LIFE+09 ENV/ES/000493

www.lifedomotic.eu

DOMOTIC

Demonstration of Models for Optimization of Technologies for Intelligent Construction

FINAL REPORT

COORDINATOR:

fundación SANVALERO
GRUPO SANVALERO

PARTNERS:

Grazer ENERGIEAgentur

patrimonio natural de castilla y león

Europa, Innovación y Desarrollo

ADeSOS
DESARROLLO Y SOSTENIBILIDAD

LIFE+09 ENV/ES/000493

DOMOTIC

Demonstration of Models for Optimization of Technologies for Intelligent Construction

www.lifedomotic.eu

Project Reference: LIFE+ 09 ENV/ES/000493 DOMOTIC

TITLE: Demonstration Of Models for Optimisation of Technologies for Intelligent Construction

COORDINATOR: FUNDACION SAN VALERO

PATNERS: FUNDACION PATRIMONIO NATURAL DE CASTILLA Y LEON

GRAZER ENERGIE AGENTUR

EUROPA, INNOVACION Y DESARROLLO

ADESOS

With the contribution of the LIFE financial instrument of the European Union

TABLE OF CONTENTS

PROLOGUE

In recent years, energy management of buildings has undergone increasing attention, especially due to the economic recession, the rising energy costs and the need to reduce our energy bills and CO_2 emissions to the atmosphere.

Despite the progress made following the adoption of different European standards, the fact is that the HVAC and lighting of buildings account for about 40% of the energy consumed in the EU. It is estimated that the potential for energy savings in this sector could reach 74%.

These data give us strong arguments to justify the need to take action directly aimed at reducing energy consumption in homes, offices, hospitals, schools, hotels, etc.

In this context, we find that information technology and communication (ICT) offer great help to reduce these energy consumptions, both through monitoring and by using devices to automate equipment and services.

Home automation is precisely to address this kind of solutions offered by technology, integrating ICT, computers and automation, in what might be called smart building, in order to achieve efficient use of energy in buildings; making the life of users safer, more comfortable and economical.

At the same time, home automation nowadays offers a wide range of employment opportunities, not only in the field of device production, but also in installation and energy services, including the development of monitoring software and energy management.

The Domotic Project, funded by the LIFE program of the European Union has validated an international benchmark of great practical interest in supporting the European strategy to fight against climate change.

To do this, three buildings have been taken as test base: the Secondary Education and Vocational Training Centre and the University of San Jorge (USJ), both belonging to San Valero Group in the Autonomous Community of Aragón, and the PRAE premises of the Natural Heritage Foundation in the Autonomous Community of Castilla y León.

The results achieved and both the economic savings and the reduction of greenhouse gases emission are detailed throughout this report. They are a clear example of the great potential for transfer of this Project and of the high added value it has within a national and a European scope, as favourable impacts have been achieved for reducing consumption and CO_2 emissions in over 50% by implementing simple measures and applications that show an excellent cost-environment benefit ratio.

In addition to the achieved results, many other lesson have been learned that are of great interest to institutions, individuals and public authorities and that should also be considered in the field of construction of new buildings of intensive use or in the management of consumption in already existing facilities. Some of these lessons are also gathered in this report.

The LIFE DOMOTIC Project's success is evident, as it has obtained recognition and important institutional and professional awards during its development, having also a great impact on media. However, above all, what must be highlighted is the fact that, as a reference model, it has already shown many real and effective demonstrations of transfer and others that are being promoted and supported by various public and private stakeholders.

The reasons for the good results achieved are diverse, personally I would like to point out the election of a partnership with extensive professional and technical respectability in the field of international environmental innovation, the multi-agent nature of the partners, their different characteristics, the presence of public and private professional organizations, the international dimension of the Project, the choice of the LIFE Programme as a financial instrument to support the Project as associated label of quality and, last but not least, the people who have participated in the development of LIFE DOMOTIC believing in what they do, because their contribution and a job well done, contributes generously to improving our environment.

