to the addition of new systems and the extension to other BMS.

A Service Oriented Architecture (SOA) is a distributed computing paradigm in which the business functionalities are provided by autonomous systems called services, which are exposed in a network infrastructure through well-defined interfaces. This allows building complex yet flexible systems as well as reusing application logic through the composition of services.
SOA is a concept which is not tied to a particular technology. However, Web Services are currently the preferred framework to deliver interoperable a SOA. In Web Services-based SOA, also called message-oriented services, the contract is described by a WSDL (Web Services Description Language) document, which defines how service consumers can bind to a service producer by exchanging messages using a defined XML (Extensible Markup Language) grammar.
The key advantage of a SOA approach is to offer modularity, isolation, flexibility, loose coupling and interoperability among a large-scale of heterogeneous networked systems.

2.2.1 Web Services (WS)

The W3C consortium defines a "Web service" as "a software system designed to support interoperable machine-to-machine interaction over a network".
Web services can implement a service-oriented architecture and make functional building-blocks accessible over standard Internet protocols independent of platforms and programming languages. Typically, a basic Web services platform is based on XML and HTTP.
The HTTP protocol is the most used Internet protocol, and in order to be compliant with security aspects, HTTPS should be the preferred implementation to consider (Ref. **ARC_035**).
XML is useful to describe and develop interoperability features between heterogeneous platforms even using different software coding languages, and still expressing complex messages and functions.

The main web services platform elements to consider are:

- SOAP (Simple Object Access Protocol), a protocol specification for exchanging structured information in the implementation of Web Services in computer networks;

- UDDI (Universal Description, Discovery and Integration), a platform-independent XML-based Internet registry for business services used worldwide, including a mechanism to register and locate web service applications;

- WSDL (Web Services Description Language), an XML-based language that provides a model for describing Web services.

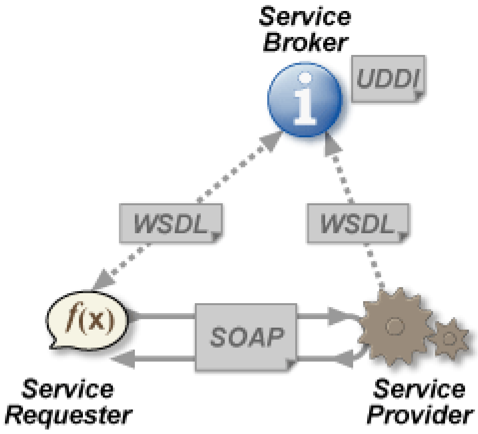


Figure 3 – Web Services Architecture

There are many reasons to justify the use of Web Services (WS) in BEAMS:

- they are application components
- communication is based on open protocols
- they are self-contained and self-describing
- they can be discovered using UDDI
- they can be easily used by other applications
- they are based on XML

These advantages are very crucial in order to develop standard, open and highly reusable interfaces in BEAMS, and in particular for the OGEMA gateway.

2.2.2 Enterprise Service Bus (ESB)

An enterprise service bus (ESB) is a software architecture model used to design and implement the interaction and communication between interoperable software applications in a Service Oriented Architecture. As a model for distributed computing, it is a special variant of the more general client server software architecture model and promotes an asynchronous message oriented design for communication and interaction between applications. Its primary use is in the Enterprise Application Integration of heterogeneous and complex scenarios.
Unfortunately, a commonly accepted definition of the term ESB is not yet available, mainly due to a disagreement among middleware providers. However, the most of today's implementations based on ESB technologies use event-driven and standards-based Message-oriented middleware in combination with message queues as frameworks.

We can summarize the main duties of an ESB as follows:

- to monitor and control the routing of the message exchange between services
- to resolve any contention between communicating service components
- to control deployment and versioning of services
- to marshal the use of redundant services
- to cater for commonly needed commodity services like event handling, event choreography, data transformation and mapping, message and event queuing and sequencing, security or exception handling, protocol conversion and enforcing proper quality of the communication service.

Therefore an ESB combines message-oriented processing and Web services to create a so called “event-driven SOA”.

2.2.2.1 ESB Architecture

An ESB is a modular and component based architecture. It assumes that the services are generally autonomous, and that their availability at any given moment cannot be guaranteed. Therefore the messages need to be routed through a message bus for buffering (message queuing) and to allow inspection, content enhancement as well as filtering, correction and rerouting of message flows.
The word “bus” reflects the analogy with a computer bus, which is a basic concept for applications that are easily plugged in and out (or switched on and off) the network, without impact on other components and without the need to restart the system or stop running processes.
A bus acts as the single message turntable between applications and reduces the number of point-to-point connections between communicating endpoints.
This, in turn, makes the impact analysis for any major software change simpler and more straightforward. By reducing the number of points-of-contact from and to a particular application, it is easier to monitor failures and misbehavior in highly complex systems and facilitate the change or upgrade of components.

As one of its essential design concepts, an ESB client directs all its requests towards the ESB instead of passing it directly to the final recipient (i.e. a server). This allows the ESB to efficiently monitor and log the traffic, and possibly intervene in the message exchange and overwrite standard rules for service execution. For instance the ESB can:

- buffer and delay a message in a staging area and automatically deliver it when the receiver is ready
- monitor messages and services to be well-behaving
- enforce compliance with dynamic processing and security policies
- marshal service execution based on dynamic rules
- prioritize, delay, and reschedule message delivery and service execution
- write logs and raise exception alerts

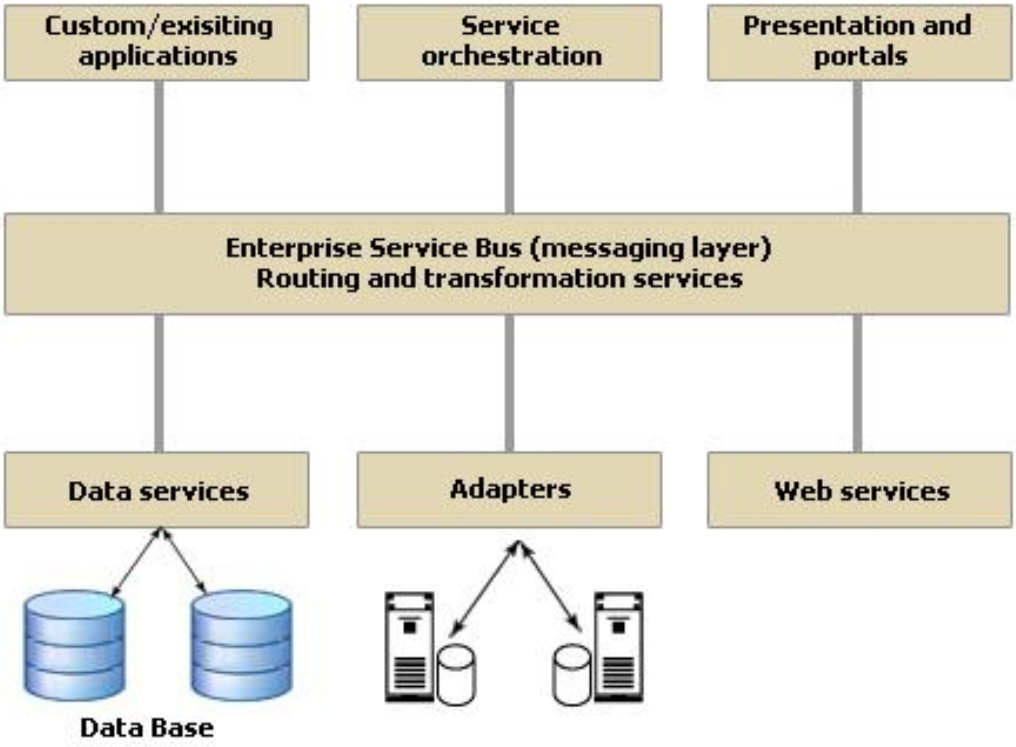


Figure 4 – Enterprise Service Bus Architecture

The main advantages introduced by the use of an ESB are:

- increased flexibility: it is easier to change as requirements change
- scaling from isolated solutions to enterprise-wide deployment (distributed bus)
- less development effort, focusing more on configuration rather than integration coding
- no need for a central rules-engine, nor for a central broker
- reduced down-time for the incremental patching (enterprise becomes "refactorable")

On the other hand, the main disadvantage of an ESB is the increased overhead and impact on the communication speed, that may be a critical aspect to consider in some cases (although very unlikely in the case of BEAMS) an that can require an appropriate design analysis.

2.2.2.2 ESB Software

In a complex architecture, the ESB represents the piece of software that lives between the business applications and enables the communication among them. Ideally, the ESB should be able to replace any system messaging framework, so that all communications can take place via the ESB. To achieve this objective, the ESB must encapsulate the functionality offered by its component applications in a meaningful way. This typically occurs by using an **enterprise message model**. The message model defines a standard set of messages that the ESB will both transmit and receive. When the ESB receives a message, it routes the message to the appropriate application. Considering that applications use different message-models or often evolve changing it, the ESB will have to transform the message into a format that other applications can interpret. A software “adapter” fulfills this task, similarly to a physical adapter.
An ESB strongly relies on the accurate interconnection between enterprise message models and functionalities offered by applications. If the message model does not completely encapsulate an application’s functionality, then other applications wishing to use that functionality may have to bypass the bus, and invoke the mismatched application directly. Doing so violates all of the principles outlined above, and negates many of the advantages of using an ESB.

Considering the BEAMS objectives, the following table presents some of the typical and most interesting characteristics of an ESB, that in some case are also vendor-dependant:

Category	Functions
Invocation	support for synchronous and asynchronous transport protocols, service mapping (locating and binding)
Routing	addressability, static/deterministic routing, content-based routing, rules-based routing, policy-based routing
Mediation	adapters, protocol transformation, service mapping
Messaging	message-processing, message transformation and message enhancement
Process choreography	implementation of complex business processes
Service orchestration	coordination of multiple implementation services exposed as a single, aggregate service
Complex event processing	event-interpretation, correlation, pattern-matching
Other quality of service	security (encryption and signing), reliable delivery, transaction management
Management	monitoring, audit, logging, metering, admin console
Agnosticism	general agnosticism to operating-systems and programming-languages; for example, it should enable interoperability between Java and .NET, C++ applications
Protocol Conversion	comprehensive support for topical communication protocols service standards
Message Exchange Patterns	support for various MEPs (Message

	Exchange Patterns) (for example: synchronous request/response, asynchronous request/response, send-and-forget, publish/subscribe)
Adapters	adapters for supporting integration with legacy systems
Security	a standardized security-model to authorize, authenticate and audit use of the ESB
Transformation	facilitation of the transformation of data formats and values, including transformation services (often via XSLT) between the formats of the sending application and the receiving application
Validation	validation against schemas for sending and receiving messages
Governance	the ability to apply business rules uniformly
Enrichment	enriching messages from other sources
Split and Merge	the splitting and combining of multiple messages and the handling of exceptions
Abstraction	the provision of a unified abstraction across multiple layers
Routing and Transformation	routing or transforming messages conditionally, based on a non-centralized policy (without the need for a central rules-engine)
Queuing and staging	queuing, holding messages if applications temporarily become unavailable or work at different speeds
Commodity Services	provisioning of commonly used functionality as shared services depending on context

Table 3 – ESB Characteristics

Among the various ESB solutions currently available or on the market, the open source Apache “ServiceMix” has been chosen because of its completeness, scalability and good support (Ref. **ARC_001, ARC_070, ARC_032, ARC_007, ARC_042, ARC_043, ARC_044, ARC_069**). The deliverable D2.3 (development framework and tools) will provide additional information about this package and describe how to use and configure it and how to develop specific components for BEAMS.

2.2.3 SOAP Message Exchange Patterns (MEP)

Messaging pattern is a network-oriented architectural pattern which describes how two different parts of a message passing system connect and communicate with each other.
The term "Message Exchange Pattern" has a specific meaning within the SOAP protocol. SOAP MEP types include:

1. **In-Only**: equivalent to *one-way,* it is a standard one-way messaging exchange where the consumer sends a message to the provider that provides only a status response.

2. **Robust In-Only**: reliable one-way message exchanges pattern, where the consumer initiates with a message to which the provider responds with a status; if the response is a status, the exchange is complete, but if the response is a fault, the consumer must respond with a status.
3. **In-Out**: equivalent to *request-response*, that is a standard two-way message exchange where the consumer initiates with a message, the provider responds with a message or fault and the consumer responds with a status.
4. **In Optional-Out**: a standard two-way message exchange where the provider's response is optional.
5. **Out-Only**: it is the reverse of In-Only, primarily supports event notification, cannot trigger a fault message.
6. **Robust Out-Only**: similar to the out-only pattern, except for the possibility in this case to trigger a fault message; the outbound message initiates the transmission.
7. **Out-In**: it is the reverse of In-Out; the provider transmits the request and initiates the exchange.
8. **Out-Optional-In**: it is the reverse of In-Optional-Out; the service produces an outbound message; the incoming message is optional ("Optional-in").

2.3 Architectural references specific to the energy sector

We present here a list of initiatives that we found useful for consultation and to draw a reference baseline for the architectural conception in BEAMS. Together with an analysis of the current state of the art of other ongoing projects in the same field, these inputs will be considered for the activities in other tasks and work packages of BEAMS, starting from the Information and data model definition. Based on the first sharable deliverables that will be made available by BEAMS, any available result from collaborations with external initiatives or projects will be considered and reported if useful in the next deliverables.

OpenSG (Smart Grid) group: technical committee of the UCA (Utilities Communications architecture) International Users Group that includes the following working-groups:

- SG Security (AMI Security)
- SG Communication (SG-Network, Network Interop)
- SG Systems (OpenHAN, OpenADE, OpenADR, AMI-Enterprise, UtilityAMI)
- SG Conformity (Edge Conf, Security Conf, Enterprise Conf).

OpenADR alliance: initiative dealing with interoperable information exchange and automated demand response (www.openADR.org).

UtilityAMI: working-group which defines security categories (access, integrity, accountability, registration) to promote open, standards-based, interoperable HAN (home area networks).

OpenHAN initiative: working-group which has produced the UCAlug Home Area Network System Requirements Specification-SRS.

Other initiatives that are worth of consideration are: OASIS-Smart Grid, NIST (Smart grid interoperability panel), the ETSI Board Smart grid Strategic Topic, the NAESB (North America energy standards board) and the ICT4E2B forum, or other similar projects funded under FP7.

2.3.1 ICTBE2B Forum

ICT4E2B Forum is a European project that brings together all relevant stakeholders involved in ICT and construction sector to investigate the role of ICT for Energy Efficiency in Buildings.

The Objectives of ICT4E2B Forum are:

- Bringing together relevant stakeholders to identify and review the needs in terms of research and systems integration:
  - invite expert groups to provide advice in the key areas of focus
  - set up a wider community in the ICT4E2B domain
  - provide a virtual cooperation environment to facilitate communication between stakeholders
  - organize expert hearings, validation workshop, sessions inside international conferences and national/regional events
  - promote networking and collaboration between the stakeholders in these events;
  - build consensus of RTD priorities in the ICT4E2B domain

- Updating the REEB research roadmap:
  - identify key knowledge areas and related application fields
  - analyze state of the art in industry and research, and other related RTD strategies
  - identify current industry requirements
  - define vision exemplified by a representative set of application scenarios
  - identify and rank gaps between the state of the art, recent and ongoing research and industrial needs
  - develop and validate the updated research roadmap

- Promoting the use and further development of ICT for improved energy efficiency of buildings:
  - provide knowledge content about the state of the art, best practices, RTD results
  - propose a future extended collaborative value chain in ICT for energy efficient buildings
  - provide guidelines for the implementation of R&D results and best practices
  - contribute to dissemination of standards and regulation
  - disseminate project results and recommendations to the ICT and Construction Communities, national/regional research and industry policy makers, and widely to European industry, research community, policy makers and media

Several European projects are following and supporting this initiative. The following table includes a list of projects that have been considered of interest for BEAMS. In particular, the focus of this preliminary analysis is to gather information about data models and open standards in use in the field of BMS. This analysis is necessary in order to fulfill the interoperability objectives of the OGEMA framework and suggest a common ontology to adopt in the project.

This analysis is still ongoing and will be completed in the D2.2.1 deliverable.

Project Acronym	Project Full Name	Ref. Document	Project Scope	Reference Data Models	Key concepts
PEBBLE	Positive-Energy Buildings through Better controL dEcisions	PEBBLE_D41A_AnnexDataModel_CSEM_cka_1.0	PEBBLE covers the aspects of building description, sensor and actuator device deployment in the building, sensor data, information flow between the Building Optimization and Control (BO&C) system and the deployed components, as well as the interactions with the users, mainly the occupants of the building	eDiana, FIEMSER, IntUBE SSN (Semantic Sensor Network)	Building Description (*BuildingElement*) Sensing (*Device, SensorMeasurement*) BO&C model information (*Information*) • sensor measurements • actuator commands • weather forecast • two types of input by building occupants • model recommendations to users Users and their interaction with the system
MIRABEL	Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution	MIRABEL D2.2_Final	Addresses the challenge of balancing electricity consumption and production by leveraging flexibilities in energy demand and supply. Entities that can both consume and produce energy are allowed to request and offer electricity with defined flexibility (e.g., flexibility across time). Such requests and offers are continuously collected and scheduled. Handles very large volumes of electricity-related data and provides services tovery large numbers of users in near real-time actuation of the energy balance in the electricity network - Based on schedules that are delivered as the response to every demand request or production offer of the lower level parties. The feedback from the electricity network is provided as near real-time measurements and local forecasts of consumption and production.	Common Information Model (CIM) + eBIX	• FlexEnergy (express constraints in terms of time, energy and costs; financial aspects; energy profile) • FlexOffer
SmartCoDe	Smart Control of Demand for	SmartCoDe-EuP-	Optimal utilisation of renewable energy resources, especially small-scale wind-power	N/A	Energy-using Products (EuPs)

	Consumption and Supply to enable balanced, energy-positive buildings and neighbourhoods	classification-outline	and photovoltaics (PV) by managing the demand of smart appliances. The target areas are neighbourhoods and offices where such local energy resources are used, while also being connected to the public grid. Provides a *wireless* communication infrastructure to implement such a local energy management. Wireless sensor/actor nodes are integrated into appliances to enable re-mote control by an Energy Management Unit (EMU).		• schedulable service • virtually storable service • variable service • event-timeout controlled service • complete control • charge control • custom control Local Energy Provides (LEPs) • Energy Grid • Volatile Energy Provider • Local Energy Generator • Energy Storage
TIBUCON	Self Powered Wireless Sensor Network for HVAC System Energy Improvement – Towards Integral Building Connectivity	TIBUCON D2 3 High Level Data Models and Message Structures	Proposes a solution beyond the existing wireless based HVAC control systems, derived from the use of Self Powered Multi Magnitude Wireless Sensor Network (SP-MM-WSN) for building thermal condition monitoring. The SPMMWSN completely avoids the use of cables and removable batteries, thanks to the combination of extremely energy efficient wireless communication technology, ultra low power electronics, and the power harvesting concept. The use of SPMMWSN therefore, results in an easy-to-deploy and maintenance free building monitoring system that makes it the ideal candidate for either new or existing HVAC installations	SensorML	temperature sensor humidity sensor remaining battery monitoring
IntUBE	Intelligent Use of Buildings‘ Energy Information	IntUBE Energy Model (BIM/SIM/PIM)	The business models and ICT tools developed in IntUBE will enable the multi-phase, multi-role management of buildings' energy information. In the IntUBE concept, the Energy Information Service Provider (EISP) will use different kind of information to provide customers with the required knowledge for making energy-efficient decisions related to the buildings they use, own or operate: • A database containing building information (size, structure, materials,	Building data: Industry foundation Classes (IFC) and related technologies (IFD, IDM, MVD) + GreenBuilding XML + CityGML;	Building design (planned static) Building usage (planned dynamic) Meter/sensor (actual dynamic)

			HVAC-systems) • Intelligent Building sensors (temperature, occupancy, lightning, energy consumption) • information provided by the Neighbourhood System • energy forecast information, weather data and energy prices	Building automation interoperability: KNX + LonWorks + BACnet + oBIX; Operational data storage: HDF + NetCDF;	
Hesmos	ICT Platform for Holistic Energy Efficiency Simulation and Lifecycle Management Of Public Use FacilitieS	HESMOS_D6.1_Appendix	Provide advanced simulation capabilities to decision makers in the whole life-cycle of buildings, taking into account energy savings, investment and life-cycle costs Integrate a Virtual Laboratory to connect CAD and eeTools (energy efficiency Tools) in order to enhance building industry actor's ee-competences Close the gap between Building Information Modelling (BIM) and Building Automation Systems (BAS) so that decisions can be made economically (energy & cost related) in all life-cycle phases Integrate surrounding areas extending current BIM to eeBIM	BAS: "Dibowski Henrik und Kabitzsch Klaus Ontology-Based Device Descriptions and Device Repository for Building Automation Devices" BIM: IFC	BAS components: • Device • Functional Profile • Input • Output • OperationMode • Function • Configuration Parameter • Parametrization BIM ontology Linking ontology • Mapping to LON, EnOcean, KNX, BACnet, ZigBee • Mapping to BAS application layer
FIEMSER	Friendly Intelligent Energy Management System for Existing Residential Buildings	D5_FIEMSER data model_m9_CSTmb_REVIEW	Minimization of energy demand from external resources through the reduction of the energy consumption in the building and the correct management of local generation (heat and electricity) and energy storage equipment. Provide the capability to export energy to the utilities when needed. Interaction with the building user, increasing the consciousness of the consumer about his CO2 emissions, providing hints to make punctual	IFC + gbXML;	• Environment and contextual data (location, climate zone, shadowing, building orientation, weather data, energy prices) • Energy-focused BIM (space organization, home equipments) • WSN-data (sensors&actuators, data collected from sensors, log of activations) • User preferences (usage, definition

			changes in his behaviour.		of scenes, use of appliances, control rules and energy strategy) • Resources scheduling • Advices (orders created as result of an event, user action or system suggested actions) • Energy performance indicators (log of consumptions, performance) • User access rights
eDiana	Embedded Systems for Energy Efficient Buildings	EDIANA_D2.2 - A_ONTOLOGYDEVICEAWARENESS_M10	Enable the interoperability of heterogeneous devices at the Cell and MacroCell levels, and it will provide the hook to connect the building as a node in the producer/consumer electrical grid. The eDIANA Platform realisations will then cope with a variable set of location and building specific constraints, related with parameters such as climate, Cell/MacroCell configuration (one to many, one to one etc), energy regulations etc	N/A	• Information Layer - direction - comfort variable - smart actuator command • service layer - external service - internal service (configuration, profile, sensor data, status, userdata) • device layer - actuator - appliance - complex sensor - physical sensor - threshold sensor
BeyWatch	Building EnergY Watcher	BeyWatch_TN_EE Buildings Contribution_BeyWatch IF-v03	Interactive energy monitoring, intelligent control and power demand balancing at home and neighbourhood level • Energy-aware white goods • Low-cost in-home communications • Devices control & monitoring • Photovoltaic & solar home system • Load / energy management • Business Support Systems	N/A	• Residential Gateway • Customer • User (there might be some users per utility customer) • Operator • Node • Device or Energy Profile
BeAware	Boosting Energy Awareness with Adaptive Real-time Environments	BeAware-D3.1	BeAware wishes to foster the creation of new services that turn householders into active players in energy and inspire creation of new services and products for energy awareness The Energy Life architecture consists of three	SensorML	User Application layer Service layer • Energy monitoring & notification

			different logical layers: a sensing platform, a service layer and an application layer. The sensing platform provides consumption measurement data from a wireless network of sensors and base stations. This data is stored in a computation grid, which offers real-time analysis and scalability. The service layer provides an open and distributed web service infrastructure oriented towards consumers and detailed analysis of electricity consumption in households. The service layer represents the natural bridge between the sensing platform and the consumer application layer. The application layer provides information to the consumer and makes them an active stakeholder into the consumer energy conservation chain.		• Remote switch controller • Awareness cues synthersizer • Energy user profile • Administration & configuration Sensing layer • Sensor data storage • Analysis & event correlation

Table 4 – ICT4E2B projects data models and context analysis

To summarize, here is the list of referenced data models:

eMIX	OASIS	v1.0	Exchanging price information and product definitions in energy markets and to those following markets	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=emix
CIM	IEC		Common Information Model	http://en.wikipedia.org/wiki/Common_Information_Model_(electricity)
SensorML	OGC		sensor model language	http://www.opengeospatial.org/standards/sensorml
IFC	ISO		Industry Foundation Classes	http://www.ifcwiki.org/index.php/Main_Page
gbXML			Green Building XML	www.gbxml.org
CityGML	OGC		city geography markup language	www.citygml.org
oBIX	OASIS	v1.1	open building information exchange	http://www.obix.org/
EEML			extended environments markup language	www.eeml.org
eBIX			energy business information exchange	www.ebix.org
SSN	W3C		Semantic Sensor Network	http://www.w3.org/2005/Incubator/ssn/wiki/SSN_Sensor

Table 5 – ICT4E2B projects data models reference

3 Overall BEAMS architecture

In this section, the architecture selected for BEAMS is presented and is used as reference for a detailed allocation of the requirements and scenarios identified in the previous Work-Package 1.

3.1 Reference architecture and components

The following picture represents a high level view of the architecture blocks considered in BEAMS. Basically, the ESB will enable the communication between all the components of the system, acting as a router and buffer of messages exchanged by each component. The messages content will be defined in WP2 D2.2.1 and now we refer to it as “BEAMS Protocol”.
The ESB may add some business logic to the system, like manipulation of messages or other common functionalities (i.e. maintenance services, clock synchronization, etc).
The scenario presented in the following picture is just an example that highlights the interactions between the involved components.

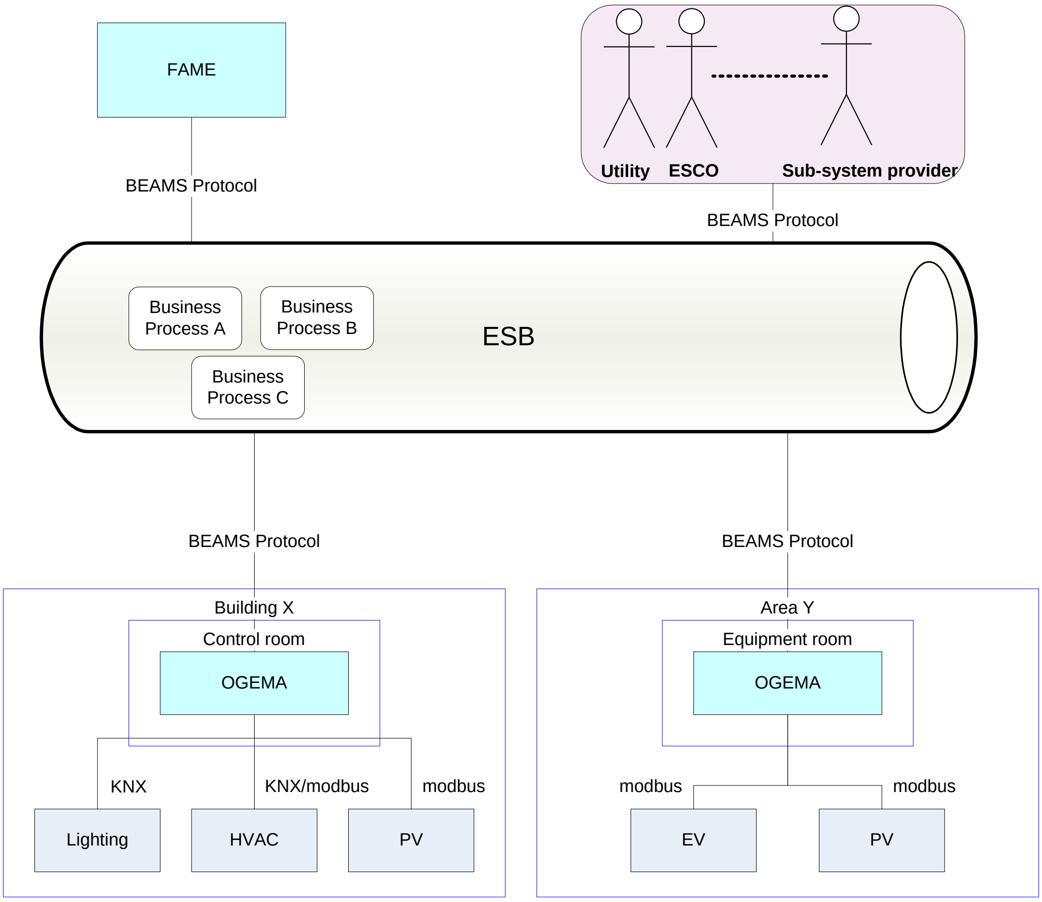


Figure 5 – Conceptual ESB architecture in BEAMS

3.2 Capabilities Views

The scope of the capability view is to capture essential elements useful to elaborate a strategic vision and define the main associated concepts.
A capability is defined as “the ability to deliver a specified type of effect or a specified course of action” and our main purpose here is to make an effective analysis of the capability gaps and overlaps.

In BEAMS the capabilities will be described based on a capability taxonomy.
In order to obtain a complete taxonomy it is necessary to capture the essential elements of the BEAMS strategic vision and concepts and decompose them. Capabilities mainly derive from the system requirements analysis done in WP1. The following box reports the main outputs from that analysis.

BEAMS Capabilities

- **Energy Sub-System Capabilities**
  - Manage energy generation/consumption information
    - Integrate Real Time data
      - energy generation/consumption
      - sub-system or dynamic resource availability
        - New loads or DER resources are detected
        - Operational Status of Sub-system (Normal/Fault)
    - Historical energy consumption data
  - Monitoring and Controlling Energy Sub-Systems
    - HVAC system
    - Lighting system
    - Photovoltaic Generation (PV)
    - Electrical Vehicle (EV)
  - Alarm Management
    - Alarm detection and processing rules
    - Alarm reporting to HMI and acknowledgement
- **Simulation and Reporting Capabilities**
  - Simulate Deployment Scenario
    - Simulate Weather conditions
    - Simulate Energy Consumption/Generation
    - Modeling sub-systems and dynamic resources
      - Availability
      - EV Charge and discharge
      - EV Storage capacity
      - PV Power prediction model
    - Simulate People Occupancy
    - Match simulated behavior against constraints
    - Analysis over a period of time (simulate schedules of weather/usage/generation/occupancy)
  - Report energy generation/consumption information
    - Reporting to HMI
    - Export of reports files
  - Generate Short & Long term DER (Distributed Energy Resources) energy generation forecast
- **Optimization Capabilities**
  - Orchestrate Site Optimizations
    - Monitor Local Optimizations
    - Control Local Optimizations
  - Perform Local Optimizations
    - Generate control schedule plan
      - using on actual data
      - using historical data
        - using forecasts
      - evaluating effects of simulations
    - Deploy control schedule plans to sub-systems
    - Manage control schedule plan priorities
- **Environment information capabilities**
  - People Occupancy Information
    - Manage Static Occupancy Data (configured manually by user)
    - Integrate Real Time Occupancy Data (gathered automatically by integrated systems)
    - Update "Static Occupancy Data" with statistical information from integrated Real Time Occupancy systems (FUTURE EXPANSION CAPABILITY)
  - Manage Weather Information
    - Local Weather
    - Solar irradiation
    - Climate (Seasonal data)
    - Historical Weather data
- **Utilities Interaction Capabilities**
  - Manage price tariff
  - Manage utilities' Demand/Response (DR)
    - Automatic optimization
    - Optimization Decision Support
      - Confirm/Deny optimization action
  - Manage grid failure

3.3 Operational Views

The purpose of the operational views is to define the operational nodes, activities and tasks, and the information exchange requirements.
An *operational node* is the logical entity that performs operational activities. The *needlines*, represented as arrow lines, are the graphical specification of a need of information exchange.
The operational views adopted in BEAMS include an operation node connectivity description and a list of operational information requirements. The former illustrates the operational domain's needs for information exchange in support of operational activities. The latter is used to identify and describe all the information exchanges that make up all the information *needlines* between operational nodes, as identified before.
It is then necessary to capture every information exchange of every operational node and identify the most important aspects of them.
For the purposes of the BEAMS project, we will focus on the needlines connected to Interoperability Gateway nodes.

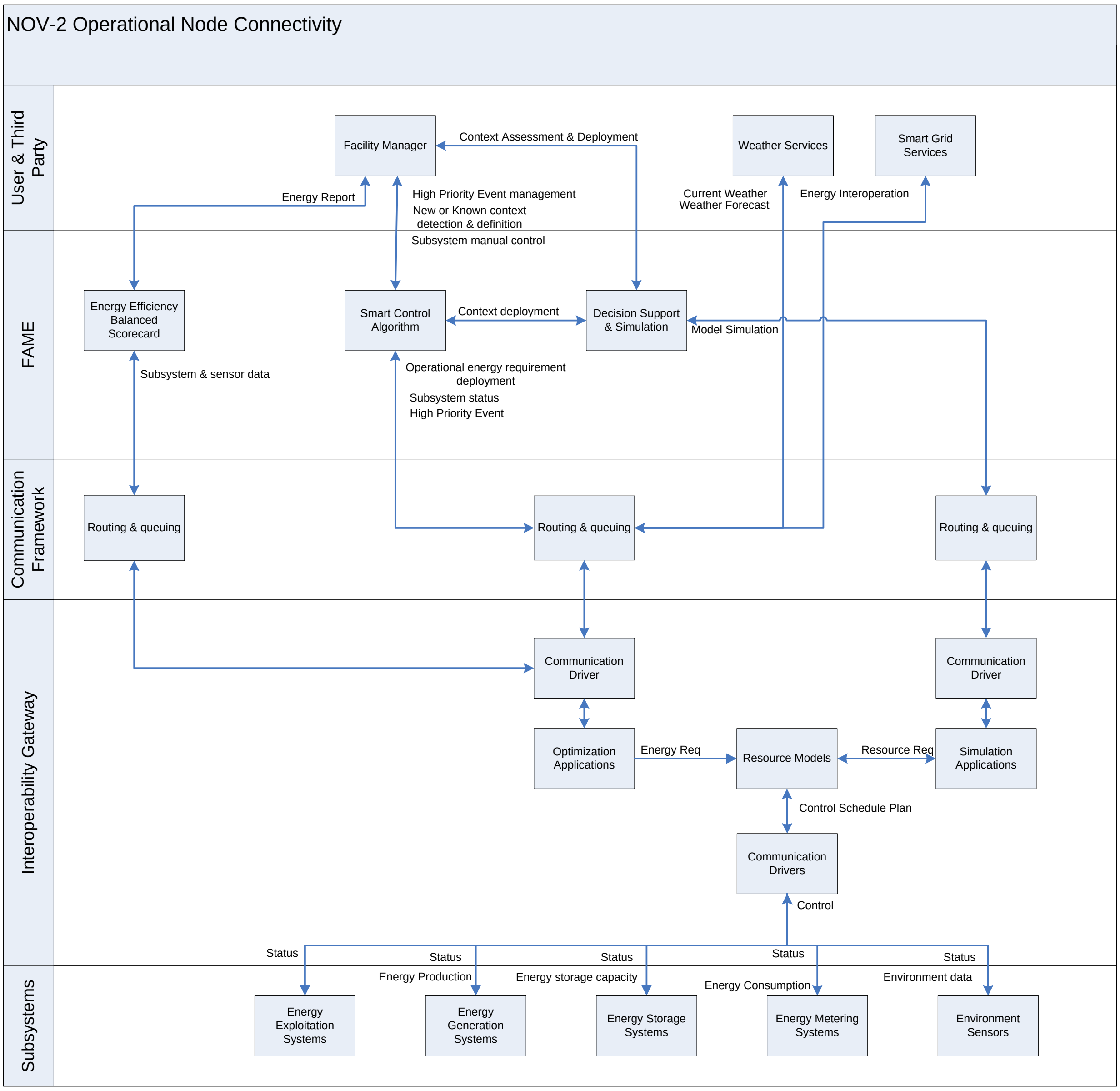


Figure 6 – Operational Node Connectivity

NOV3 Operational Information Requirements

Needline	Information Exchange	Elements Involved Sending Node (Consumer)	Receiving Node (Provider)	Criticality	Transaction Type (MEP)
Subsystem & sensor data	Request / response of energy consumption or production data of subsystems and components monitored or environmental sensor data	Energy Efficiency Balanced Scorecard	Optimization Applications	High	In-Out
Subsystem & sensor data		Optimization Applications	Energy Efficiency Balanced Scorecard	High	
Operational energy requirement deployment	deploy the request to change the subsystem setting in order to reach some specific energy reduction objectives	Smart Control algorithm	Optimization Applications	Medium	In-Out
Operational energy requirement deployment	confirm the requirement deployment	Optimization Applications	Smart Control algorithm	Medium	
Subsystem status	relevant diagnostic information of the subsystems and operational status	Optimization Applications	Smart Control algorithm	High	In-Only
High priority event	priority events coming from third parties (ex. Emergency)	Optimization Applications	Smart Control algorithm	High	Robust In-Only
Model simulation	request resource simulation	Decision Support & Simulation	Simulation Applications	Medium	In-Out
Model simulation	model simulation results	Simulation Applications	Decision Support & Simulation	Medium	
Current Weather	Weather real time data (temperature, humidity, wind, etc.)	Weather services	Optimization Applications	Low	In-Only
Weather Forecast	Weather forecast data for next days (hourly forecast would be better)	Weather services	Optimization Applications	Low	In-Only
Energy Interoperation	market participation as defined in OASIS EIP v1.0	Smart Grid Services	Optimization Applications	Medium	In-Optional Out
	Load predictability and generation as defined in OASIS EIP v1.0	Smart Grid Services	Optimization Applications	Medium	
	Dynamic price as defined in OASIS EIP v1.0	Smart Grid Services	Optimization Applications	Medium	
	Reliability & Emergency as defined in OASIS EIP v1.0	Smart Grid Services	Optimization Applications	Medium	

Table 6 – Operational Information Requirements

3.4 Service Oriented Views

A service -as it is understood in its broadest sense- is a well defined way to execute a unit of work with a provider that provides a useful result to a consumer. A service defined in this way is not necessarily equivalent to a web service.
A service is essentially a set of a strictly delineated functionality that answers to a what-question, independently of construction or implementation issues.
A service‘s set of functionality clearly marks the service‘s responsibilities, which should ideally be mutually exclusive and highly cohesive.
The Service-oriented views lay between the business and the system architecture: services are close to the operational domain but also allow the design of a set of system components which implement the architecture.

In BEAMS the service-oriented views will be described based on service taxonomy and a service definition.
In the Service-Oriented View the service taxonomy represents the operational domain‘s knowledge, as described in the Operational View, in terms of services that are structured in some useful way.
The services themselves are defined by the NSOV-2 view of the architectural framework, where they are strictly delineated in order to understand the operational domain.

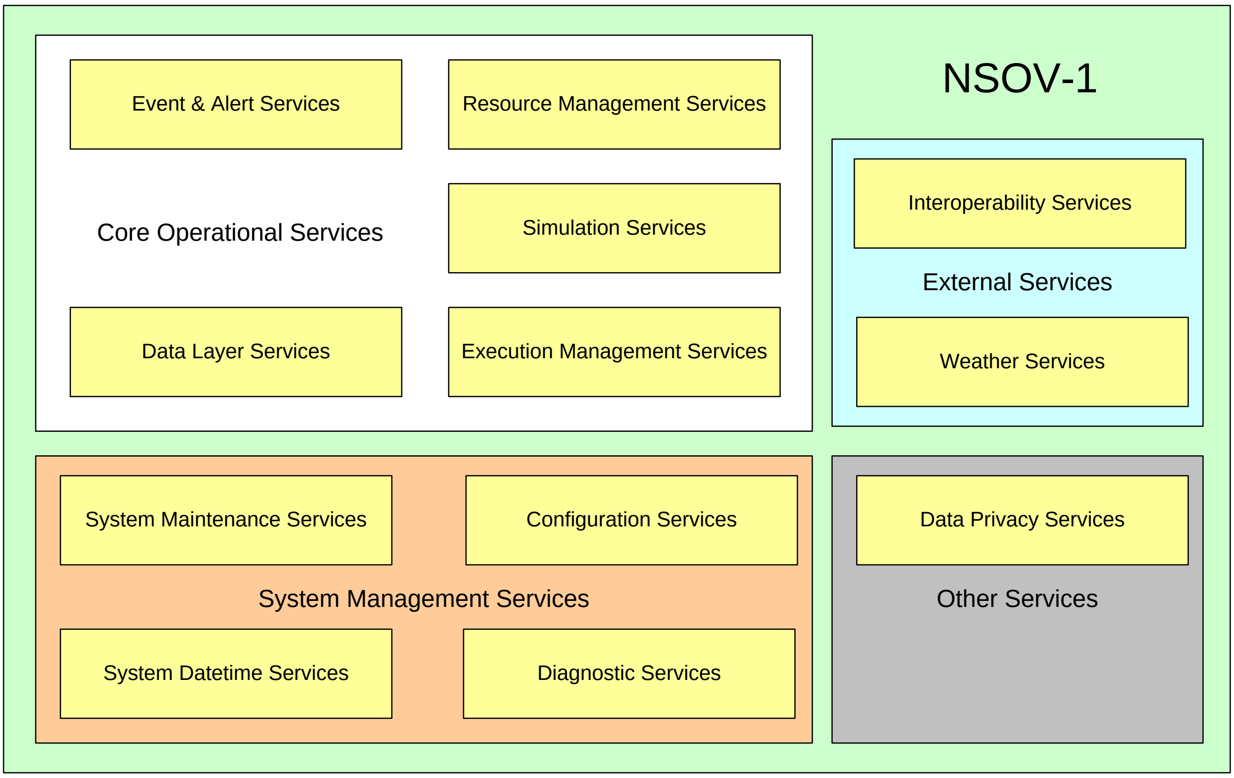


Figure 7 – Services Taxonomy

In the following paragraphs each services group is further detailed with some additional description provided.
The services coloured in grey are the low-priority. The services coloured in yellow are the high-priority and represent the public service interface. Finally the services in white are support services for internal use.

3.4.1 Core Operational Services

3.4.1.1 Events & Alerts Services (High/Low Priority)

Ref. **ARC_065**, **ARC_074**, **ARC_039, ARC_066** (Low), **ARC_068** (Low)

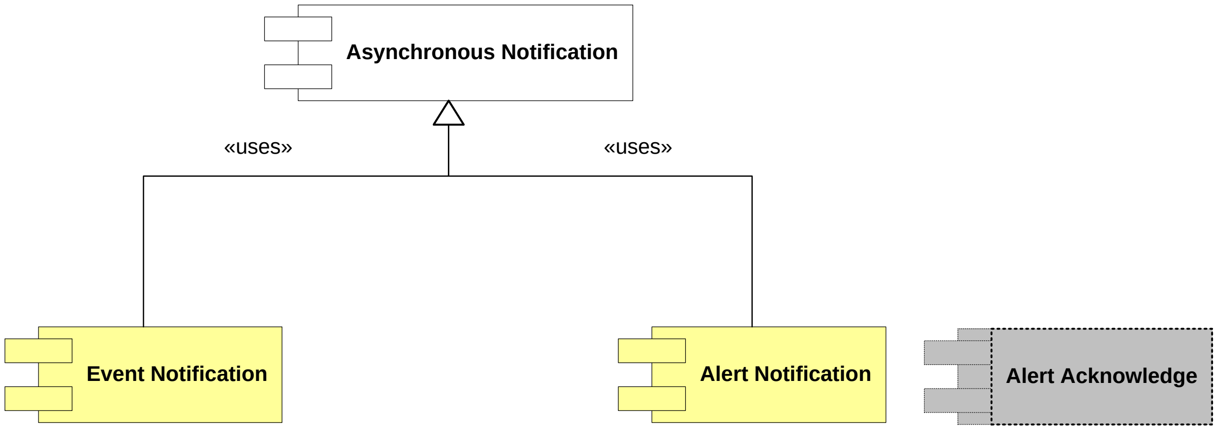


Figure 8 – Event & Alerts Services

Events & Alert services allow for a publisher-subscriber communication pattern in which every subscriber can be notified autonomously and asynchronously by the message publisher on specific messages (events and alert).
Alerts are high priority events which need to be notified to the facility manager, and optionally could need user acknowledgement through the UI (Alert Acknowledge service). In BEAMS the high priority data coming from third parties have to be considered as alerts and FAME shall be notified about them. Events are the other low priority asynchronous notifications of the system.