To all of them: thank you.

César Romero Tierno

General Director of San Valero Group.

1. THE PROJECT AND ITS PARTNERS

1. The Project and its Partners

The development of the LIFE Project (Demonstration of Models for Optimisation of Technologies for Intelligent Construction) **started in September 2010 to demonstrate and quantify the potential of CO_2 emissions reduction derived from the application of technologies and smart building models (domotics and inmotics) to high occupancy buildings.**

The project has received the support of the "LIFE+ Program" of the European Union, a financial tool aimed at encouraging the development of innovation projects within the framework of the community policy in regard to environment.

From a functional and geographic complementarity, the project partners have ever since covered and carried out the actions planned for the corresponding areas of responsibility that had been assigned:

- **(FSV) San Valero Foundation(Spain):** as a developer and beneficiary coordinating the project, it has led and taken responsibility for the actions aimed at the "Project´s Management" (Action 1); at the implementation and modeling of actions on demonstrations to be developed within the "San Valero Foundation Vocational Training Centre" and "University of San Jorge" (Actions 3a and 3b); and at the development of a financial audit of the project (Action 7), as well as at the maintenance of the exploitation of results in the after-LIFE phase (Action 8).

- **(FPN) The Natural Heritage Foundation of Castilla y León (Spain):** has led and taken responsibility for the execution of actions aimed at the implementation and modeling of the actions on demonstration to be developed within the "Proposals for Environmental Education Centre –PRAE" of The Regional Executive Government of Castilla y León (Junta de Castilla y León) (Action 3c).

- **(GEA) The Graz Energy Agency (Austria):** has led and taken responsibility for the execution and coordination of actions aimed at "Defining models" to be implemented within the three actions on demonstration developed in Spain, as it is an expert authority on analysis and implementation of measures for "energy efficiency" in its region; collaborating closely with EID.

- **(EID) Europe Innovation and Development (Spain):** has led and taken responsibility for the execution and coordination of actions aimed at guaranteeing the "Internal quality assurance, monitoring and results analysing" (Action 4); as well as the "Validation and characterization of the tested models" for transference (Action 5).

- **(ADESOS) Association for Development and Sustainability (Spain):** has led and taken responsibility for the execution and coordination of actions of "Dissemination and exploitation of results" (Action 6).

2. PROJECT OBJECTIVES

2. Project Objectives

1. To demonstrate, by contrast with high energy demand buildings, the added value and transfer potential arising from the implementation of home automation systems and other efficiency measures in buildings, based on their potential to reduce energy consumption and CO_2 emissions; measured and compared according to Directive 2006/32/EC on energy end-use efficiency and energy services.

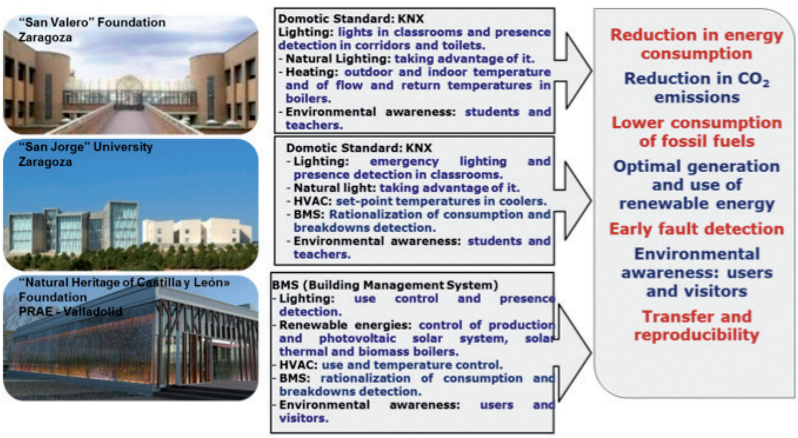
2. To quantify the ammount of CO_2 emissions of possible reduction derived from the application of technologies and smart building models (domotics and inmotics) to buildings with high exemplifying potential.