In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
Event Notification	Asynchronous event notification	P=OGEMA C=FAME	M	Yes
Alert Notification	Asynchronous alert notification	P=OGEMA C=FAME	M	Yes
Alert Acknowledge	Reset Alert (UI acknowledgement)	P=OGEMA C=FAME	O	Yes
Asynchronous Notification	Base service for asynchronous notification	N/A	M	No

3.4.1.2 Data Layer Services (High/Low Priority)

Ref. **ARC_071, ARC_057** (Low)

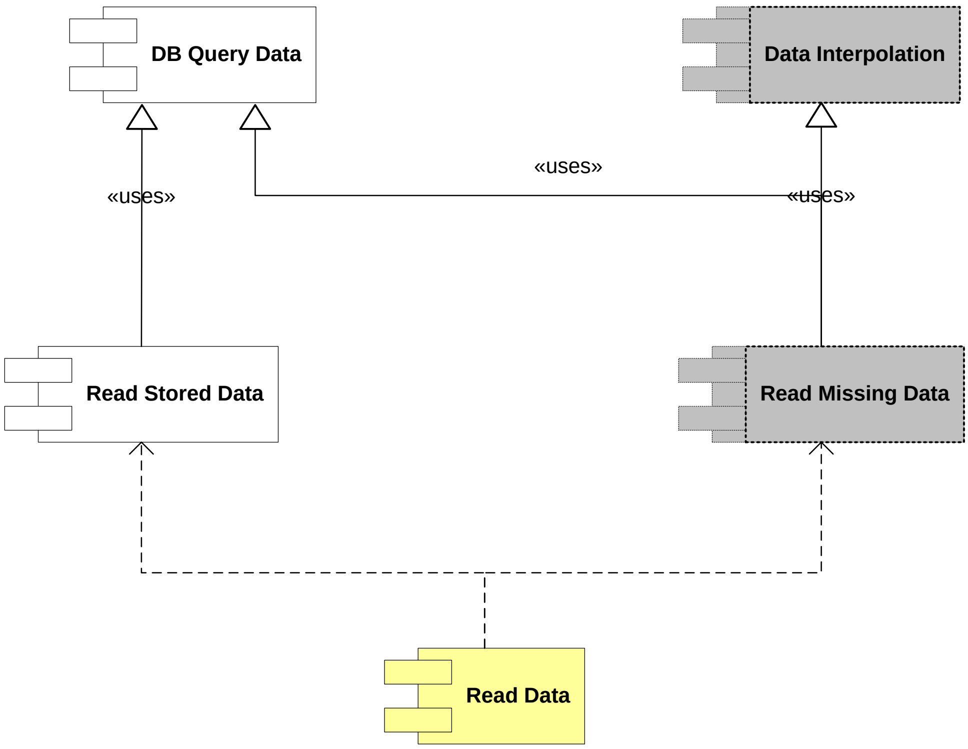


Figure 9 – Data Layer Services

The data layer access services allow requesting measurements data from OGEMA. Normally these data are stored in the OGEMA database, and FAME will request to put these data in its own database. The FAME database will have greater storage capacity than the OGEMA DB and at first analysis it should also use a similar structure, considering that it will store the same data. We can consider these data as raw measurement data, because they still need to be processed in order to calculate energy optimizations for the system.

Optionally, the system shall be able to cope with missing data from the database, either because the measurement is wrong or the data from sensors are corrupted or the sensor itself is switched off or broken. In this case, some data interpolation algorithm can fix the gap and provide statistically correct data.

In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
Read Data	Read subsystems measurement data	P=OGEMA C=FAME	M	Yes
Read Stored Data	Read data stored in OGEMA database	N/A	M	No
Read Missing Data	Read data which is not available in OGEMA database	N/A	O	No
DB Query Data	DB query	N/A	M	No
Data Interpolation	Calculate missing data by interpolation of contiguous points in the database	N/A	O	No

3.4.1.3 Simulation Services (High Priority)

Ref. **ARC_067**, **ARC_078**

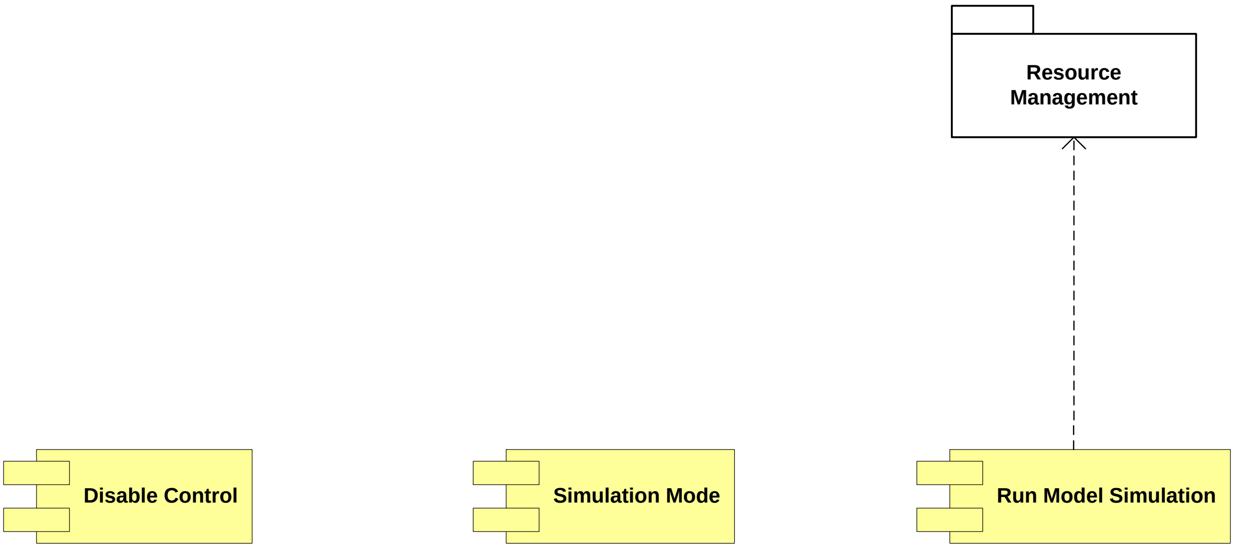


Figure 10 - Simulation Services

Simulation Services provide all the functionalities required to run the system in full "demo" mode without real control & monitoring of the subsystems or partially "demo" mode in which the OGEMA is still collecting measurement data but excluding any control of the system.
With "Run Model Simulation" service it is possible to simulate the behaviour of a single resource through its model stored in OGEMA, even if the resource does not exist in the real environment.
The services necessary to run the model simulation are classified under the "Resource Management" group of services (see §3.4.7).

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
Disable Control	Disable/Enable the control over the subsystem (subsystems will continue to work autonomously, monitoring is still active)	P=OGEMA C=FAME	M	Yes
Simulation Mode	Disable/Enable the simulation runtime mode (in simulation all subsystems are fully simulated by algorithms)	P=OGEMA C=FAME	M	Yes
Run Model simulation	Simulate the resource behaviour through the models available in OGEMA	P=OGEMA C=FAME	M	Yes

3.4.1.4 Resource Management Services (High Priority)

Ref. **ARC_067**, **ARC_078**

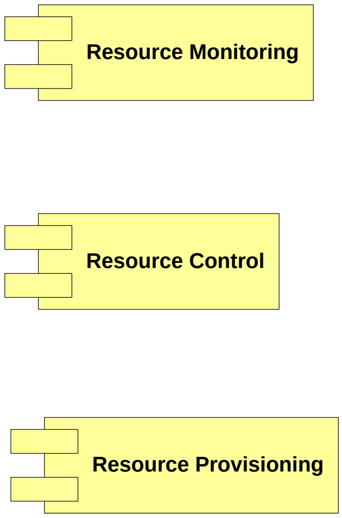


Figure 11 – Resource Management Services

The Resource Management Services are necessary to run the model simulation of both existing and not existing resources (Resource Provisioning) and manage the individual resource control and monitoring (Resource Monitoring and Control).

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
Resource Monitoring	Monitor resource	P=OGEMA C=FAME	M	Yes
Resource Control	Control resource	P=OGEMA C=FAME	M	Yes
Resource Provisioning	Provide resource model and calculation	P=OGEMA C=FAME	M	Yes

3.4.1.5 Execution Management Services (High Priority)

Ref. **ARC_075**

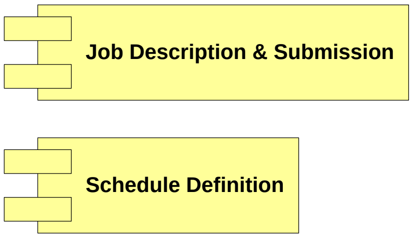


Figure 12 – Execution Management Services

The Execution Management Services allow the execution on OGEMA of energy optimization “jobs” calculated by FAME. A clear definition of job will be finalized in another deliverable (D2.2.1 information model) and at this stage of the project it is sufficient to define just a basic concept: a job is some action on the subsystems that could be executed by OGEMA.

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
Job Description & Submission	Describe and execute an optimization job as calculated by FAME	P=OGEMA C=FAME	M	Yes
Schedule Definition	Define schedule which is associated to one or more jobs	P=OGEMA C=FAME	M	Yes

3.4.2 System Management Services

3.4.2.1 System Maintenance Services (High/Low Priority)

Ref. **ARC_076**, **ARC_041** (Low)**, ARC_077** (Low)

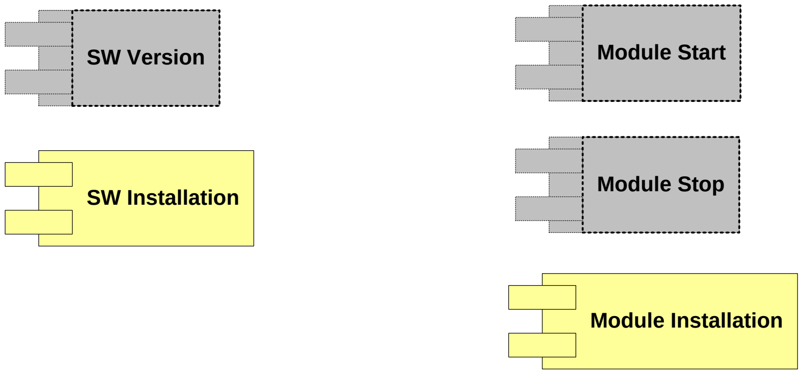


Figure 13 – System Maintenance Services

Maintenance services allow the software maintenance (upgrade, installation and runtime configuration of modules).
OGEMA Framework already provide similar services for updating the software modules, therefore for the BEAMS purposes, we rely on this current updating mechanisms (the above picture should be updated accordingly).
Optional services, as the current running SW version, could be added to OGEMA at a later stage.
In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
SW Installation	Install a new SW version (set of modules)	P=OGEMA C=FAME	M	Yes
Module Installation	Install a new single module	P=OGEMA C=FAME	M	Yes
SW Version	Get the current running SW version	P=OGEMA C=FAME	O	Yes
Module Start/Stop	Start/Stop specific modules (applications or drivers) to configure the runtime environment	P=OGEMA C=FAME	O	Yes

3.4.2.2 System DateTime Services (High/Low Priority)

Ref. **ARC_030, ARC_058** (Low), **ARC_064** (Low), **ARC_048** (Low), **ARC_049** (Low)

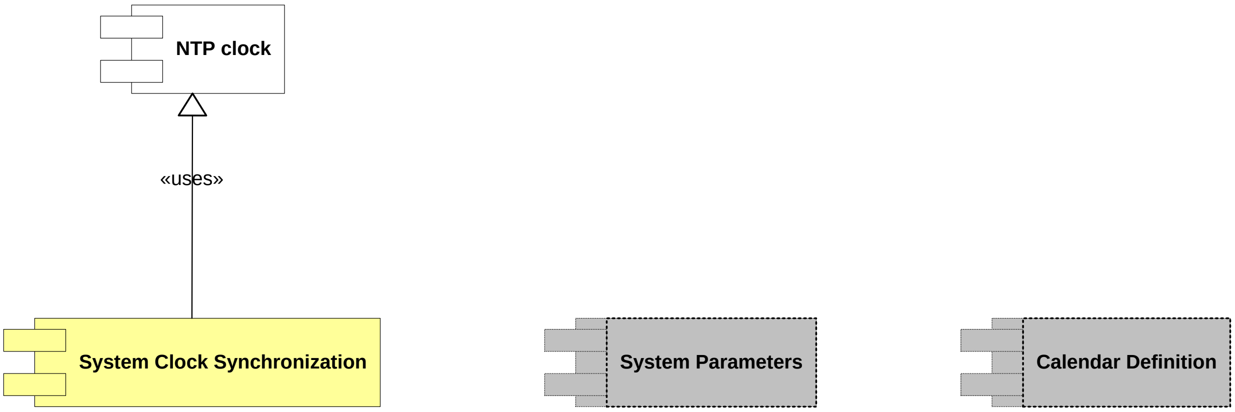


Figure 14 – System DateTime Services

System DateTime Services main role is the clock synchronization of each BEAMS component. It is a crucial aspect because measurement data must refer to a precise DateTime associated.
This can be achieved by using a third component that provides the clock synchronization service and that can be allocated to a dedicated business process of the ESB. Alternatively FAME can provide this service, but this may be a solution with less flexibility.
Optional services are the definition of system date and time parameters (summer time change, system time step, max data resolution) and calendar definition (e.g. to specify the national festivity days).

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
System Clock Synchronization	Synchronize the clock	P=ESB Business process C=FAME,OGEMA	M	Yes
System Parameters	Definition of system parameters	P=OGEMA C=FAME	O	Yes
Calendar Definition	Definition of calendar	P=OGEMA C=FAME	O	Yes
NTP clock	Get the clock from an external NTP source	N/A	M	No

3.4.2.3 Configuration Services (Low Priority)

Ref. **ARC_050**

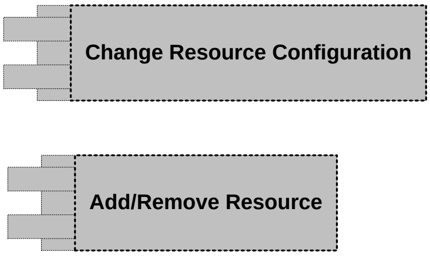


Figure 15 – Configuration Services

Configuration Services are all optional and they can be used to modify the runtime site configuration, by adding or removing resources or by modifying existing resources.

In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
Change Resource Configuration	Modify the resource configuration or parameters	P=OGEMA C=FAME	O	Yes
Add/Remove Resource	Add or remove resource	P=OGEMA C=FAME	O	Yes

3.4.2.4 Diagnostics Services (Low Priority)

Ref. **ARC_055**, **ARC_056**

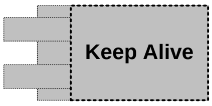


Figure 16 – Diagnostics Services

Diagnostics Services are represented by the Keep Alive service which monitors each component and test its responsiveness. A timeout is normally associated to the Keep Alive, so if the keep alive is not received after a given timeout, the component is considered malfunctioning.

This service shall be independent from each component and therefore it should be implemented in a dedicated ESB business process that continuously receives the keep alive messages in background. Alternatively, the keep alive service can be executed by FAME on OGEMA instances.

In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
Keep Alive	Keep alive with timeout	P=ESB Business Process C=FAME,OGEMA	O	Yes

3.4.3 External Services

3.4.3.1 Weather Services (High/Low Priority)

Ref. **ARC_010**, **ARC_005** (Low)

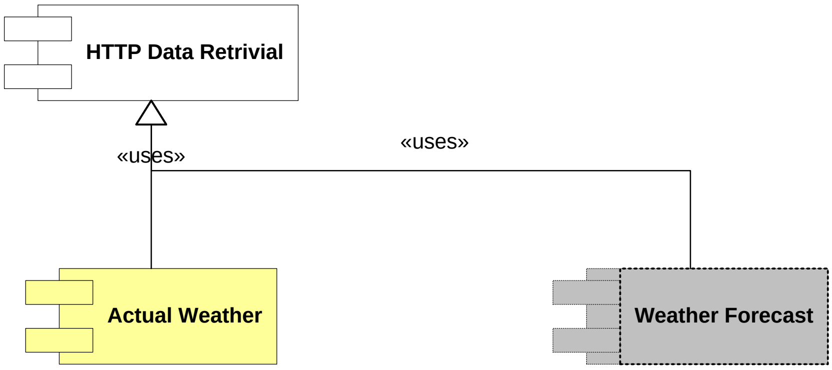


Figure 17 – Weather Services

Weather services give the possibility to access to current weather and forecasts reports in order for OGEMA to generate short term and long term DER power generation forecasts and calculate energy optimizations.

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
Actual Weather	Get the current weather information from the local weather station or local environment sensors	P=Weather Provider C=OGEMA	M	Yes
Weather Forecast	Get the weather forecast information from a public internet service	P=Weather Provider C=OGEMA	O	Yes
HTTP data retrivial	HTTP data access	N/A	M	No

3.4.3.2 Interoperability Services (Low Priority)

Ref. **ARC_002**, **ARC_009**, **ARC_073**

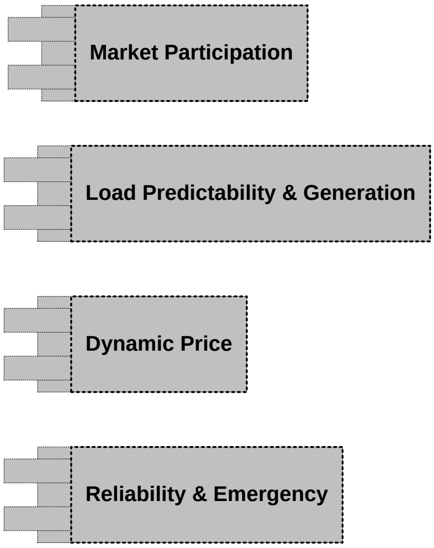


Figure 18 – Interoperability Services

Interoperability Services groups all the services offered by third parties including smart grid interactions.

In the table below a description and some characteristics of each service are summarized:

Service	**Description**	**Producer & Consumer**	**Mandatory/ Optional**	**Public Service**
Market Participation	Sell & Buy energy	P=Third Party C=OGEMA	O	Yes
Load Predictability & Generation	Site load and generation forecasts	P=Third Party C=OGEMA	O	Yes
Dynamic Price	Price tariff information	P=Third Party C=OGEMA	O	Yes
Reliability & Emergency	Emergency communications	P=Third Party C=OGEMA	O	Yes

3.4.4 Other Services

3.4.4.1 Data Privacy Services (High Priority)

Ref. **ARC_040**

Figure 19 – Data Privacy Services

All the communications with OGEMA shall be previously authorized. Therefore a user authentication is necessary to access the OGEMA data. For the purposes of the project a simple login/logout mechanism is sufficient. A list of authorized users shall be managed by OGEMA.
After successful Login, the client (FAME) shall get an access token and use it to communicate with OGEMA until a Logout occurs.
OGEMA shall then refuse all requests coming from any invalid token.

In the table below a description and some characteristics of each service are summarized:

Service	Description	Producer & Consumer	Mandatory/ Optional	Public Service
Authentication & Authorization	Login, Logout of authorized users	P=OGEMA C=FAME	M	Yes

3.5 Systems Views & Technical Views

The purpose of the System Interface Description is to illustrate which systems collaborate and how, in order to support the operational domain's information and the information exchange needs that have been defined in the Operational Views.
The system architectural view links together the Operational and System Views of the NATO architectural framework by depicting systems and system connections and how they realize the expected information exchanges.
A system is defined as any organised assembly of resources and procedures united and regulated for interaction or interdependence to accomplish a set of specific functions.

The Technical Standards Profile provides a list of standards or guidelines for the implementation of systems as defined in the various subviews of the NATO architectural framework's System View. This View is merged with the system view for simplicity.
It is explained how standards like Web Services, KNX or Modbus protocols are applied to the architecture.

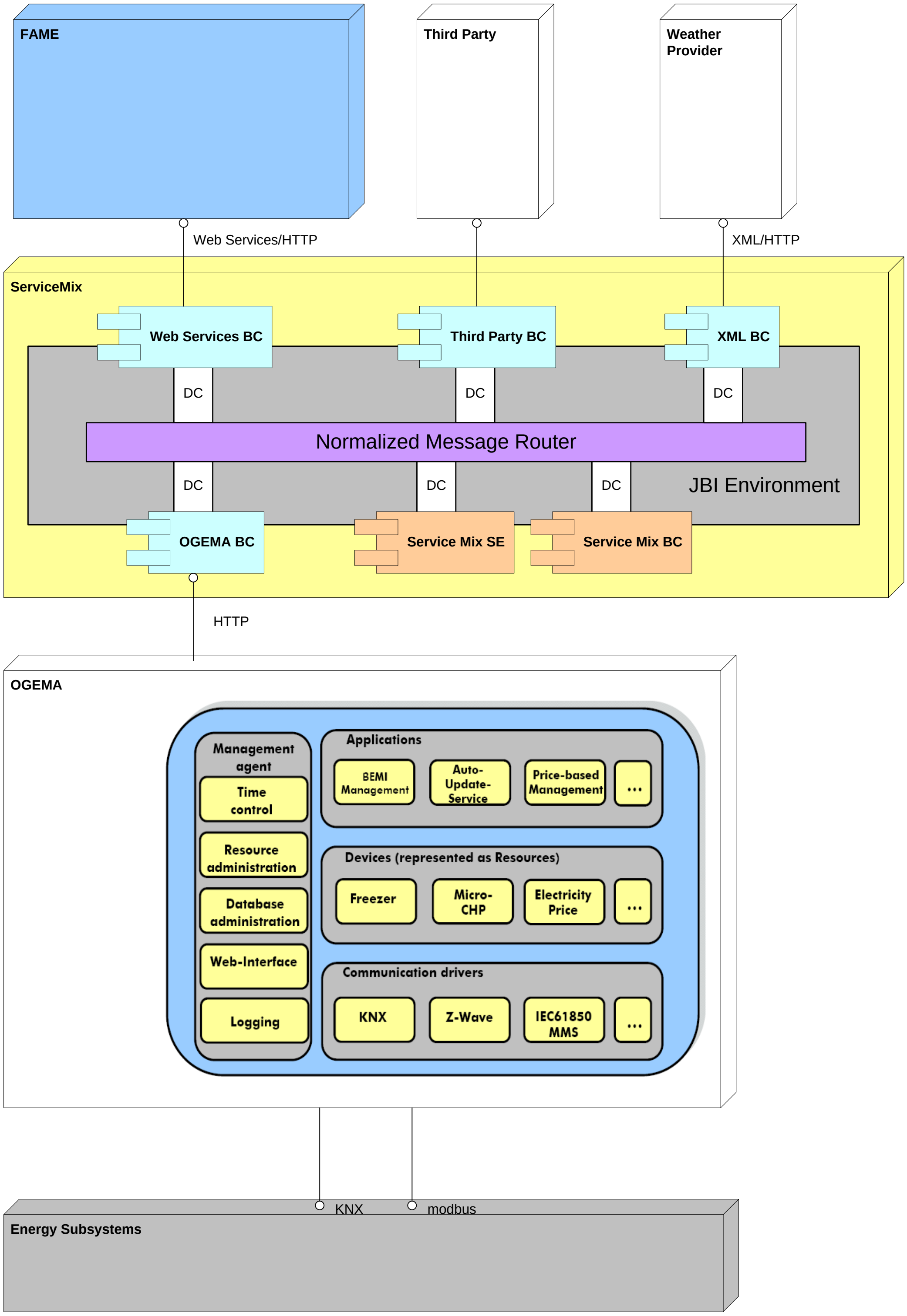


Figure 20 – System Interface Description

3.5.1 System components interactions

The main system components (FAME, OGEMA) interact through a message exchange supported by the ESB bus. The communication protocol, also called "BEAMS protocol", still needs to be defined (task of D2.2.1). All the communication is realized through Web Services over HTTP or HTTPS.

3.5.2 External Interfaces

All external interfaces (third parties and weather services) are realized through Web Services or XML over HTTP.

3.5.3 Field bus protocols

The communication between sensors, actuator and OGEMA are of particular importance to ensure proper control and management of the building. Existing protocols are either owned by private technology providers, or based on open communication languages.
In particular, the open protocols give the possibility to use sensors from several providers with normalized interoperability (e.g. EN ISO 16484-5 and 6).
For the BEAMS purposes, the following two widely adopted open protocols have been chosen: **KNX** and **Modbus**. Below a brief overview including more details is provided, and references to technical documentation can be found in [6] and [7].

Ref. **ARC_006**, **ARC_072**, **ARC_062**, **ARC_059** (Low), **ARC_060** (Low), **ARC_080** (Low), **ARC_081** (Low)

3.5.3.1 KNX

Konnex/KNX is the European open standard bus technology for Home & Building Automation Systems. Established by the convergence among the three former European technologies "BatiBUS" (French), "EHSA" (Dutch) and "EIB" (German) with decades of experience in this market, Konnex has integrated three different mechanisms of system configurations and different physical media in the unique KNX protocol.
The technological convergence of these three European standards meant that the three relevant European Associations (EIB Association-EIBA, BatiBUS Club International-BCI and the European Home System Association-EHSA) were fused to form the Konnex Association. This allowed a substantial expansion of the application field to include home and building automation influencing a broader multivendor market.
KNX technology has become one of the leading global protocols for home and building automation and the link of systems with ICT devices. As reported on the official website, the KNX technology has the following advantages:

- it facilitate designers, manufacturers and installers to "speak the same language", even using components from different Vendors/Manufacturers;
- it increases opportunities for industry and end-users to deploy a wide range of components;
- it offers complete solutions for the residential sector as well as for large-scale building automation;
- it allows to implement in one system the best solution for software development and use;
- it is totally independent from any specific technological application hardware/software, with the application profiles incorporated as an integral part of the standard;

- it applies a procedure for product certification, that is mandatory in order to distribute products with the brand "KNX" and ensure interoperability between products from different manufacturers;
- it is totally devoid of additional royalties for members of the Konnex Association;
- it has a single, integrated software tool for installation, design, engineering and commissioning;
- it ensures an appropriate cost-benefit ratio for all building types and applications.

The KONNEX Association counts on more than 200 manufacturers that offer a wide range of interoperable products, solutions, and applications based on the KNX technology. The Association members have recently agreed to release 61 patents necessary to implement products based on KNX technology and to sign partnership agreements with more than 20,000 installation companies and about 70 universities. Among its members the Konnex Association includes also energy distributors and telecommunications operators. The KNX technology is now a standard for Home and Building Automation also known as EN 50090 and ISO/IEC 14543.

3.5.3.2 Modbus

Modbus is an open serial communication protocol which was published by Modicon in 1979 for use with programmable logic controllers for industrial applications. It has become a de facto standard communications protocol in industry and is now the most commonly available means of connecting industrial electronic devices. The simplicity of Modbus TCP/IP enables any field device, such as an I/O module, to communicate across Ethernet links without the need for powerful microprocessors or huge internal memories. Due to the high speed of the Ethernet protocol, the performance of the Modbus TCP/IP is excellent. Since Modbus is implemented on top of the TCP/IP layer, users can benefit from the IP routing functionality and the possibility to reach devices located anywhere on a intranet or the internet, without worrying about the distance between hosts.

4 Demonstration sites architecture and configuration

The following sections provide a more detailed view of the pilot sites (FCB Stadium and Unisalento Campus) and describe how the BEAMS system will interface them in order to perform the demonstration activities.

4.1 Football Club Barcelona Stadium

The first phase of the project focuses mainly on defining the maximum possible scope of data from the current consumption of facilities (monitoring) and establish a reliable history of consumption as a comparative to the future results of the project. This scope of data will include:

- ELECTRICAL Subsystem: monitoring and control of consumption of general electrical power installations
- HVAC Subsystem: monitoring and control of energy consumption and air conditioning equipment performance efficiency
- METEOROLOGICAL STATION Subsystem: monitoring of atmospheric conditions
- ELECTRICAL VEHICLE Subsystem: electric vehicle power consumption monitoring
- PHOTOVOLTAIC PANEL Subsystem: tracking of photovoltaic panels power generation

The facilities and subsystems from the pilot site defined to achieve the objective of this first phase take into account the impossibility of the wireless communications during the match days because of the presence of the media that could interfere. It also takes into account the values given by the club concerning the partial remodeling of the facilities.

The facilities and subsystems defined are:

- STADIUM FACILITY: (monitoring & control)
  - ➢ ELECTRICAL Subsystem / monitoring: monitoring of the power consumption of all the 5 transformative stations of electrical voltage of the facilities of the stadium
  - ➢ ELECTRICAL Subsystem / control: monitoring and control of the power consumption of 8 lines of distribution of the general switchboard of the "Tunnel" transformation station (at the stadium facilities). This lines of distribution control the switching rounds of security surveillance and outdoor lighting
- PAVILION FACILITY: (Basketball court) (monitoring & control)
  - ➢ ELECTRICAL Subsystem: monitoring and control of the energy consumption of the coolers of the Sports Hall
  - ➢ HVAC Subsystem: monitoring and control of heat output and efficiency of performance of 4 coolers of the Sports Pavilion
  - ➢ Meteorological station Subsystem: monitoring of atmospheric conditions
  - ➢ Photovoltaic panel Subsystem: tracking of photovoltaic panels power generation
- GENERAL FACILITIES: no fix charging point (monitoring)
  - ➢ Electrical Vehicle Subsystem: monitoring of the consumption of electric vehicles located on installations
    - ▪ 2 vehicles used by surveillance and security services
    - ▪ 1 vehicle used by the waste management service

The installed devices shall be capable of picking up the productivity and consumption data and, therefore, able to "talk" with OGEMA. To this end, installed devices must have KNX or Modbus (bus) protocols.

Technical interventions will involve the installation of:

- Equipment for monitoring and control of the facilities
- Elements necessary to establish communication between equipment monitoring and control with the respective instances of OGEMA as well as between the different instances of OGEMA
- Possible installation of a meteorological station, or alternatively import data from other meteorological stations
- Possible installation of a photovoltaic panel or alternatively import data from a simulator of power generation.
- Instances of OGEMA, one for each subsystem and covered area

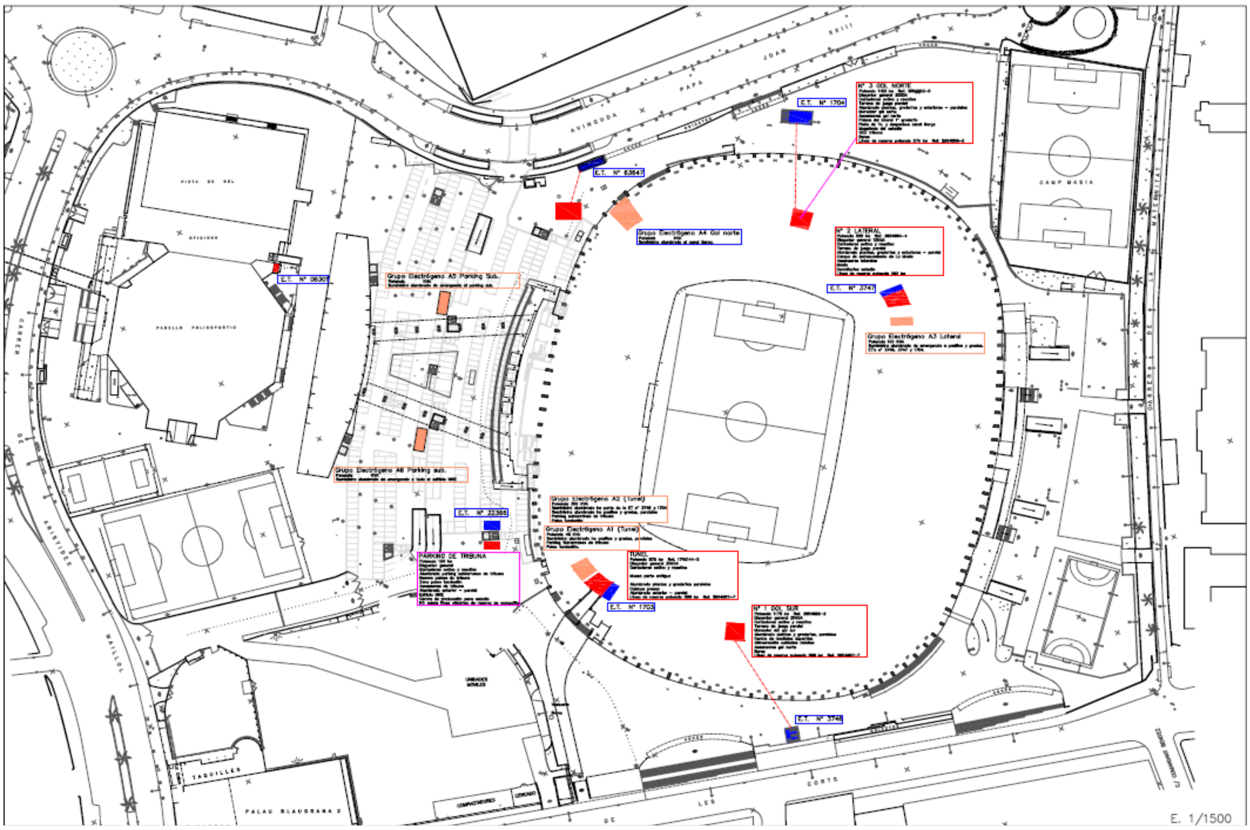


Figure 21 – Location of transformative stations, Futbol Club Barcelona

4.1.1 Stadium Facility

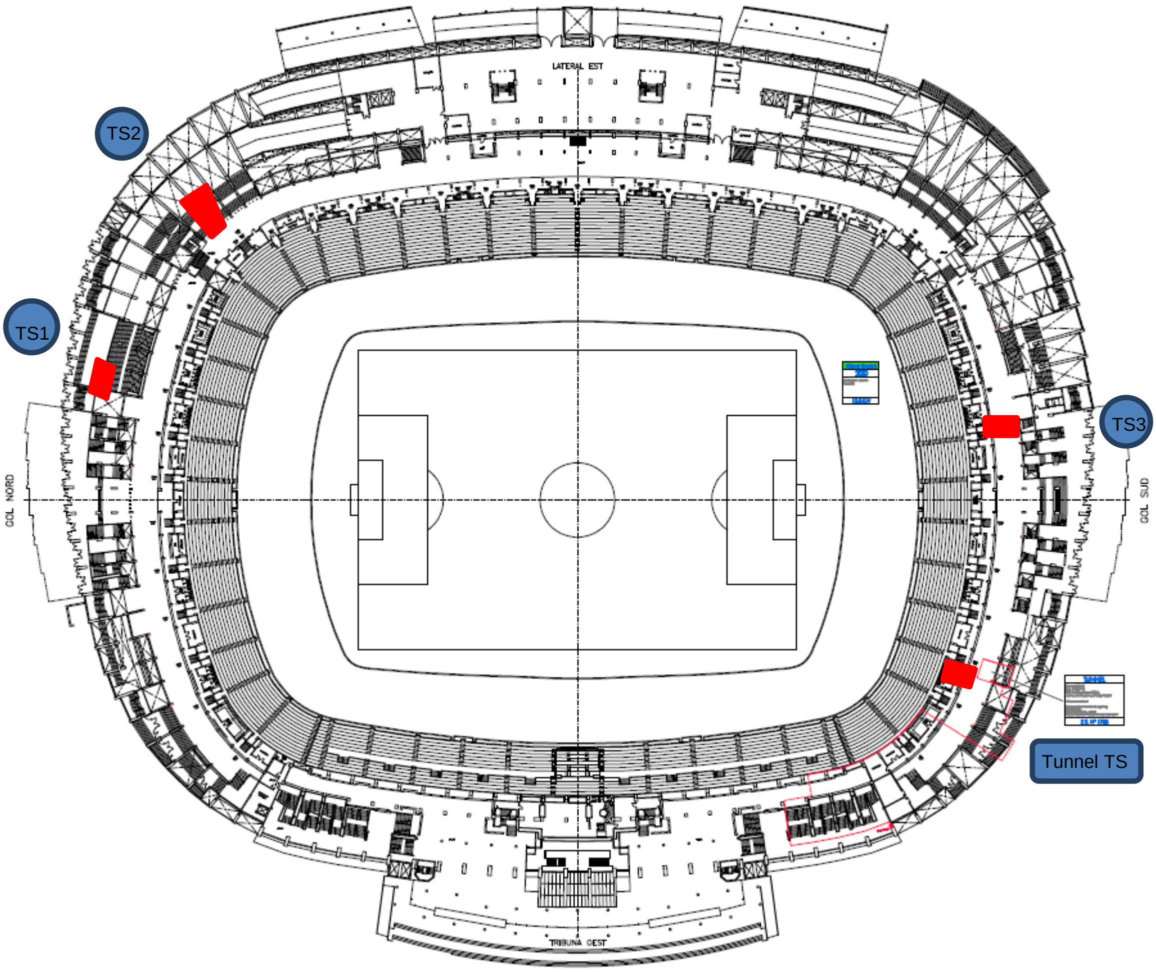


Figure 22 – Location of the transformative stations and communications wiring, Stadium. Level + 10.50 + 12.25

Figure 23 – Stadium Tunnel TS. Electrical switchboards

4.1.2 Stadium Electrical Subsystem

The technical interventions for controlling the energy of lighting consumption system contemplate:

- The installation of suitable measuring devices
  - Substation #1
    - Installation network analyzer CIRCUTOR CVM-Mini-HAR-RS485.
    - Installation breaker IV 6 A, protection analyzer
    - Installation 3 transformer TP2000/5
    - Installation 3 CVM 1D for ignition circuits
    - Installation 3 which sets of differential protection + magneto of 16 A II, for ignition circuits (RGU-10C-MT+ WGC20+E62 16 A)
    - Installation conversor RS232/485 / Ethernet
  - Substation #2
    - Installation network analyzer CVM-Mini-HAR-RS485.
    - Installation breaker IV 6 A, protection analyzer
    - Installation 3 transformers TP2000/5
    - Installation 3 CVM 1D for ignition circuits
    - Installation 3 which sets of differential protection + magnet of 16 A II, for ignition circuits (RGU-10C-MT+ WGC20+E62 16 A)
    - Installation conversor RS232/485 / Ethernet
  - Substation #3
    - Installation network analyzer CVM-Mini-HAR-RS485
    - Installation breaker IV 6 A, protection analyzer
    - Installation 3 transformers TP2000/5
    - Installation 3 CVM 1D protection analyzer
    - Installation 3 which sets of differential protection + magnet of 16 A II, for ignition circuits (RGU-10C-MT+ WGC20+E62 16 A)
    - Installation conversor RS232/485 / Ethernet

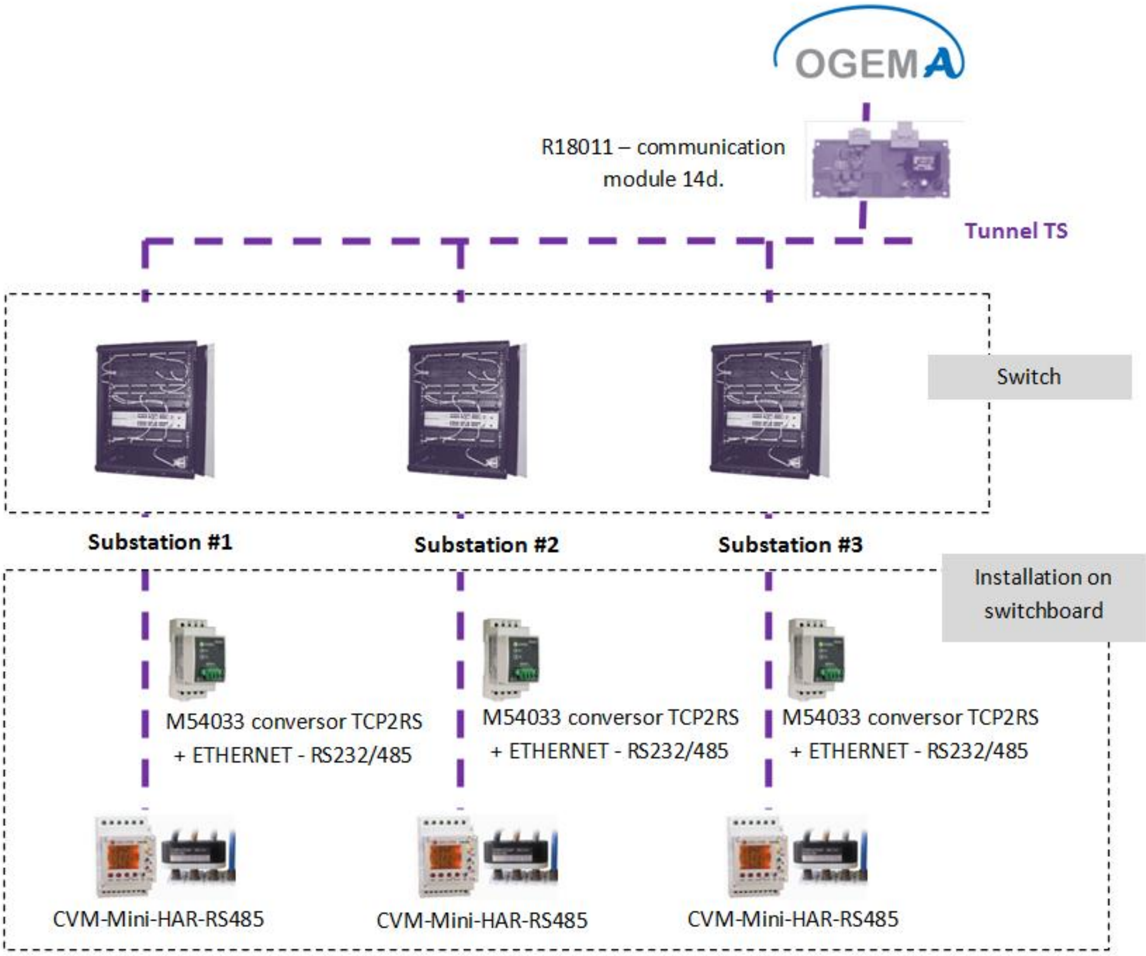


Figure 24 – Scheme of the Measuring Devices

- The installation of suitable measuring & control devices
  - Tunnel Substation
    - Installation network analyzer CVMk2-RS485
    - Installation breaker IV 6 A, protection analyzer
    - Installation 3 transformers TP2000/5
    - Installation regulator of battery of 1 module of communications RS485
    - Installation 3 CVM 1D protection analyzer
    - Installation 3 resettable set of protection differential + magneto of 16 A II, for ignition circuits (RGU-10C-MT+ WGC20+E62 16 A)
    - Installation convertor RS232/485 / Ethernet
    - 10 electrical lighting lines of the switchboard:
      - 15 – corridor
      - 31 – 1st floor 3 and 4
      - 39 – Tunnel I
      - 50 – Tunnel II
      - 59 – 2nd floor 3 and 4
      - 65 – Tunnel III
      - 66 – Tunnel IV
      - 70 – Parking zone 4