3. To model and promote standardization patterns of “smart facilities”, reinforcing the objectives of Directive 2002/91/CE on the Energy Performance of Buildings; taking as indicator tests the two schools and the public institutional building.

To achieve these objectives, methods, techniques and technologies for energy efficiency have been modeled, implemented and applied, including home automation and energy management systems; with three public buildings with a high indicator on energy demand and intensity of use: Vocational Training Centre, Private University and Institutional Exhibitions Building.

As a whole, the actions on demonstration developed have shown a potential to improve **the energy efficiency on 42,48% annual; and a potential to reduce emissions on 680t CO_2/year.**

At the same time, during the development of the project and in order to favour the transfer and reproducibility potential, a permanent dissemination campaign of actions and results has been carried out aimed at generating synergies for implementation and use of the tested technologies and systems, especially in public and private buildings with high energy demand and intensity of use.



3. FINAL REPORT FRAMEWORK

3. Final Report Framework

Once the experimentation actions came to an end, this final report was made in order to favour the transference and reproducibility of the defined and tested models and:

1. To describe the models validated under the project, their components and operating logic.
2. To show the results achieved, their projection and associated ratios.
3. To calculate the environmental cost/benefit ratio of each of the models and of the overall project as well.
4. To calculate the economic ratios to determine the simple payback periods.
5. To extract from it all lessons learned to encourage the transfer.

To do this, from the beginning of the project and throughout its development:

1. All technical documentation generated in each of the actions has been compiled and structured.
2. The initially defined models for monitoring the developments in each of the actions have progressively been fulfilled.
3. Also with incremental and permanent nature, models for "Failure Mode Effects Analysis" (FMEA) and "Strengths, Weaknesses, Opportunities and Threats" analysis (SWOT) defined and agreed by the partnership have been fulfilled.
4. The compiled information and the monitoring carried out have allowed applying remedial measures to overcome difficulties and problems identified.

Ultimately, this final report aims to reinforce the potential for transfer of the defined models, in which methods, techniques and technologies for "Intelligent Design" have been implemented and tested; so that the energy efficiency of buildings will be improved and Greenhouse Gases (GHG) emissions will be reduced, favouring the fight against climate change.

The characterization of the models developed by the DOMOTIC Project is the key action to ensure its transfer, so this is the key part of this final report.

The characterization was performed in the final stage of the Project, from the results obtained and the demonstrated validity of the models being tested, which on average exceeded 24 months per action and was developed from 2011 to 2014. However, from the beginning work has been carried out in order to define, adapt and complete the models developed for its monitoring.

The profuse amount of data and contrast information compiled, which is directly linked to the development of demonstrative actions, comes from measurements, audits and calculations in projection carried out in the execution phase of the project. They correspond to the records registered until 30 June 2014 and are referred to the following experimental periods: FSV (Floor "C": from 01/09/2011 to 30/06/2014 - 34 months; Floor "E": from the 01/09/2012 to 30/06/2014 - 22 months; LED luminaires in the final stage of the project: 2 months); USJ (from 01/10/2012 to 30/06/2014 - 21 months) and FPN (from 01/02/2012 to 30/06/2014 - 29 months). The results and ratios obtained were finally subjected to contrast with those reported by final audits for their final validation.

The sample considered, contrasted with the results of the final energy audits, is representative enough to be able to adequately perform the characterization of the models, the final validation of the obtained results and the calculation of relevant ratios and projections to other time frames that have allowed "conclusions" and "lessons learned" from the project" to be drawn.

4. CHARACTERIZATION OF BUILDINGS FOR ACTION AND IMPLEMENTED MODELS

4. Characterization of Buildings for Action and Implemented Models

Within the project´s framework, three different models have been defined and measured to apply "technologies for an efficient energy management in construction", aimed at reducing emissions of Greenhouse Gases (GHG) and demonstrating their potential to improve the "energy efficiency" in implemented buildings that constitute the test base.