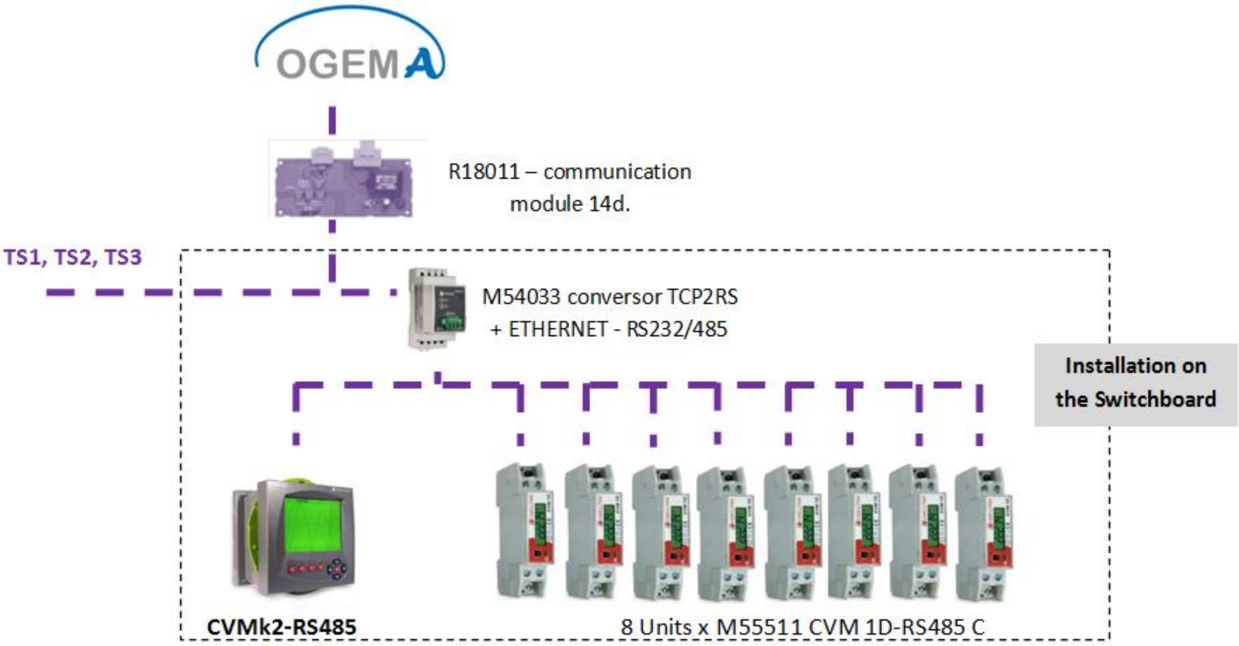


Figure 25 – Scheme of the Measuring & Control Devices

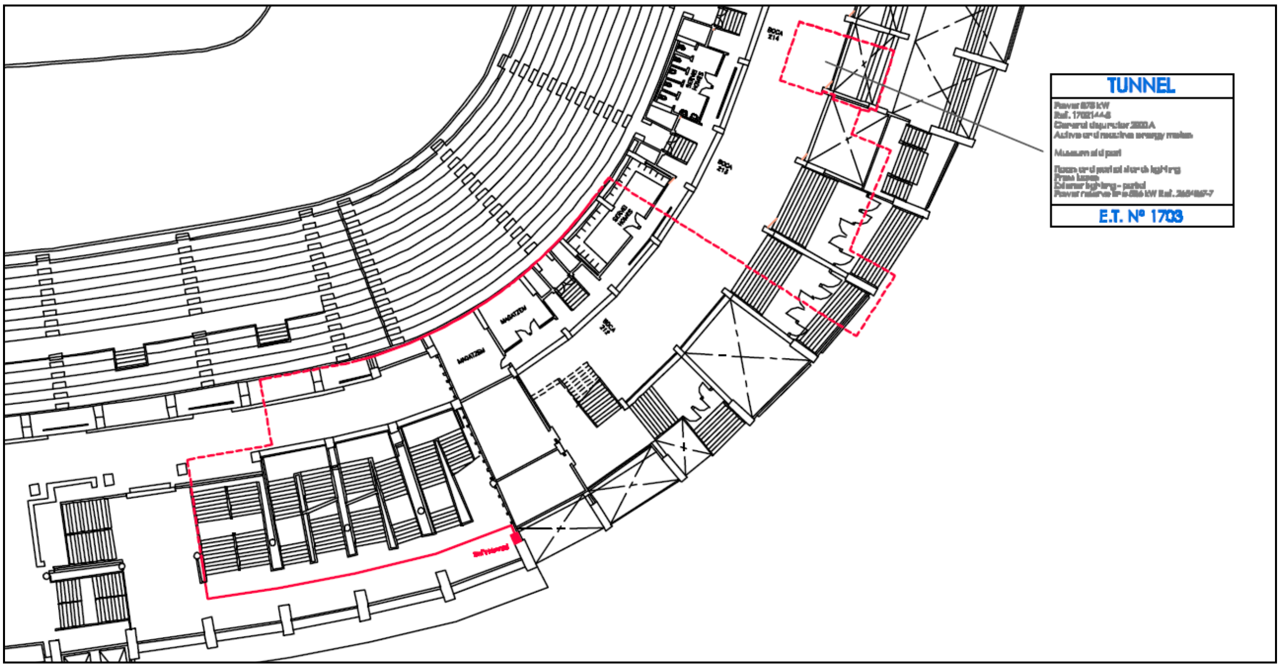


Figure 26 – Location of the "Tunnel" transformer station and communications wiring, Stadium. Level +10.50 +12.25

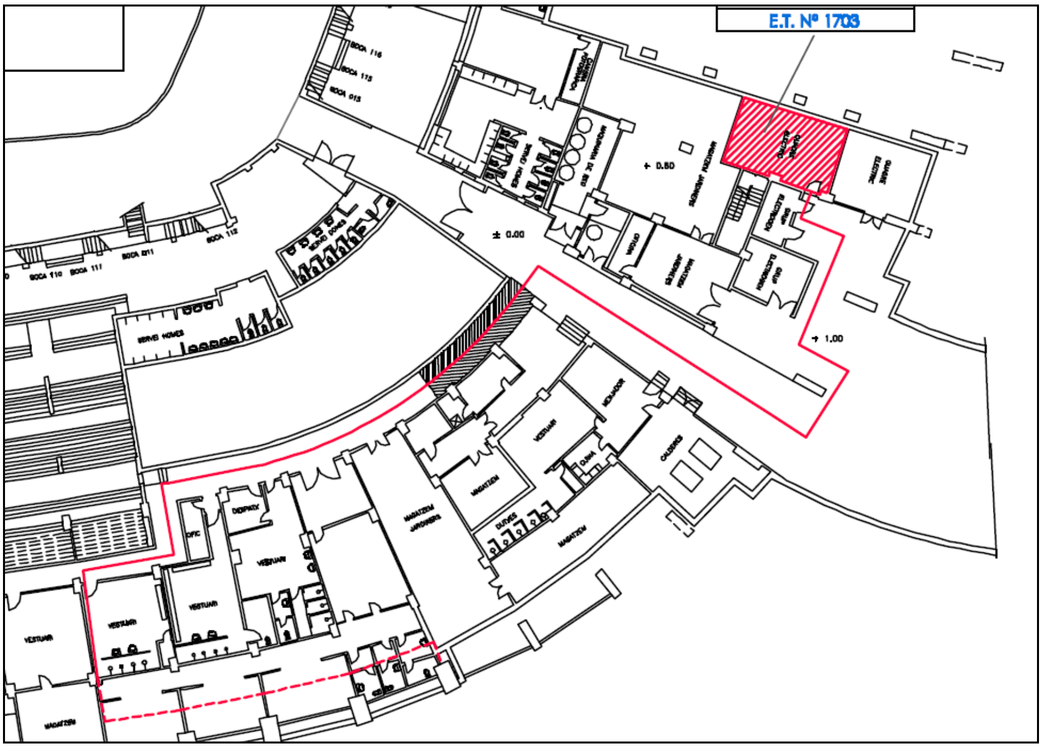


Figure 27 – Location of the "Tunnel" transformer station and communications wiring, Stadium. Level -3.30 +1.00

4.1.3 Stadium Equipment Details

- M54400 –TRIFASIC NETWORK ANALYZER CVMk2-ITF-405

  - Network analyzer three-phase
  - Model: CVMk2-ITF-405
  - Type 0,5
  - High and low voltage
  - Universal power supply: 85…265 Vac / 95…300Vcc
  - Graphic display backlit
  - Measurement of more of 500 electrical parameters
  - Communication RS485 Modbus/RTU
  - Measurement of harmonics (up to 50)
  - Control of maximum demand
  - Expandable with cards of expansion
  - Standards: IEC664, IEC801, IEC571-1, UL94, EN61000-6-3
  - Standards: EN61000-6-1, EN61010-1, EN61000-4-11, EN61000-4-2
  - Standards: EN61000-4-3, EN61000-4-4, EN61000-4-5, EN55011

- M52031 – TRIFASIC NETWORK ANALYZER CVM-MINI-ITF-HAR-RS485-C2

  - Model CVM-MINI-ITF-RS485-C2
  - High and low voltage
  - Tension nominal: 230 Vac (*)
  - LCD display
  - Two digital outputs built-in programmable
  - Measurement of more of 230 electrical parameters
  - Harmonica breakdown in V and up to 15 ° per phase
  - Communication RS485 Modbus/RTU
  - Sealable
  - Standards: IEC664, IEC801, IEC571-1, UL94, EN61000-6-3
  - Standards: EN61000-6-1, EN61010-1, EN61000-4-11, EN61000-4-2
  - Standards: EN61000-4-3, EN61000-4-4, EN61000-4-5, EN55011

- TRIFASIC NETWORK ANALYZER CVM-MINI-ITFMC3-RS485-C2

  - Network analyzer 3-phase with transformer
  - Model CVM-MINI-ITF-MC3-RS485-C2
  - High and low voltage
  - Transformer of intensity up to 125A
  - Maximum diameter of the wire35mm
  - Voltage rating: 230 Vac (*)
  - Backlight LCD
  - Measurement of harmonics of V and I (THD%)
  - Two programmable digital outputs built
  - More than of 230 measurement of electrical parameters
  - Communication RS485 Modbus/RTU
  - Standards: IEC664, IEC801, IEC571-1, UL94, EN61000-6-3
  - Standards: EN61000-6-1, EN61010-1, EN61000-4-11, EN61000-4-2
  - Standards: EN61000-4-3, EN61000-4-4, EN61000-4-5, EN55011

- M55511 CVM 1D-RS485 C

- Network analyzer monophase
- Comunication protocol Modbus RTU RS485
- Direct connection with incorporated transformer
- un module of carrli DIN
- Tension nominal: 230 V ac
- Intensity Nominal 250mA…32A
- Display Digital
- One digital output or built-in output of pulses
- Partial or Accountants of Energy
- Measures Voltage, Current, Active Power, Reactive Power, Apparent Power, Power Factor of, active and reactive energy
- Standards: IEC62053-21, IEC61000-6-4 , IEC61000-6-2, IEC61010

- M54033 CONVERSOR TCP2RS+ ETHERNET - RS232/485

  - Communications converter TCP2RS+
  - Configurable communication protocol of UDP / TCP / Modbus / TCP standard
  - converter of protocol of RS232/RS485 network
  - voltage of supply: 85 ... 265VAC / 95 ... 300VCC
  - LED indicator of operation
  - Led indicator of question / answer
  - Mounting: DIN (2 modules)
  - Ethernet input. RS485-Ethernet converter
  - Standards: IEC60664, VDE0110, IEC348, EN50081-1, IEC61010-1

- TRANSFORMER OF NUCLEUS HALVED TP-812

  - Current of transformer core of the party
  - Relationship of transformation ... / 5
  - Isolation of 3 kV
  - Thermal or Class A (105 ° C)
  - Indoor use
  - Box of terminals of secondary sealable
  - Thermal current of short circuit: 60 In
  - Frequency response: 50 ... 60Hz
  - Envelope or self-extinguishing (UL94VO)
  - Interior window Dimensions: 114 x 145 mm
  - Standards: IEC44-1, UNE 21 088-1, UL94, VDE0414

- R18011 – MODULO COMUNICACIONES COMPUTER 14d.

  - Module for Computer Communication of 14
  - RS-485 communications
  - Includes software EASYCOMM
  - Valid only for computer or 14d or 14df

4.1.4 Pavilion Facility

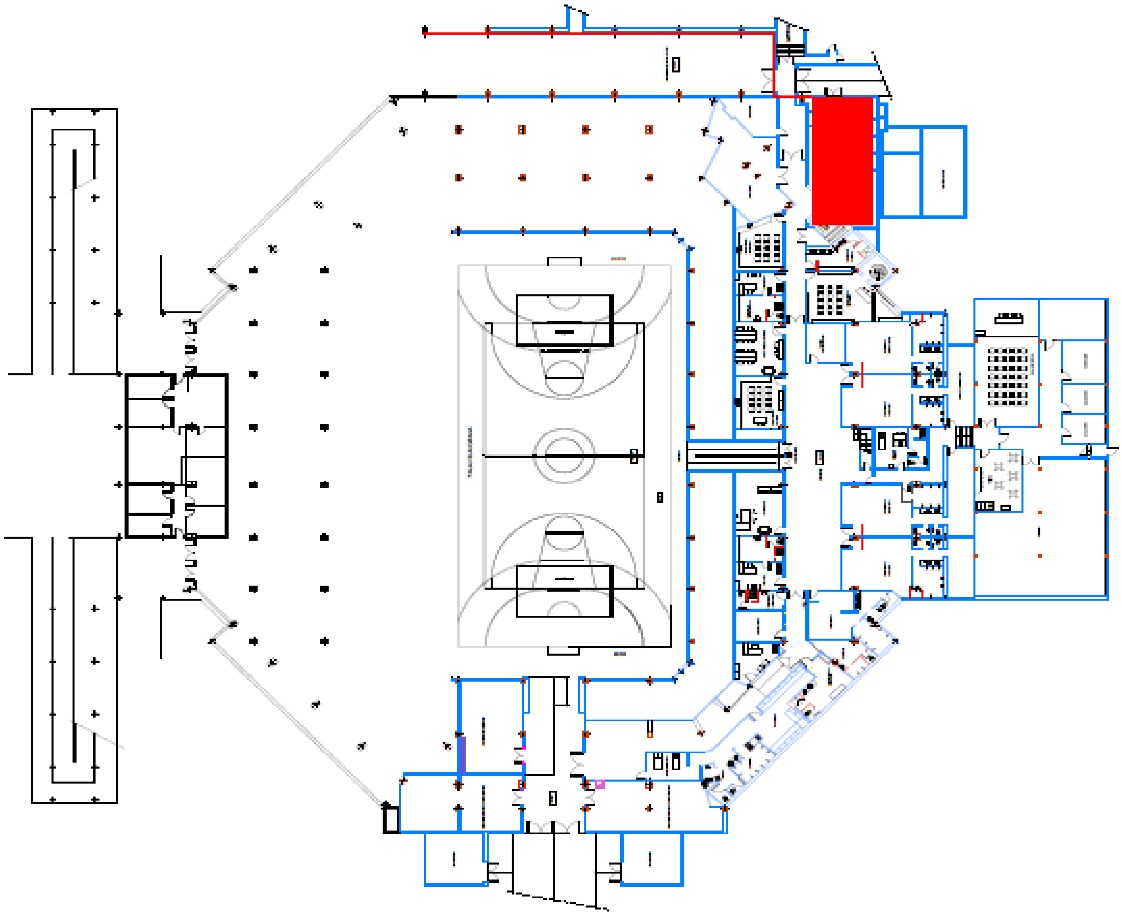


Figure 28 – Location of the "Pavilion" transformer station and communications wiring, Pavilion. Level -3.30 +1.00

The intervention for controlling the productivity of the heat pumps is structured as follows:

- Installation of a system “flow meter + temperature sensor pair”, as shown in Figure below.

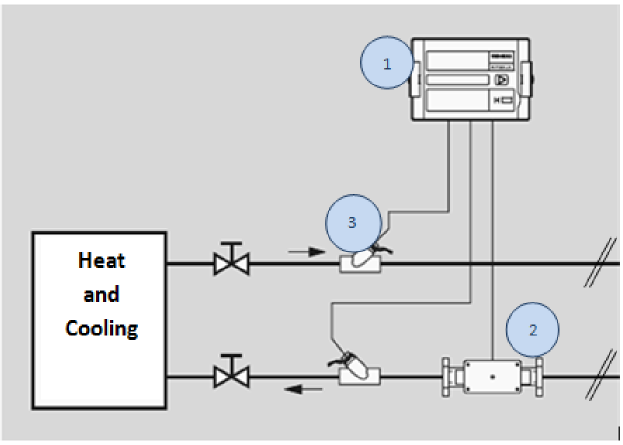
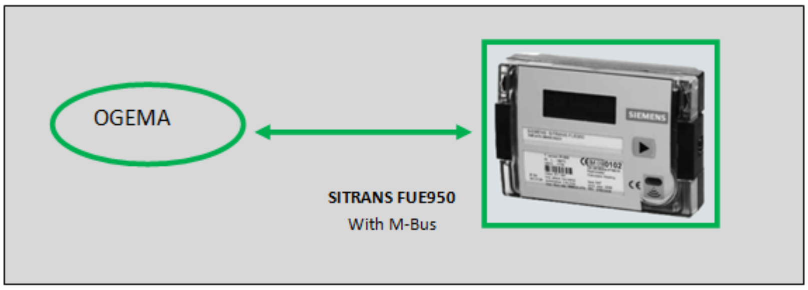


Figure 29 – Scheme of the flow meter + temperature sensor pair

The following components will be installed on the already existing circuit of the heat pumps:
- n°1 Flow meter, Siemens SITRANS FUE950 (1 in Figure above);
- n°1 Magnetic flow meter, Siemens SITRANS MAG 1100 (2 in Figure above);
- n°2 Temperature sensor, Siemens Pt500 (3 in Figure above);

The thermal energy calculator (1 in Figure above), provided with plug-in module for M-Bus communication (RS485), will directly communicate with OGEMA.



Clima inventory of the PAVILION Facilities:

TYPE	BRAND	MODEL	COND.	heating	POWER	SITUACION
SPLIT wall						
SPLIT wall						
COOLING PUMP		100/250				Pavilion (court)
COOLING PUMP		100/250				Pavilion (court)
COOLING PUMP		100/250				Pavilion (court)
COOLING PUMP		100/250				Pavilion (court)
CLIMATE CONTROL	SERVOCLIMA	CTA-60			384 KCAL	Pavilion (court)
CLIMATE CONTROL	SERVOCLIMA	CTA-60			384 KCAL	Pavilion (court)
CLIMATE CONTROL	SERVOCLIMA	CTA-60			384 KCAL	Pavilion (court)
CLIMATE CONTROL	SERVOCLIMA	CTA-60			384 KCAL	Pavilion (court)
CHILLER	ROCA YORK	YCALO241RB50XA	AIR			Pavilion (court)
CHILLER	ROCA YORK	YCAJ767ST950PA	AIR			Pavilion (court)
CHILLER	ROCA YORK	YCAJ767ST950PA	AIR			Pavilion (court)
CHILLER	ROCA YORK	YCAZ88ME2/50PB	AIR			Pavilion (court)
EXPANSION VESSEL						Pavilion (court)
EXPANSION VESSEL						Pavilion (court)
SPLIT TECHO	MITSUBISHI					Et palau
AUTONOMA	HITECSA					Palco
AUTONOMA	HITECSA					Palco
SPLIT	MITSUBISHI	PUHP2VGAA	AIR	YES	7.0 KW	Pavilion (offices & changing rooms)
SPLIT	GENERAL	AOG24 RZNL	AIR	YES	7.0 KW	Pavilion (offices & changing rooms)
SPLIT	GENERAL	AOG24 RZNL	AIR	YES	7.0 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	PUH-3 VKA	AIR	YES		Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	PUH-3 VKA	AIR	YES		Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI		AIR	YES		Pavilion (oficina entrenador)
SPLIT	ROCA	CCB-50-21/D	AIR	YES	4.6 KW	Pavilion (offices & changing rooms)

SPLIT	YORK	DBM-632BG	AIR/AIR	YES	3200 KCAL/h/ 4000KCAL/h	Pavilion despacho handbol
SPLIT	YORK	TLKC18FS-AAR	AIR/AIR	YES	5KW cooling / 5,35 KW heating	Pavilion sala de video handbol
SPLIT	MITSUBISHI ELECTRIC	MSC-GA25 VB	AIR/AIR	YES	2KW cooling / 2,35 KW heating	Pavilion antidopping
SPLIT	AIRWELL	GCNG14RC	AIR	YES	4.0 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	PUH-3VKA	AIR	YES		Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	SUZ-A18VR	AIR	YES	4.6 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI ELECTRIC	MSC-GA25 VB	AIR/AIR	YES	2KW cooling / 2,35 KW heating	Pavilion despacho futobol sala
SPLIT	MITSUBISHI	SUZ-KA17VA	AIR	YES	4.6 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	SUZ-KA17VA	AIR	YES	4.6 KW	Pavilion (offices & changing rooms)
SPLIT	GENERAL	AOG12 RZAL	AIR	YES	7.0 KW	Pavilion (offices & changing rooms)
SPLIT	GENERAL	AOG12 RZAL	AIR	YES	7.0 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	MUH-GA25VB	AIR	YES	2.65	Pavilion (offices & changing rooms)
SPLIT	GENERAL	AOG14RNE	AIR	YES	4.0 KW	Pavilion (offices & changing rooms)
SPLIT	MITSUBISHI	MUH-XV12UV	AIR	YES	3.4 KW	Pavilion (offices anexas)
SPLIT	MITSUBISHI	MXZ-18RV	AIR	YES	4.5 KW	Pavilion (offices anexas)
SPLIT	MITSUBISHI	MXZ-18RV	AIR	YES	4.5 KW	Pavilion (offices anexas)
SPLIT	MITSUBISHI	MXZ-18RV	AIR	YES	4.5 KW	Pavilion (offices anexas)
SPLIT	MITSUBISHI	MXZ-18RV	AIR	YES	4.5 KW	Pavilion (offices anexas)
SPLIT	MITSUBISHI ELECTRIC	MSC-GA50 VB	AIR/AIR	YES	2KW cooling / 2,35 KW heating	Pavilion sala de aguas
SPLIT	MITSUBISHI	MXZ-18RV	AIR	YES	4.5 KW	Pavilion (offices anexas)
SPLIT wall	FEDDERS	ANSI/UL484	AIR	YES		Pavilion (megafonia)
SPLIT wall	YORK	DBM660BG	AIR	YES		Direccion mou
SPLIT	YORK	DBM660BG	AIR	YES		Pavilion (offices mou)
SPLIT						Vestuarios palau 1
SPLIT	YORK	DBM660BG	AIR	YES	3500W cooling/4000W heating	Pavilion (offices mou esteller)
SPLIT	YORK	DBM660BG	AIR	YES	6,4 KW	Pavilion (oficina julio alberto)
SPLIT	YORK	DBM660BG	AIR	YES	6400W cooling/6800W heating	Pavilion (oficina mou despacho)

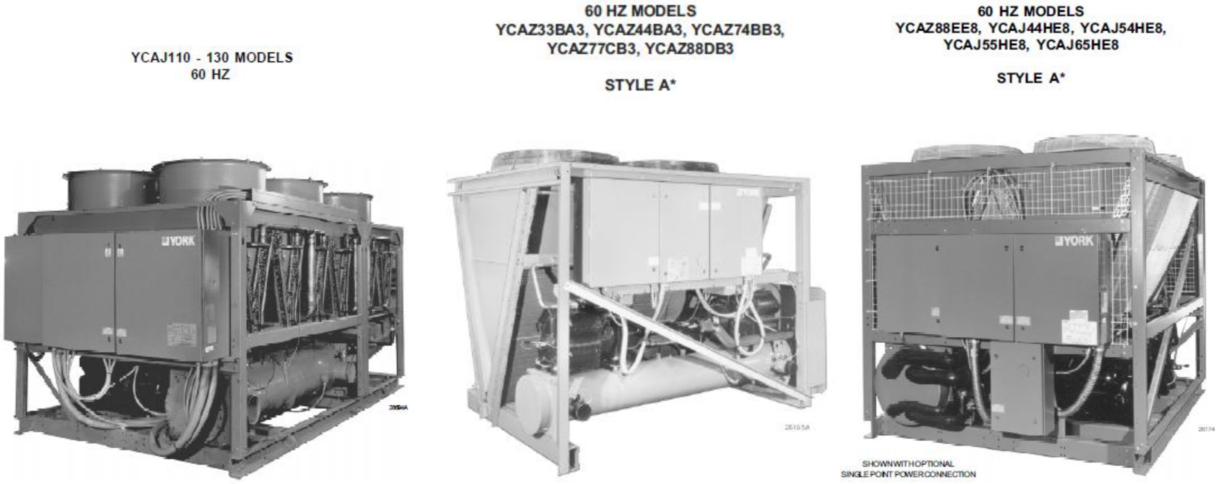


Figure 30 – Chiller models

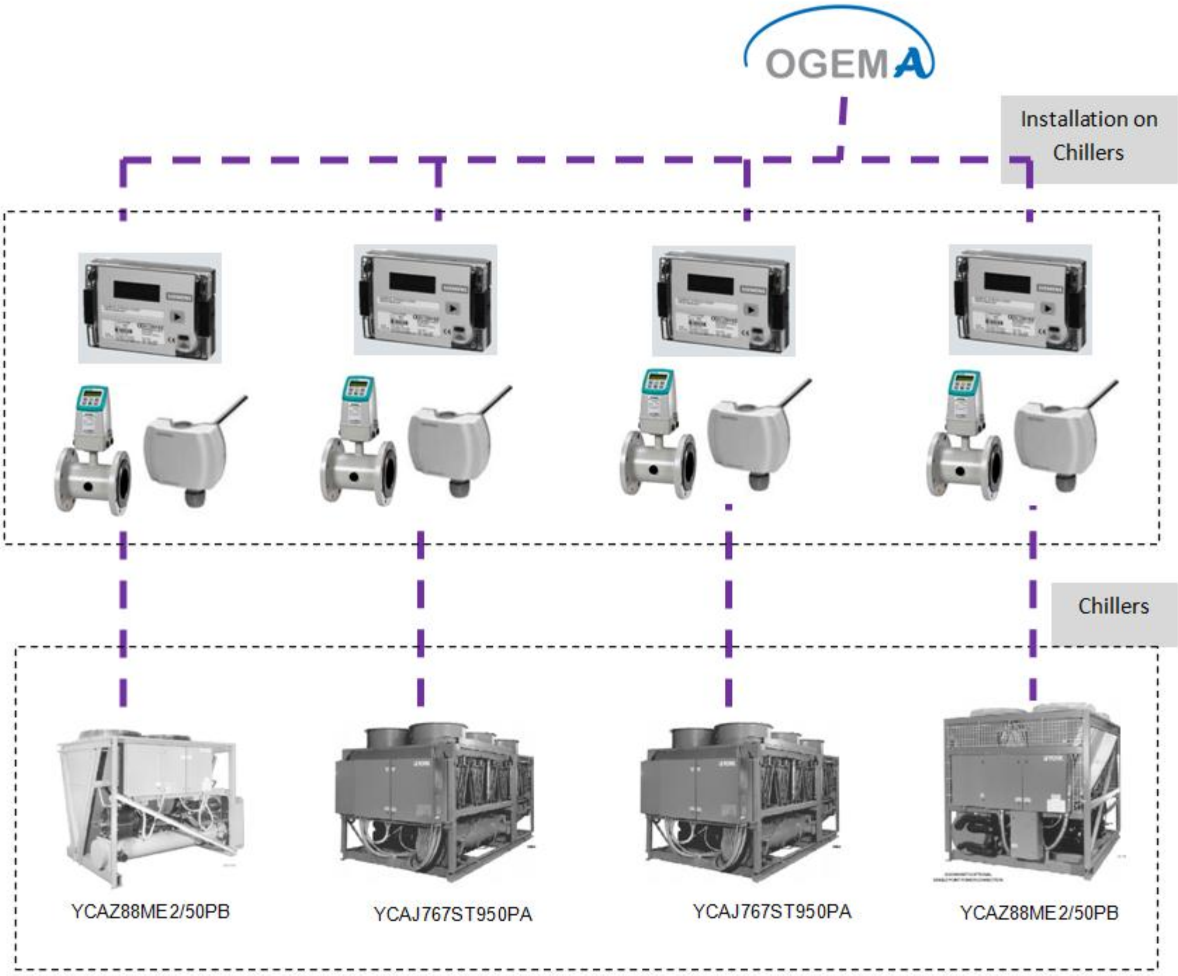


Figure 31 – Scheme of the Measuring Devices

4.1.5 Pavilion Equipment Details

- Siemens SITRANS FUE950.
  - Measuring range:
    Qp ≤ 360000 m³/h (600000 GPM)
    P ≤ 15000000 kW
  - Accuracy: EN1434 Class 3, typical ±(0.5 + 3K/ΔΘ) [%]
  - Input:
    1 Pulse of flowmeter (always included)
    2 Temperature input as PT100/500, 2 or 4-wire
    2 Pulse input (optional)
  - Output:
    2 Pulse or status (optional)
    1 M-Bus (optional)
    1 RS 232 M-Bus protocol (optional)
    1 RS485 M-Bus protocol (optional)
    2 current (4-20mA , passive) (optional)
  - Display: 8-digit LCD display with associated pictograms/symbols
  - Enclosure: IP54 (in accordance with IEC 529)
  - Power Supply: Battery (3.6V Lithium D-cell type) 230 V a.c. 24 V a.c.
  - Temperature input: From -20 to 190 °C (-4 to 374 °F)
  - Ambient temperature: From 0 to 55 °C (32 to 131 °F)
  - Approvals: MID (EN1434, heating) and PTB K7.2 (cooling)

- Siemens F M MAG 1100.

- Measuring range 0 to 10 m/s
- Nominal Sizes From DN 2 to DN 100 (1/12" to 4")
- Accuracy:
  0.2 % ±1 mm/s
  0.4 % ±1 mm/s (PFA)
- Operating Pressure Max. 40 bar (Max. 580 psi)
- Ambient temperature From -40 to 100 °C (-40 to 212 °F)
- Medium temperature From -30 to 200 °C (-22 to 390 °F)
- Liners: Ceramics, PFA
- Electrodes Platinum, Hastelloy
- Material Stainless steel AISI 316L (1.4404)
- Approvals ATEX - 2 GD Zone 1, FM Class 1 div 2

4.2 University of Salento Campus

4.2.1 General information

The campus of the "University of Salento" is located in Monteroni (Le), Italy. It includes several faculties: Mathematics and Physics Department, Engineering Department, Business Department, Biology Department and Law Department.

Figure 32 – Unisalento Site map view 1

The campus includes a Sport Centre area (1 soccer field, 2 tennis courts and 1 running path), various green open areas and four parking lots that are of great importance because they are covered by photovoltaic roofs.

Figure 33 – Unisalento Site map view 2

The Engineering Department, together with some of the open areas mentioned above, will be the main focus for the BEAMS demonstrator. In particular, the Engineering Department is composed by three buildings: "Corpo O", "Corpo Y" and "La Stecca". "La Stecca" is the oldest building of this compound.

Figure 34 – Unisalento Engineering Department buildings

4.2.2 Outdoor environmental data

The graphs below show the monthly trend of temperature, precipitations, humidity and wind speed since 1961 to 1990 in Monteroni.

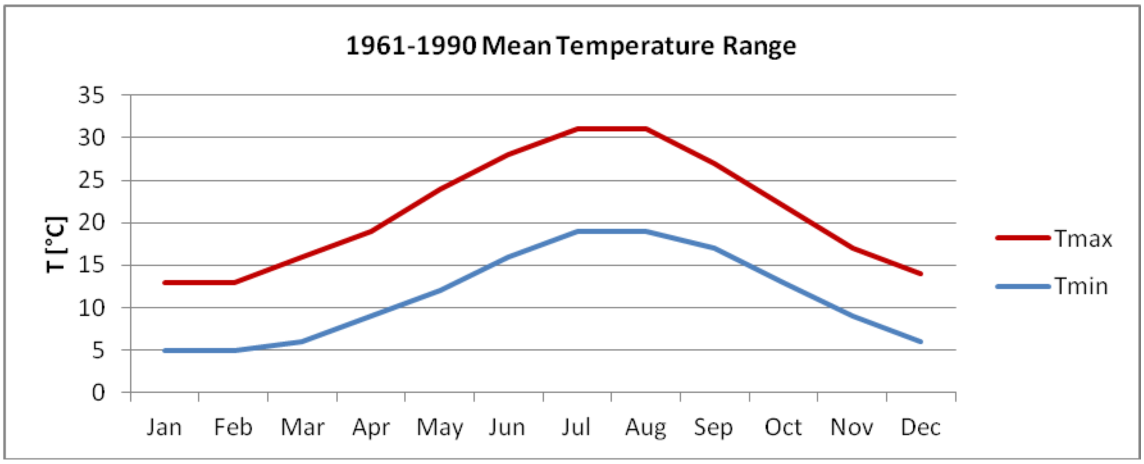


Figure 35 – Graph: 1961-1990 maximum and minimum values of temperature

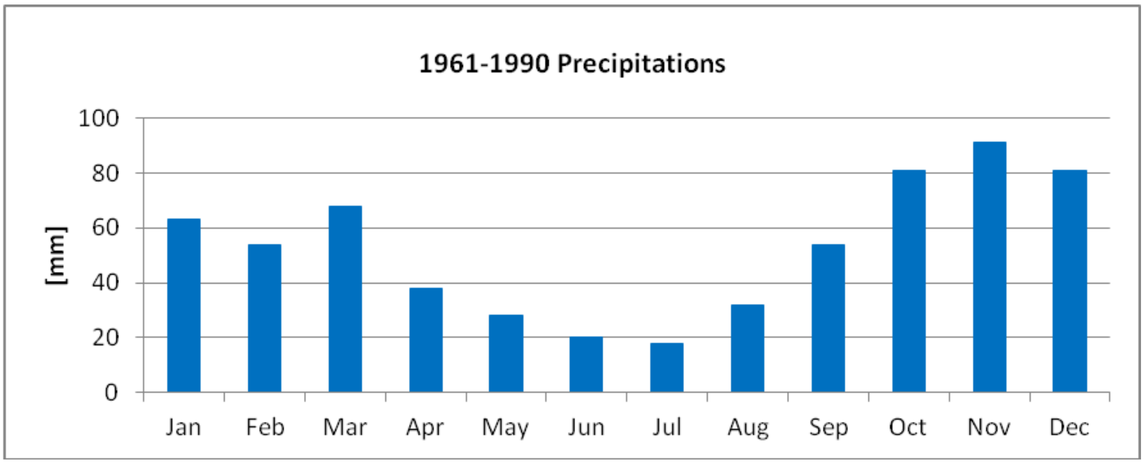


Figure 36 – Graph: 1961-1990 precipitations

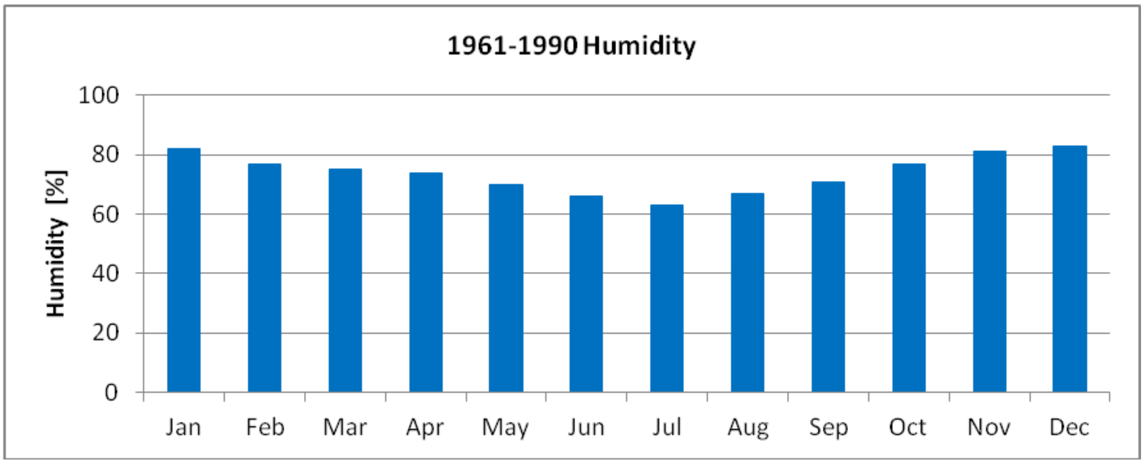


Figure 37 – Graph: 1961-1990 humidity values

In particular the trend of temperature and humidity in 2011 was:

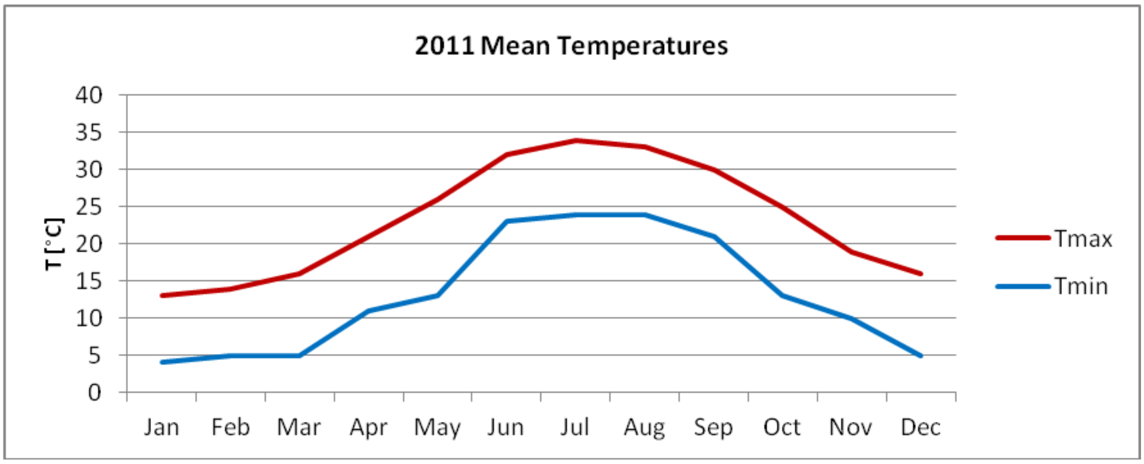


Figure 38 – Graph: 2011 maximum and minimum values of temperature

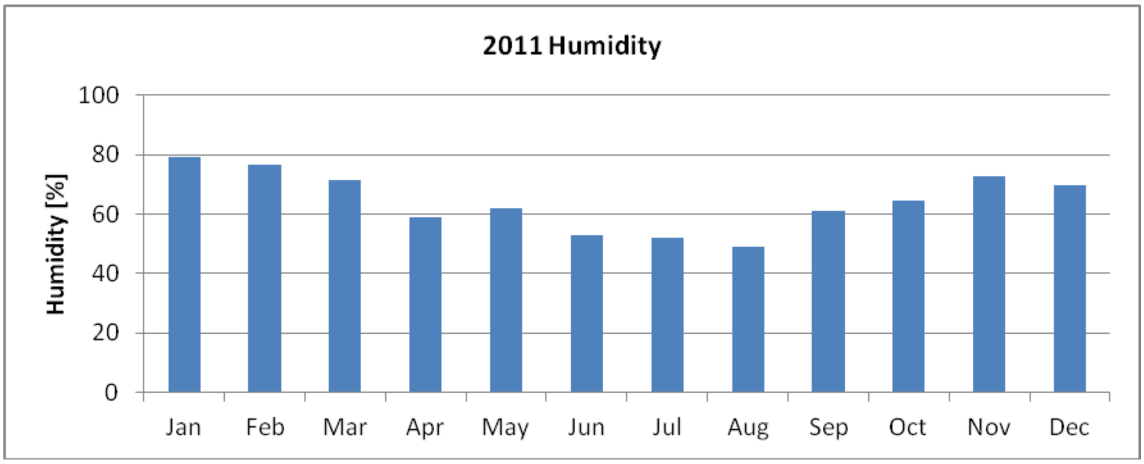


Figure 39 – Graph: Values of humidity for the year 2011

The monthly solar irradiation in the UniSalento pilot site area is shown in the chart below.

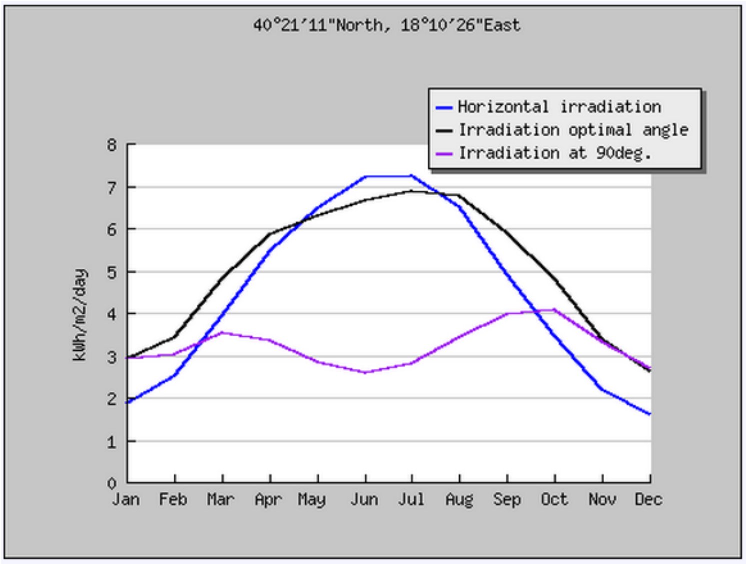


Figure 40 – Graph: monthly solar irradiation

The graph below shows the prevalent wind speed and direction data measured in the period from 2000 to 2011.

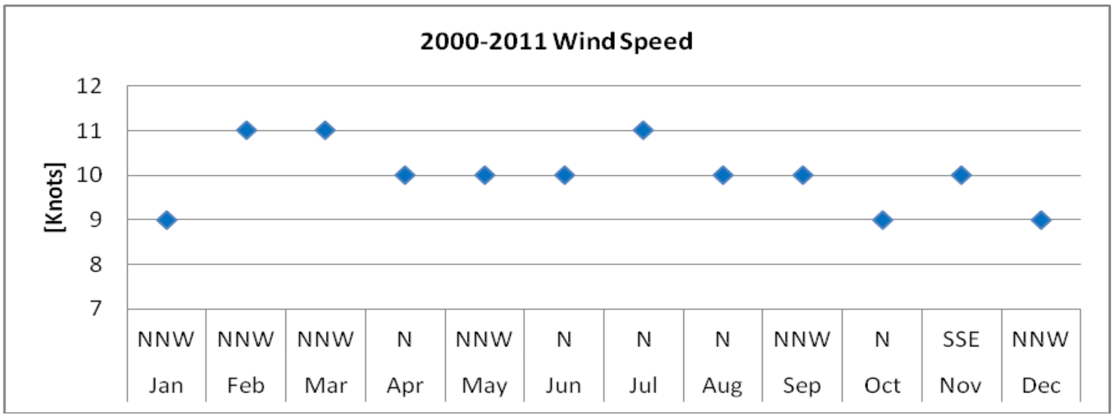


Figure 41 – Graph: 2000-2011 monthly trend of wind speed

In particular, for the year 2011:

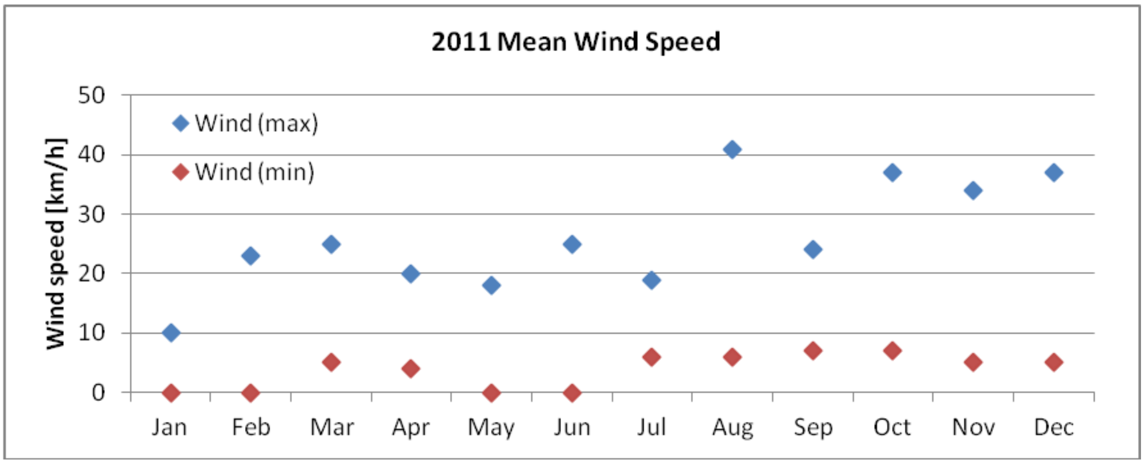


Figure 42 – Graph: wind speed for the year 2011

4.2.3 Indoor environmental data

The indoor target temperature in buildings is defined by *UNI EN 15251/2008* and *DPR 412/1993- Art.4* (Italian regulation):

- Summer air conditioning: 26 °C
- Winter air conditioning: 20 °C.

4.2.4 Characterization of the three building

The *"**Corpo O**"* is a four floor building as described in the following table and picture:

	Rooms	Human presence
Basement	- Technical area	Very low
Ground floor	- Classrooms - Laboratories - Offices	High
First floor	- Offices	High
Second floor	- Offices	High

Figure 43 – section building "Corpo O"

This building is employed for teaching; it houses the academic staff offices and the experimental laboratories.

The staff works in the building according to the following time slots:

- Monday to Friday: 8:00 a.m. - 2:00 p.m.
- Tuesday and Thursday: 3:00 p.m. - 6:00 p.m.

The lectures' timetables (for classrooms O1, O2 and O3) are updated twice a year, at the beginning of each semester and are published on the university website.