To encourage the transfer potential of the project, it has been ensured that the models could show the results of applying these technologies in buildings differentiated by their structural characteristics, age, type, generation systems, fuels used and intensity of use and weather conditions in the area; attempting to demonstrate their versatility and ability to adapt to the different needs of potential agents that are key objectives for transfer.

In a first approach, the main features and uses of each of the locations where actions on demonstration have been conducted are:

FSV (Learning Centre - San Valero Foundation Headquarters in Zaragoza – Year of Built: 1983):

set of buildings covering over more than 10,000 m2 where over 1,000 students attend to Secondary Education and Vocational Training courses.

The action of demonstration was carried out in two of the floors of the south building of the complex, in a total area of 2,062 m2, where tuition is given to more than 250 students a year.

By implementing a home automation system based on the "KNX Standard" the lighting control of 19 classrooms, corridors and toilets of the "C" and "E" floors has been developed; as well as the oil heating system for these floors.

Additionally, in the final stage of the project and in the benefit of transfer; the building automation system for lighting has been implemented in the Floor "H" of the same building on a 1,031 m2 area, but with LED lights; which has demonstrated a potential for reduction in consumption of over 72%, with this type of technology.

FSV (University of San Jorge in Zaragoza –Year of built: 2007): set of three buildings where the Faculties of Communication, Health Sciences and the Chancellor´s Office buildings are located in a total area of almost 10,000m2 and where the Bachelor of Architecture Degree is taught, together with undergraduate, postgraduate and PhD courses, to over 2,000 students.

The action on demonstration has been focused on the control of the emergency lighting of the Faculty of Communication and the Chancellor´s Buildings.

The implementation of a home automation system based on the "KNX Standard" of software for "control of consumption" has made it possible to automate the regulation of the emergency lighting in both buildings, and to have, on a real-time basis, the consumption information from virtually all the premises of the University, in order to streamline them all.

FPN (PRAE building in Valladolid – Year of Built: 2008): The building called ""Proposals for Environmental Education Centre –PRAE, for its acronym in Spanish" is aimed at promoting Environmental Education". Receiving an average of over 15,000 visits a year, it consists of two areas: the Environmental Park and the Environmental Resources Centre (CRA, for its acronym in Spanish). It is an eco-efficient and bioclimatic building of 3,500 m2 of total floor area, with exhibition hall, meeting room, library, multifunctional space for workshops and administrative area; where the action on demonstration has been carried out.

The implementation of a “Building Management System” (BMS), measuring equipment and other home automation systems provides real time information and data about production and use of renewable systems available: photovoltaic plant, solar thermal collectors and biomass boilers to optimize their performance; as well as the data about consumption of virtually all of the facilities, in order to streamline them all.The characteristics of each of the implanted models are described below, detailing the development contexts of each action (area, geographic location, power requirements, etc.) and the solutions implemented. As we shall see, these are eligible to be replicated in any other similar location within the European geographical space.

4.1. Action 3a: FSV (San Valero Foundation Headquarters in Zaragoza)

Location: Violeta Parra, 9

50015 - Zaragoza (Spain)

GPS: 41.669556, -0.878833

4.1.1. Context of Action

Demonstration Of Models for Optimisation of Technologies for Intelligent Construction

Demostración de Modelos para la Optimización de Tecnologías para la Construcción Inteligente
[LIFE+ 09 ENV/ES/000493]

Action Context

BUILDING	Centro ES y FP de Fundación San Valero - Grupo San Valero	Address	C/ Violeta Parra, 10	Date	18/08/14 0:00
Date of construction	1.983	Postal code	50015	Contact people	Dª Nieves Zubalez Marco (Dpto. Internacional)
Built square meters	10.000	Locality/City	Zaragoza	[Phone] [Fax]	00 34 976 466599 / 00 34 976 466590
Square meters audited	2.062	Province (Country)	Zaragoza (España)	Email	nzubalez@sanvalero.es
Capacity (Users number	1.700				

Students and teachers: Phase 1 "C"	264	Square meters audited	1.041
Students and teachers: Phase 2 "E"	192	Square meters audited	1.021

Types of energy used	Electricity, natural gas, heating oil
Uses of the building	Teaching: Secondary education and VET
Other relevant information	On the lighting of "C" & "E" floors and heating.