People occupancy in classrooms has been estimated as reported in the following table:

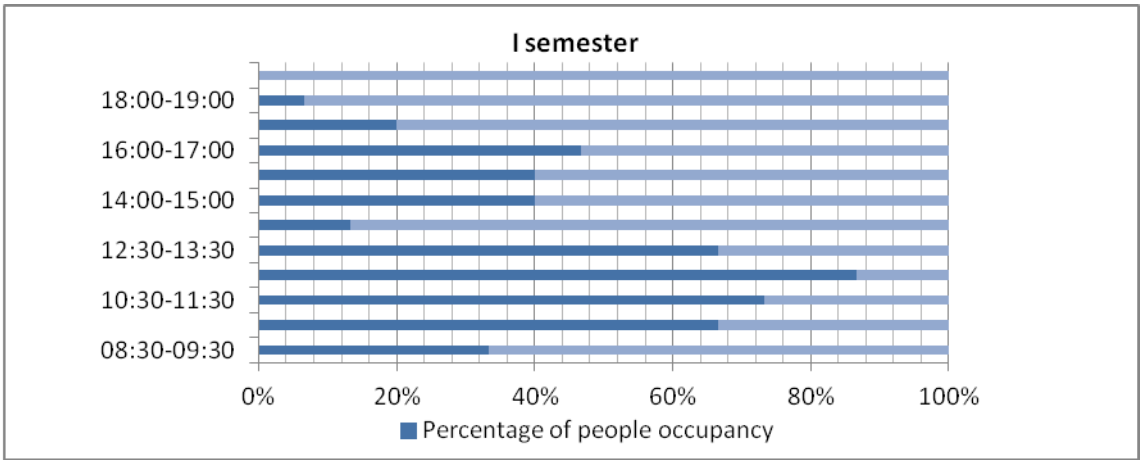


Figure 44 – Graph: estimation of the classrooms employment (I semester)

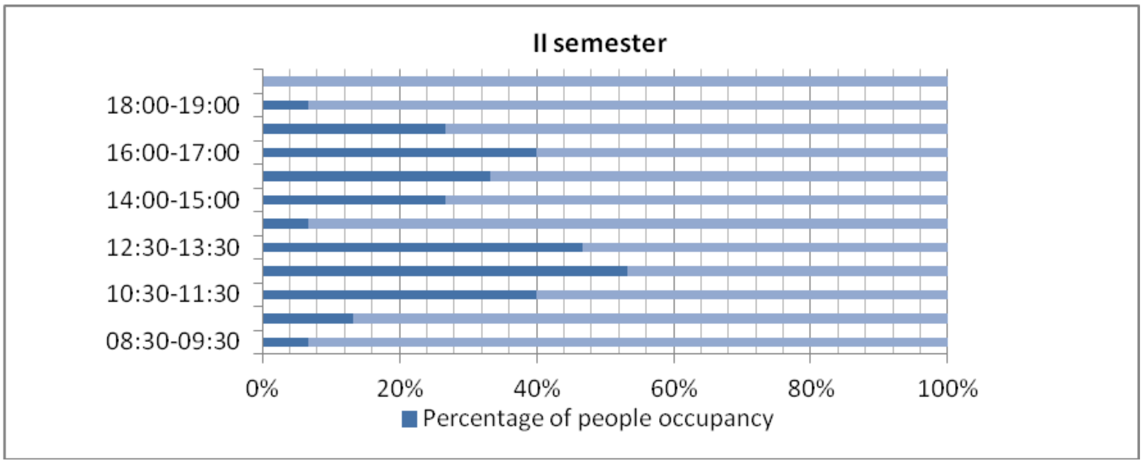


Figure 45 – Graph: estimation of the classrooms employments (II semester)

The HVAC system of Corpo O building is characterised by:

		Units	Power
Heating and Cooling Station	Heating section, based on both natural-gas burner (main used) and diesel-oil burner	2	70 kW
	Cooling section, based on two water cooling units with air condensing	2	62 kW
Air Conditioning System	AHU	2	14 kW
	Fan-coil	86	-
	Individual air conditioner	2	6600 - 7200 W
	Individual air conditioner	1	3800 - 4000 W

The switchboard currently used to manage the fan coil and the AHU on/off scheduling is constituted by two Siemens Synco RMU720 and RMZ787 expansion modules, as shown in the picture below.

Figure 46 – Current HVAC switchboard

Heat pumps are manually controlled by timers placed on the building's roof, without possibility of remote control.

Figure 47 – Heat pumps' switchboard

The Italian regulation known as "DPR 412/1993" allows the use of the heating systems for 8 hours/day (9:00 a.m.-5:00 p.m.) from the 15th of November to the 31st of March: these are in particular the winter conditioning prescriptions for the climatic zone "Zone C" and buildings of category E.7. As mentioned before the target temperature in buildings must be set to 20 °C in winter and to 26 °C in summer.
The system is set manually. Thermostats installed in each room detect the temperature and activate the air conditioning system. A manual control in each room is also possible.

The total nominal power of the lighting system in this building is around 30 kW. The following table provides a view of how it is distributed:

		Units	Power
Basement	Lights	30	2x36 W
		5	1x36 W
	Emergency lights		
Ground floor	Lights	40	4x18 W
		34	3x18 W
		4	1x18 W
		6	1x36 W
		46	2x36 W
	Night lights	5	3x18 W
	Emergency lights		
First floor	Lights	100	4x18 W
		18	3x18 W
		4	1x18 W
		6	1x36 W
		2	2x36 W
	Night lights	5	3x18 W
	Emergency lights		
Second floor	Lights	84	4x18 W
		40	3x18 W
		4	1x18 W
		6	1x36 W
		2	2x36 W
	Night lights	5	3x18 W
	Emergency lights		
	Total Power	**29 kW**	

The lighting system setting is done manually and the light can be turned on/off by using autonomous switches in each room.
The consumption of other electric loads (e.g. personal computers) is not available, but it can be evaluated starting from the total number of power sockets available and the estimated rate of simultaneous usage (30%).

Personal computer equipment	Power socket	First floor	34x[16 A]
			104x[4x16 A]
		Second floor	32x[16A]
			144x[4x16 A]

The "***Corpo Y***" is a 3 stories building. It is mainly used for academic activities and sometimes for meetings or similar events.

	Rooms	**Human presence**
Garage		Low
Basement	- Technical local	Very low
Ground floor	- Classrooms/study hall	High

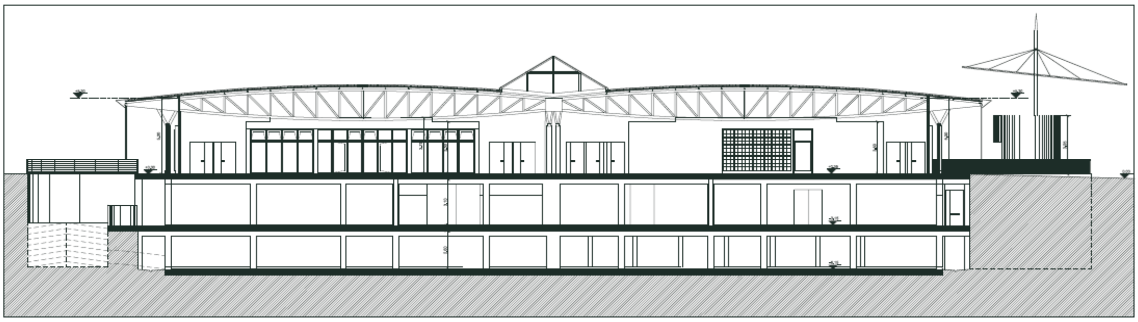


Figure 48 – section building "Corpo Y"

The lectures' timetable for this building is updated twice a year, at the beginning of each semester and is published on the university website.
People occupancy in classrooms has been estimated as reported in the following table:

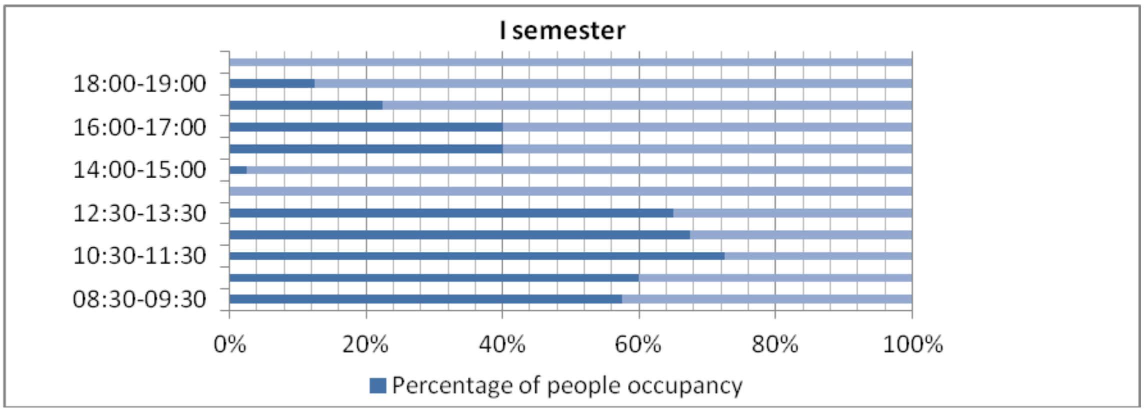


Figure 49 – Graph: estimation of the classrooms employment (I semester)

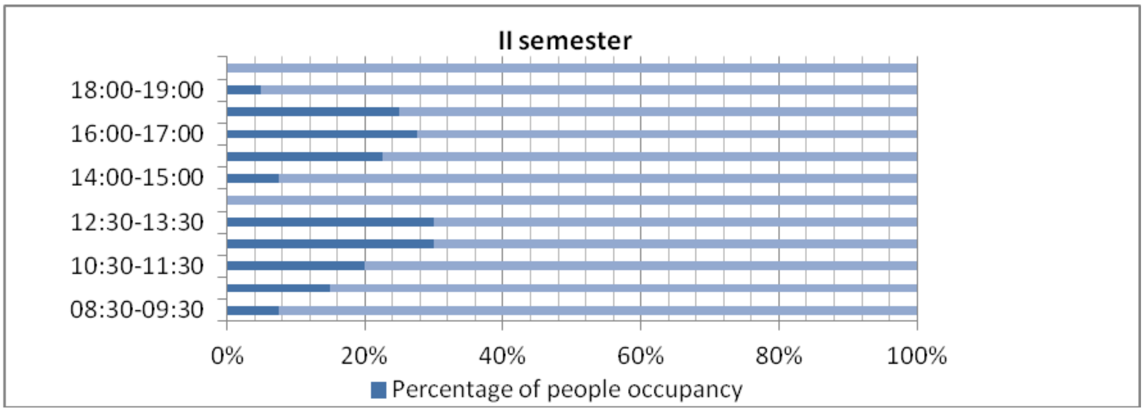


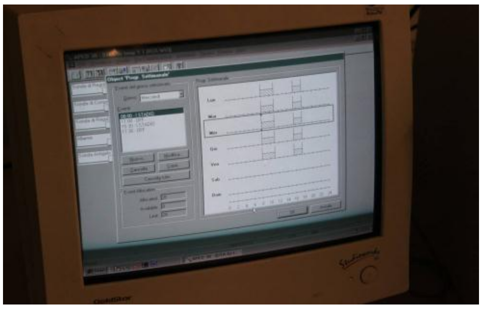
Figure 50 – Graph: estimation of classrooms employment (II semester)

The HVAC system of this building is composed by the following components:

		Units	Power/ Florate
Heating and Cooling Station	Heating section, based on both natural-gas burner	2	350 kW
	Cooling section, based on two water cooling units with air condensing	2	332 kW
	Electric pumps for water circulation	2	30 m³/h
	Electric pumps for water circulation	2	56,8 m³/h
Air Conditioning System (full air system)	AHU installed on the building roof	5	≤ 25000 m³/h

The Italian regulation known as "DPR 412/1993" allows the use of the heating systems for 8 hours/day (9:00 a.m.-5:00 p.m.) from the 15th of November to the 31st of March: these are in particular the winter conditioning prescriptions for the climatic zone "Zone C" and buildings of category E.7. As mentioned before the target temperature in buildings must be set to 20 °C in winter and to 26 °C in summer.

In this building the energy system is computerized and the values are programmed on weekly basis by specialized personnel. The schedules are set by using a *bus LonWorks.*

The total nominal power of the lighting system in this building is around 21 kW. The following table provides a view of how it is distributed:

		Units	Power
Ground floor	Lights	47	250 W
		5	400 W
		18	2x36 W
		18	70 W
		19	1x22 W
		14	2x18 W
		8	18 W
	Emergency and night lights	8	250 W
		1	400 W
		5	150 W
	Total Power	***20.50 kW***	

The lighting system is set manually and the light can be turned on/off by using autonomous switches in each room.
The consumption of the other electric loads of this building is only estimated: in particular the estimated power for the personal computer equipment is 25 W/m^2.
"La Stecca" building is mainly used for teaching activities and to house the academic staff offices and the experimental laboratories.
The staff works in the building according to the following time slots:

- Monday to Friday: 8:00 a.m. - 2:00 p.m.
- Tuesday and Thursday: 3:00 p.m. - 6:00 p.m.

The lectures timetable in classrooms is updated twice a year, at the beginning of semester I and II.
The time schedule is published on the university website.
People occupancy in classrooms has been estimated as reported in the following table:

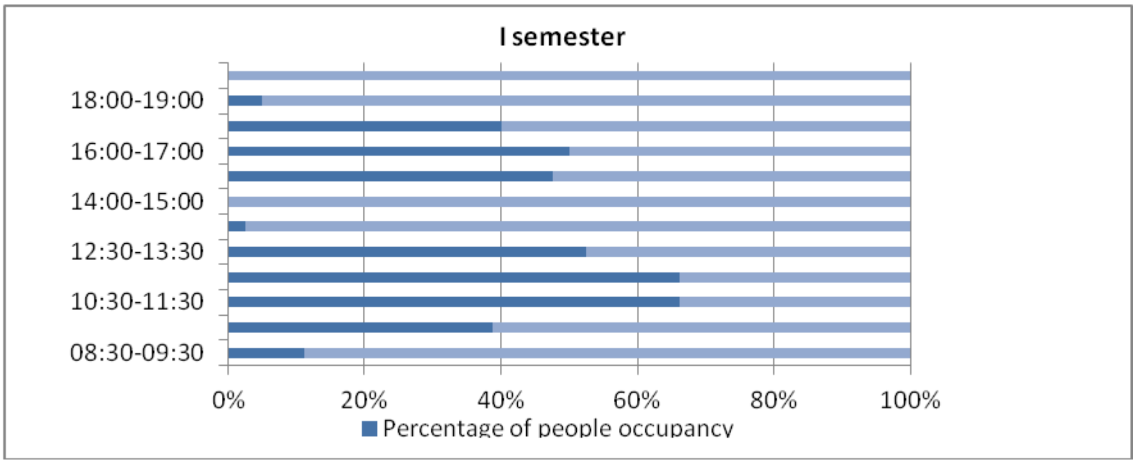


Figure 51 – Graph: estimation of classrooms usage

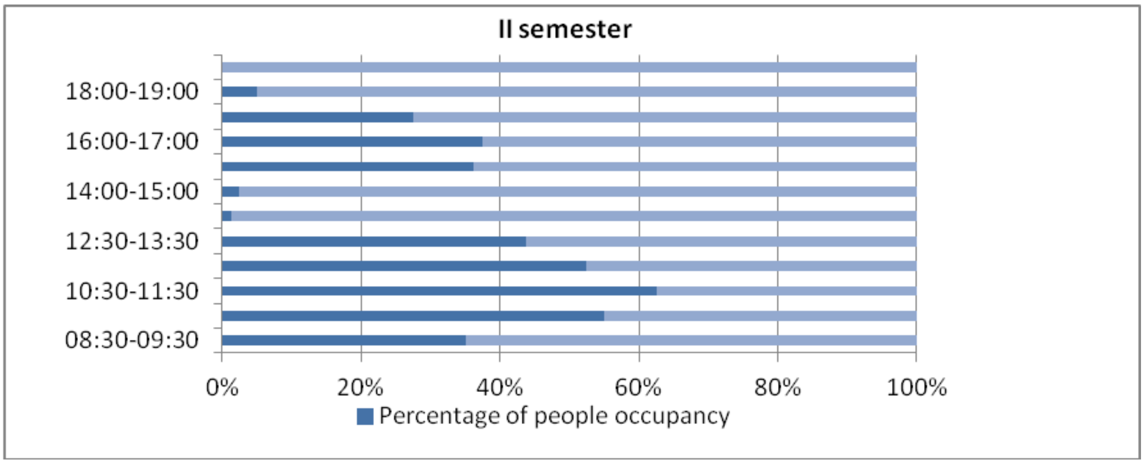


Figure 52 – Graph: estimation of the classrooms usage

The HVAC system of this building is composed by the following components:

		Units	Power/Florate
Heating and Cooling Station	Heating section, based on gas burner	1	1060 kW
	Heating section, based on oil burner	1	1060 kW
	Cooling section, based on two water cooling units with air condensing	2	252 kW
	Electric pumps for heating section	3	3 kW
	Electric pumps for cooling section	2	1,5 kW
Air Conditioning System (Full air system)	AHU installed on the building roof	4	10000 m³/h (engine power=3 kW)
	AHU installed on the building roof	2	12000 m³/h (engine power=2,5/4 kW)
	Electric pumps	3	11 kW
Air Conditioning System (Fan-coil with use of primary air flow)	Air Conditioning System	4	8300 m³/h
	Electric pumps	4	1,17 kW
	Electric pumps no-condensation	2	1,5 kW
Air Conditioning System (Fan-coil without use of primary air flow)	fan-coil hot/cold	258	-
	Autonomous fan-coil	60	1700-6000 frig/h
	Electric pumps	4	1,17 kW

The Italian regulation known as "DPR 412/1993" allows the use of the heating systems for 8 hours/day (9:00 a.m.-5:00 p.m.) from the 15th of November to the 31st of March: these are in particular the winter conditioning prescriptions for the climatic zone "Zone C" and buildings of category E.7. As mentioned before the target temperature in buildings must be set to 20 °C in winter and to 26 °C in summer.

The system is set manually. Thermostats installed in each room detect the temperature and activate the air conditioning system. A manual control in each room is also possible.

The total nominal power of the Lighting system is more than 86 kW.

	Units	Power
Lights	750	4x18 W
Lights	270	2x58 W
Lights	20	1x58 W
Emergency lights		
	Total Power	**86.50 kW**

The lighting system is set manually and the light can be turned on/off by using autonomous switches. The consumption of the other electric loads of this building is only estimated: in particular the estimated power for the personal computer equipment is 25 W/m^2 while the electric load of the equipment in the laboratories is difficult to be determined.

4.2.5 Electric energy consumption

During the year 2011, the total consumption of electricity was 2.856.114 kWh. The monthly distribution is shown in the following Figure.
This value is referred to the energy consumption of five buildings (La Stecca, Corpo O, Corpo Y, Ibil and Fiorini) and it was detected by a single electricity meter.

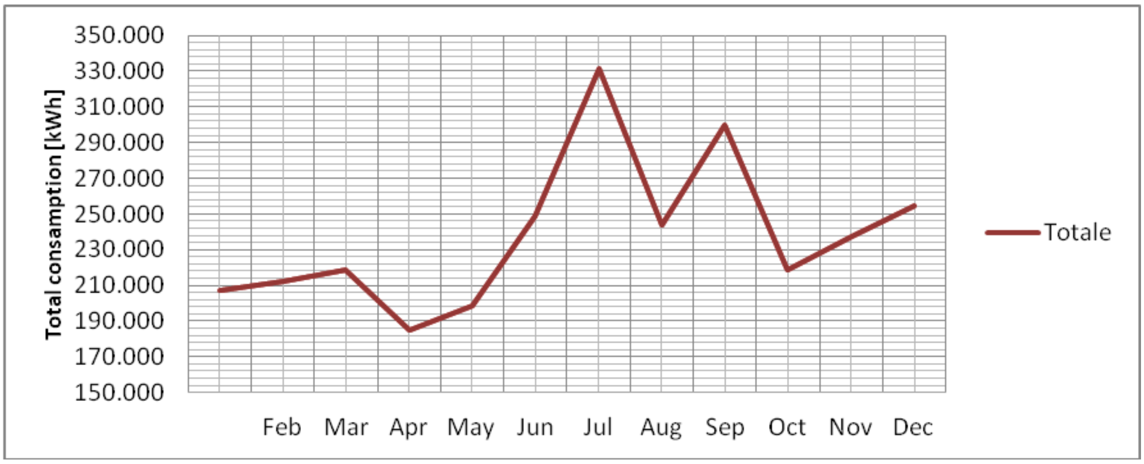


Figure 53 – Graph: total electricity consumption

In particular, the following picture presents the consumption of electricity in the following three time slots:

- F1: peak hours (8:00 a.m. – 7:00 p.m. from Monday to Friday)
- F2: intervening hours (7:00 a.m. – 8:00 a.m. and 7:00 p.m. – 11:00 p.m. from Monday to Friday; 7:00 a.m. – 11:00 p.m. on Saturday)
- F3: off-peak hours (0:00 a.m. - 7:00 a.m. and 11:00 p.m. - 12:00 p.m. from Monday to Saturday; 0:00 a.m. – 12:00 p.m. on Sunday)

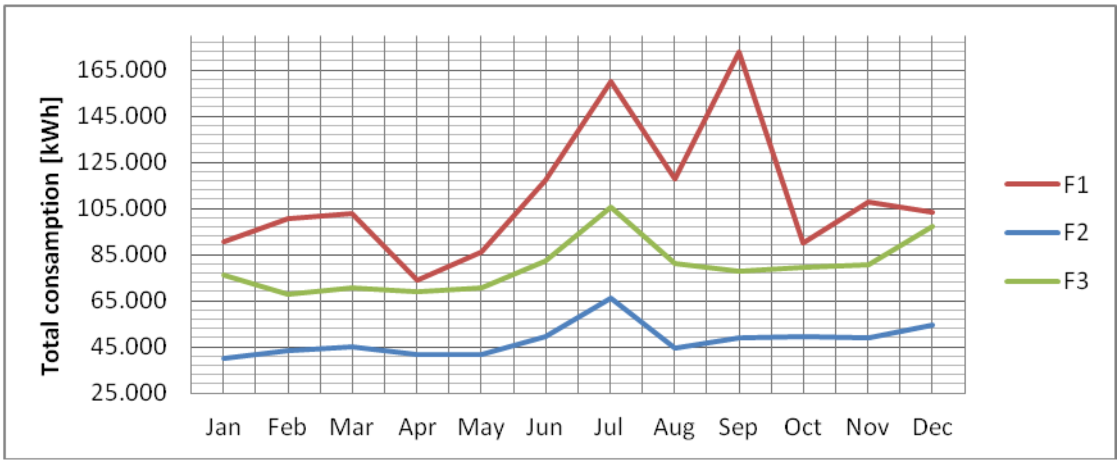


Figure 54 – Graph: consumption of electricity in each time slots

To date we are not able to detect the exact electricity consumption for each of the three buildings because there is one only electricity meter serving all the five buildings. Hence, we can only provide an estimate of this consumption.

The electricity retailer for UniSalento is Enel (Italy).
According to the general supply conditions of Enel, the maximum cost of energy during the year 2011 was **0.11417 €/kWh** and **0.08117 €/kWh** for respectively the peak and off-peak time slots (F1, F2, F3).
We calculate the energy cost for each month from the electricity bills of the year 2011 as reported in the Table below. For the objectives of this project we should refer to Enel (DSO).