Estimated average occupancy level (TOTAL of facilities -Standard School course

Average occupancy level (Action area: Phase 1

Estimated average occupancy level	Year	january	february	march	april	may	june	july	august	september	october	november	december
		60%	90%	90%	90%	90%	70%	10%	10%	90%	90%	90%	70%
	187	**158**	**238**	**238**	**238**	**238**	**185**	**26**	**26**	**238**	**238**	**238**	**185**
Days...:	**205**	17	20	23	16	22	22	5	0	22	21	22	15
Hours/day...:	**5,20**												
Average of Hours/Month...:	**96,89**	88,38	103,98	119,57	83,18	114,37	114,37	25,99	0,00	114,37	109,17	114,37	77,98
TOTAL - Hours/Year...:	**1.065,75**												

Estimated average occupancy level (Action area: Phase 2

Estimated average occupancy level	Year	january	february	march	april	may	june	july	august	september	october	november	december
		60%	90%	90%	90%	90%	70%	10%	10%	90%	90%	90%	70%
	136	**115**	**173**	**173**	**173**	**173**	**134**	**19**	**19**	**173**	**173**	**173**	**134**
Days...:	**205**	17	20	23	16	22	22	5	0	22	21	22	15
Hours/day...:	**5,23**												
Average of Hours/Month...:	**97,40**	88,85	104,53	120,20	83,62	114,98	114,98	26,13	0,00	114,98	109,75	114,98	78,39
TOTAL - Hours/Year...:	**1.071,39**												

Monthly average temperature (30 years)		
Maximum	24,5	ºC
Minimum	6,4	
Annual average	**15,45**	

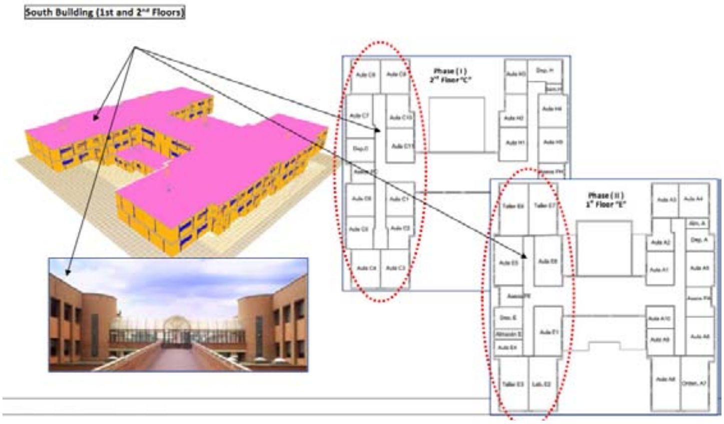
Average temperature in summer (30 years)		
Maximum	28	ºC
Minimum	15,2	
Annual average	**21,6**	