	F1 [€/kWh]	F2 [€/kWh]	F3 [€/kWh]
Jan	0,104579975	0,08528	0,05859
Feb	0,105090019	0,08579	0,0591
Mar	0,092189963	0,08562	0,05835
Apr	0,09378999	0,08722	0,05995
May	0,095799986	0,08923	0,06196
Jun	0,097269974	0,0907	0,06343
Jul	0,098889973	0,09232	0,06505
Aug	0,10078004	0,09421	0,06694
Sep	0,102019988	0,09545	0,06818
Oct	0,103170021	0,0966	0,06933
Nov	0,10401004	0,110488	0,090687
Dec	0,104660018	0,09809	0,07082
arithmetic mean	**0,10018749**	**0,092583**	**0,066032**

Table 7 – Energy cost for the year 2011 (Enel)

4.2.6 Gas energy consumption

The gas energy consumption refers only to the building “La Stecca” and for the year 2011 it amounted to 68990 m^3 (70297 standard m^3).
The gas operator for Unisalento is Enel (Italy).

The monthly tariff reported on the gas bills is 0.4298 €/Smc in 2011 and 0.5236 €/Smc in 2012.
For the objectives of the project we should refer to the Enel Company to obtain the exact tariffs.

4.2.7 UniSalento's PV power plant

A PV power plant, with a total capacity exceeding 960 kWp, is installed using PV panels as rooftops of the following parking areas (located near the three buildings):

- "Parking 11" (capacity: 16 cars)
- "Parking 12" (capacity: 35 cars)
- "Parking 13" (capacity: 25 cars)

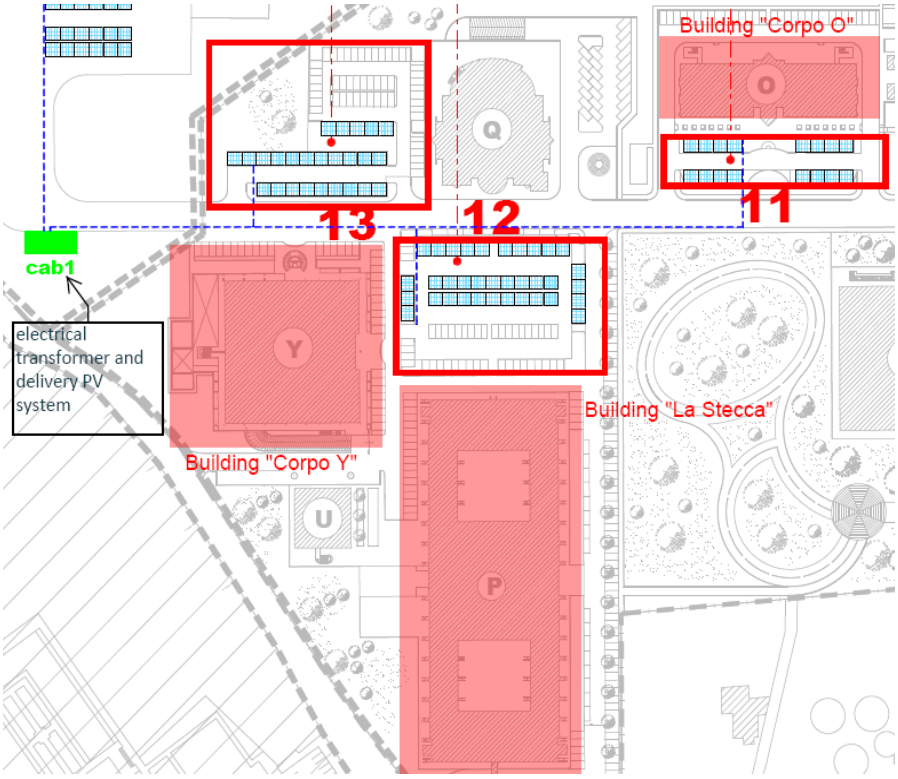


Figure 55 – PV power plants

Figure 56 – planned PV-generation parking for cars in the campus if University of Salento

In addition, another PV power plant with a capacity of 171 kWp has been installed on the rooftop of “Museo dell’ambiente” building.

Figure 57 the photovoltaic roof on “Museo dell’ambiente”

The PV power plants use an inverter which is equipped with a ES851 data logger board with Modbus RTU interface.

Figure 58 – smart string of the photovoltaic roof on “Museo dell’ambiente”

4.2.8 UniSalento's EV charging station and electrical vehicles

In the frame of the E-MOBILITY Italian project whose purpose is reducing CO_2 emissions by increasing the use of electric vehicles, the Italian DSO Enel has installed a EV charging station in the campus, and is performing tests using a Smart Fortwo electric vehicle.

Figure 59 – picture of an electric Smart Fortwo

The Smart Fortwo can be charged from a standard socket or using the dedicated charging station.
A total charge of the lithium battery (Tesla) can be completed in 6/8 hours, and the vehicle has and autonomy of 135 km. Alternatively a 2.5 hours rapid charge can guarantee an autonomy of 50 km. The ideal condition is to charge the battery during the night. The technical characteristics show that the maximum power of this small car is 30 kW with a constant engine torque of 120 Nm. The batteries have a capacity of 16.5 kW/h and are placed between the two axes. The maximum speed is self-limited to 100 km/h with 6.5s to accelerate from 0 to 60 km/h. The Smart Fortwo has a good driveability.

The charging station installed by Enel has the following characteristics:

- Access to the service by RFID ID card
- Centralized authentication
- GPRS communication with the Central System
- Power line communication between the charging station and the car
- Data acquisition and transmission for each charge
- Centralized control of the whole infrastructure

The following picture shows where it has been installed, near the building “Corpo Y”.

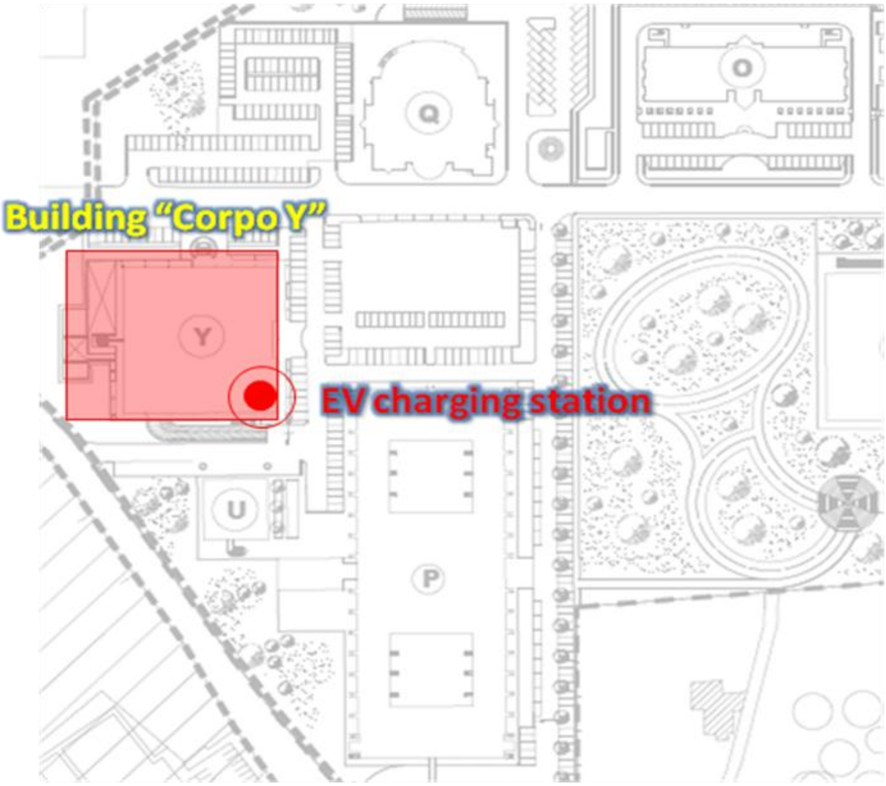


Figure 60 – EV charging point in the campus of University of Salento

In particular, the Engineering department can benefit of the two electric vehicles “ETAN” and “VEUS” realized in the frame of previous thesis works at the Research Center “CREA” of the Department of Innovation Engineering of the University of Salento.

Figure 61 – ETAN vehicle

Figure 62 – VEUS vehicle

ITAN 500 is a plug-in hybrid electric vehicle, designed to carry two passengers, with a low environmental impact and particularly designed for mobility in urban centres. It is rechargeable using a quadruple socket at 380 V.

Traction power	9.9 kW
Maximum speed	90 km/h
Acceleration 0-40 km/h 0-90 km/h	 4 s 16 s
Noise	< 70 dB
Emissions **(ECE driving cycle)** CO2 CO HC NOx	 < 100 g/km < 1 g/km < 0.1 g/km < 0.08 g/km

Table 8 – characteristics of ITAN 500

VEUS08 project developed an electric-photovoltaic vehicle to use exclusively in the urban area (urban concept). It is a full electric vehicle and the batteries are charged by solar panels placed on the entire hull and by the combination of solar panels and power supply when the car is parked.
The aim was to realize a vehicle as similar as possible to a utility car, dedicated only to urban circulation, with an autonomy of about 100 km and a speed limit of about 50 km/h.
The battery can be charged from standard domestic sockets using a dedicated charger, and from the solar panels placed on the vehicle.

Technical data (electric engine)	
Power	6,8 kW
Tension	48 V
Current	163 A
Number of revolutions	1650 rpm

Table 9 – characteristics of VEUS08

4.2.9 UniSalento's BEAMS deployment

4.2.9.1 First phases: control of the building “Corpo O”

The first phase of the project should be mainly focused on:

- Monitoring power consumption of the HVAC, the lighting and the sockets system, for the whole building “Corpo O”
- Controlling a portion of the building “Corpo O”

UniSalento will proceed with the installation of devices that are capable to collect the data of productivity and consumption and communicate with the OGEMA gateway. The installed devices should be provided with KNX or Modbus protocols.

At the beginning, the technical deployment will cover only a portion of the building “Corpo O”. Then it will be extended to the whole building.
Considering any appropriate adaptations, the design will be replicated for the buildings “Corpo Y” and “La Stecca”.

4.2.9.2 Monitoring power consumption of the HVAC, the lighting and the sockets system, for the whole building “Corpo O”

Concerning the HVAC System, the control of productivity and of the heat pumps should be deployed as follows:

- Installation of a system “flow meter + temperature sensor pair”, as shown in the following figure.

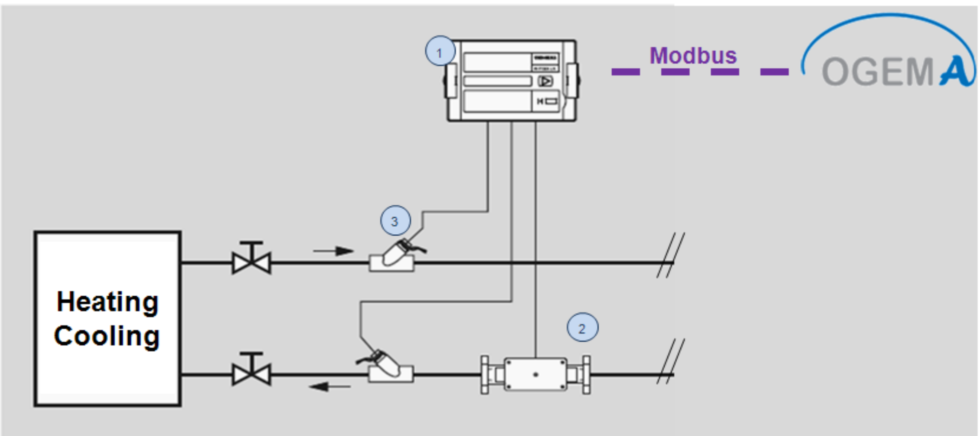


Figure 63 – Scheme of the flow meter + temperature sensor pair

The following components will be installed in addition to the already existing circuit of the heat pumps:

- n°1 Flow meter (1 in Figure)
- n°1 Magnetic flow meter (2 in Figure)
- n°2 Temperature sensor (3 in Figure)

The thermal energy calculator (1 in Figure) provided with plug-in module for Modbus communication (RS485), will directly communicate with OGEMA.

The system to monitor the electrical energy consumption of the heating, lighting and sockets systems will be deployed as follows:

- Installation of suitable measuring devices on the switchboard for each of the three consumption channels (lighting, HVAC and sockets), as presented in Figure below.

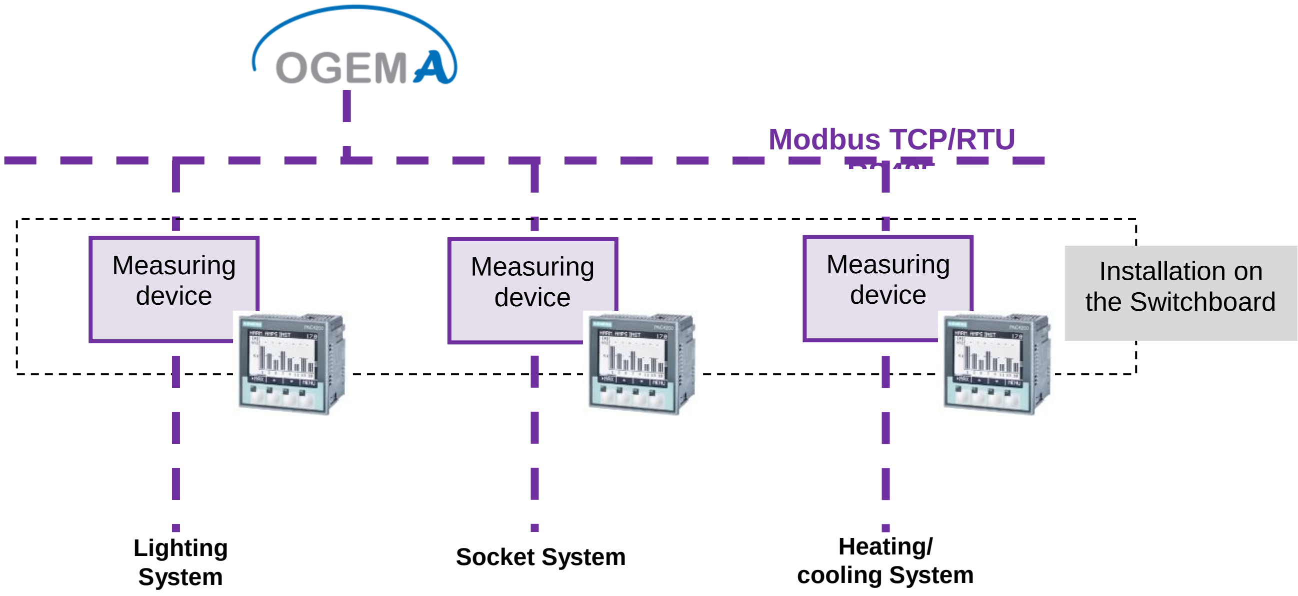


Figure 64 – Scheme of measuring devices

4.2.9.3 Controlling a portion of the building "Corpo O"

Specific devices will be installed to allow the control of each room. In particular:

- n°1 Thermostat with protocol KNX
- n°1 presence detector with constant light level control with KNX protocol
- modular switch actuators, on the switchboard, for the remote switching of the Lighting System

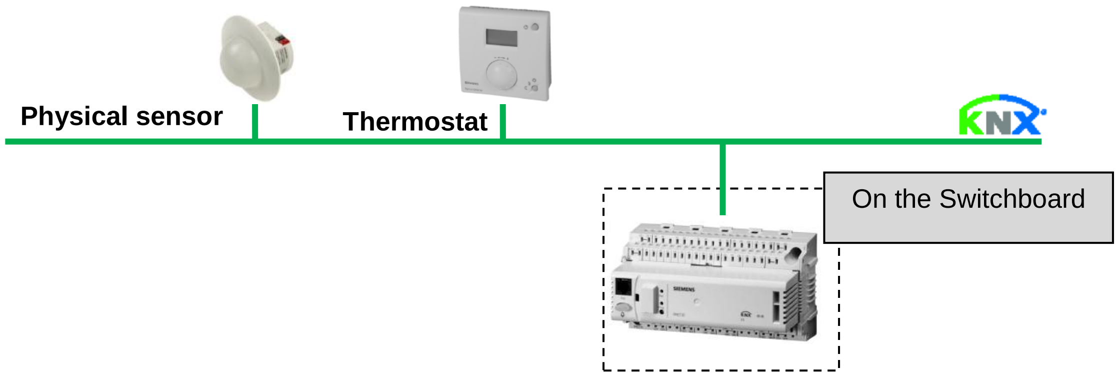
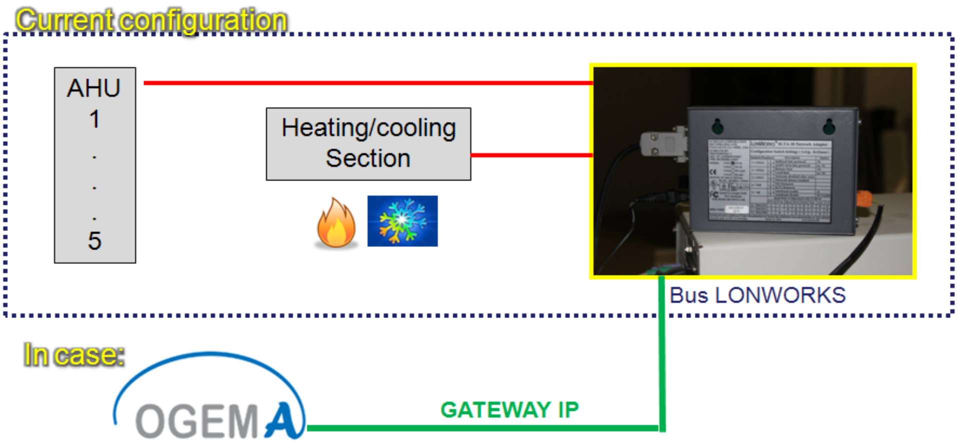


Figure 65 – Scheme of the KNX devices in each room

4.2.9.4 Second phases: implementation for the building "La Stecca" and "Corpo Y"

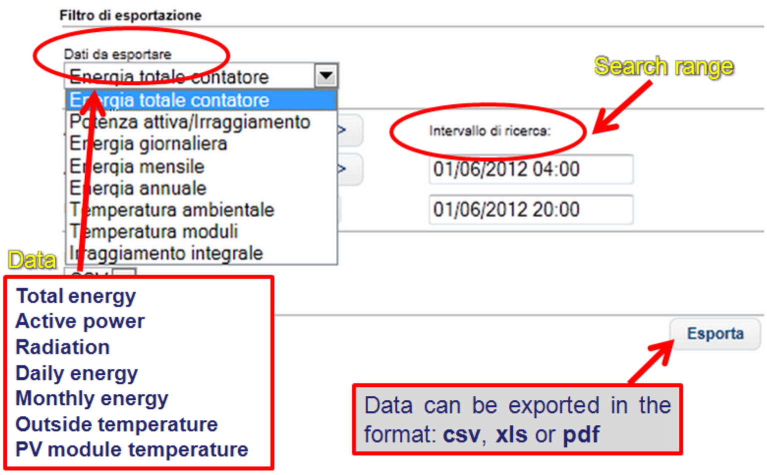
The technical deployment at the building "La Stecca" is different because it includes a gas-flow meter that is able to communicate with OGEMA.

Being "Corpo Y" already equipped with a LonWorks bus for controlling the five AHU the communication with Ogema can be obtained by adding an IP Gateway, as represented in the following picture:

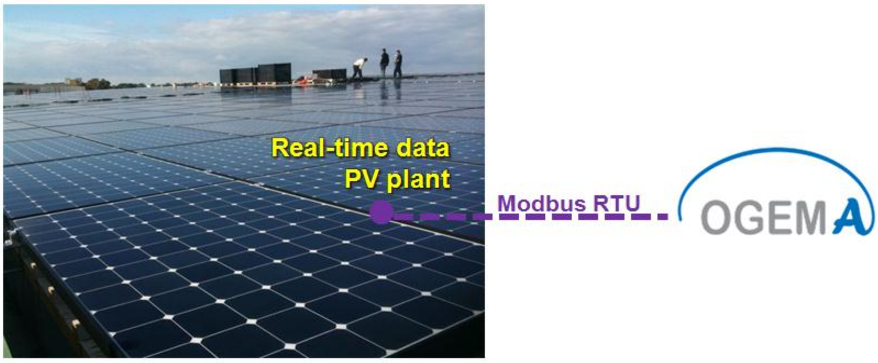


4.2.9.5 Photovoltaic system

The data acquisition from the PV power plant of the Parking Area can be carried out directly from the web site made available by the external company in charge for the management of the system (Esapro website).



In the case of the PV Power Plant installed at the museum site, being such inverter equipped with an ES851 data logger board with a Modbus RTU interface, the data acquisition can be direct.


Real-time data
PV plant
Modbus RTU
OGEMA

5 Open Discussion Points and Conclusion

Following the system analysis done in WP2, some requirements initially classified as ARC are actually considered as not impacting the final architecture.
These requirements are: **ARC_034, ARC_036, ARC_004, ARC_051, ARC_052 and ARC_053**.

6 References and Acronyms

6.1 References

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2. **BEAMS Consortium.** *D8.1 Dissemination Master Plan.* Valencia, Spain : s.n., 2011.

3. **EC.** *Annex II General Conditions.* Brussels : v5, 2009.

4. **NAF**. Nato Architecture Framework: v3. - http://www.nhqc3s.nato.int/ARCHITECTURE/_docs/NAF_v3/ANNEX1.pdf

5. **TOGAF**. The Open Group Architecture Framework: v9. - http://www.opengroup.org/architecture/togaf9-doc/arch/

6. **KNX –** www.knx.org.

7. **Modbus –** www.modbus.org

6.2 Acronyms

Acronyms List	
BMS	Building Management System
CP	Consortium Plenary
DM	Dissemination Manager
DoW	Description of Work
EM	Exploitation Manager
ESCO	Energy Service Company
EMS	Energy Management System
LV	Low Voltage
EV	Electrical Vehicles
FAME	FAcility Management Environment
OGEMA	Open Gateway Energy Management Alliance
HVAC	Heating, Ventilating, and Air Conditioning
IPR	Intellectual Property Rights
M&C	Monitoring and Control
PC	Project Coordinator
PPP	Public-Private Partnership
PPR	Project Periodic Report
PSC	Project Steering Committee
QM	Quality Management
QoS	Quality of Service
QR	Quarterly Report
RES	Renewable Sources
RM	Risk Management
SLA	Service Level Agreements
SVN	Subversion
TM	Technological Manager
WL	Work package Leaders
MMI	Man-machine Interface
AF	Architectural Framework
NAF	NATO Architectural Framework
TOGAF	The Open Group Architectural Framwork
SOA	Service Oriented Architecture
WS	Web Services
ESB	Enterprise Service Bus
XML	Extensible Markup Language
WDSL	Web Services Description Language

SOAP	**Simple Object Access Protocol**
UDDI	**Universal Description, Discovery and Integration**
MEP	**Message Exchange Pattern**
UI	**User Interface**