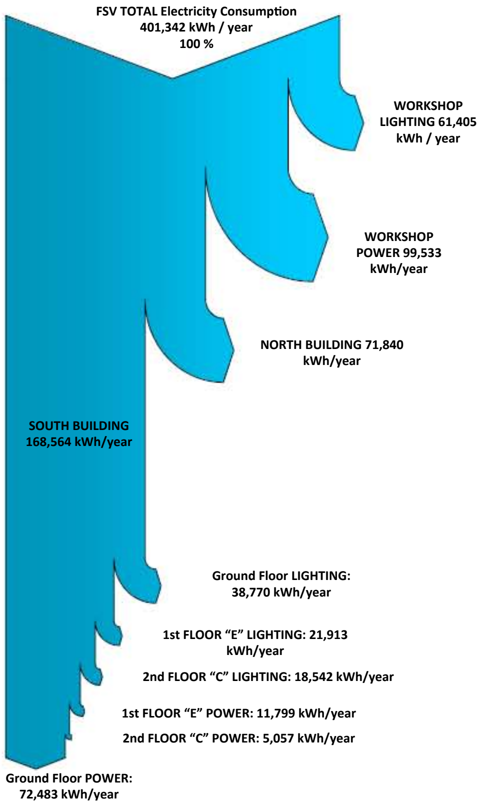
Average temperature in winter (30 years: Oct-Apr)		
Maximum	14,9	ºC
Minimum	5,4	
Annual average	**10,15**	

Altitude	**247**	Meters
Yearly PV power [Average-Optimal]	**1.520**	kWh/1kWp
Annual average rainfall [30 years]	**318**	liters/m2

http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

With actions in FSV, the DOMOTIC project has demonstrated the potential of domotics and inmotics for improving energy efficiency in old buildings that lack active and passive systems for energy efficiency which may be present in new buildings. The actions have been carried out in two phases; the first focussed on the lighting control in the 2nd floor of the South Building ("C") and the second on the lighting control in the 1st floor of the same South Building ("E"), as well as on the oil heating system in both floors.





At baseline, electricity consumption by lighting floors "C" and "E", on which action has been taken, represented 10% of the total electricity consumption in the building (40,455 kWh / year); whereas that of diesel, averaging the contrast between 2009-2011, was set to an average consumption of 31,900 l / year.

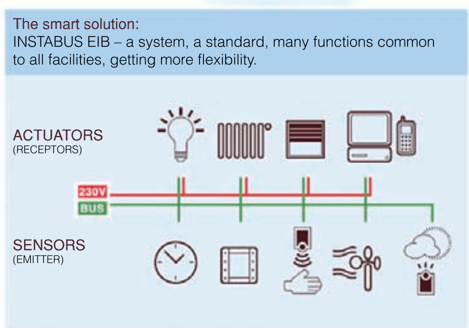
4.1.2. Technical Description "KNX Standard System"

The "Automation KNX Standard System" carried out is common to the entire action and the implemented programming allows controlling the working modes and operating status of the devices and systems connected to it.

The solution chosen will allow a gradual integration and management of all areas of consumption within the building: lighting, ventilation, heating, air conditioning, water, etc. It is a versatile "open standard" for managing all applications to control a building: energy management, lighting, HVAC, blinds, security, presence, monitoring, etc…

This technology can be applied both in new buildings and in existing ones; on any microprocessor platform with a single commissioning tool (ETS) using various transmission systems (TP, PL, RF, IP) and in different configurations.

The standard includes the functionality of its predecessor systems EIB, EHS and BatiBUS; it has nearly 7,000 KNX certified product groups in its catalogues, and covers almost all the needs for a building automation.



The choice of system has been made taking into consideration the following advantages:

European International Standard:

Harmonized European Standard, EN-50090 for "Home and Building Electronic Systems (HBES)", is based on technology solutions KNX-EIB (Konnex-European Installation Bus).

KNX is a European technology that ensures compatibility between devices from different manufacturers; which prevents future dependence on a single supplier with privately owned technology.

Simplicity

KNX is a worldwide standard bus system for intelligent building control and automation which allows all the devices to share information and be fed through it.

The KNX bus, with a single twisted two-wire cable, is sufficient to communicate and feed all the network elements.

The distributed intelligence forms a decentralized system that does not need to be dependent on any central computer, so all devices are able to continue to function even if one of them presents whichever problem.

Flexibility and Scalability

The functions reprogramming enables functional adaptation to architectural and / or decorative alterations without necessity of any works to be carried out in the system.

The KNX system is provided with a tool for software engineering projects, the ETS-3, this is indepe dent from any manufacturer and has the capacity to unite different individual devices within a facility, integrating the different ways and means of system setting.

The programming of each of the system parameters has been done with this KNX software for programming; allowing the definition of each of the elements of the system and its association with a specific functionality, either individually or collectively.

The extension of the system is simple, as long as it is intended for pre-installing wiring pipes during the construction phase.

Integration Capability

It allows the integration of virtually any system belonging to any building (lighting, air conditioning, blinds, security ...) by modules with digital and analogue inputs and outputs; so as to allow, for example, commuting a light switch, powering up an engine, opening or closing a valve, etc.

Robustness against External Affecting Factors

It relies on system of signalling that is not affected by external interferences, as it uses sources of power protected against short-circuits and overloads, and reconnects automatically.

Security

It is highly secure against the risks of indirect contact, as it runs at 24V (SELV: Safety Extra Low Voltage, according to LVD: Low Voltage Directive); and provides a significant reduction in power wiring, which often causes fire **Improved Comfort and Energy Saving**

4.1.3. Lighting Control

The solutions implemented to monitor and improve the energy efficiency of lighting in “C” and “E” floors, where action has been taken, provide, for each area and depending on needs and uses, different systems of regulation and control that meet the following characteristics:

Lighting Control According to the Actual Occupancy, for Areas of Occasional Use:

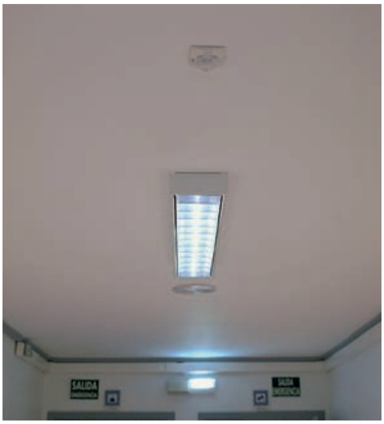
This was the adopted solution for the common areas of public coincidence: corridors and toilets.

An on-and-off presence detection system is available, so metimes timers are also used.

Two key elements are essential for lighting adjustment by presence detection according to actual occupancy: a sen sor element (motion detector), and an actuator element (binary switching actuator).

Savings of up to 20% on the controlled power can be obtained through this solution.

It works as follows:



The motion detector sends the order to release the charge at the beginning of a movement, as long as the natural light is below the previously set threshold.

Once the movement stops, the switching-off timing starts. Afterwards, provided that no other mov ment is detected, the charge is turned off.

To avoid the user having direct control of the circuits has been attempted, meanwhile offering an optimum level of efficiency and comfort.

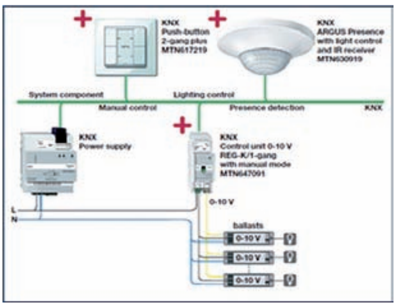
Lighting Control Taking Advantage of Natural Lighting (DALI System)

DALI (Digital Addressable Lighting Interface) is a digital communication protocol used in both fluorescence and LED lighting reactants, allowing the introduction of direct feedback of the physical lamp state, letting to know their state and that of the reactant at all times; therefore it is the most versatile, powerful and inexpensive option for lighting control in systems formed by many lamps that require to be regulated.

This was the solution adopted for **the control of lighting in classrooms.**

Systems have been installed for prioritizing on natural lighting, which regulate the lighting level depending on the amount of sunlight available; the first parallel line of luminaires located closer than 3 metres from the window.

The solution also includes the possibility of regulating absolutely all luminaires, as well as opening and closing of blinds; seeking to maximize energy savings.



Just based on a sensor and an actuator, combined with the capability of regulation of the luminaires, it has made it possible to act continuously on the overall level of illumination; which is not feasible by just on-and-off switching.

The implanted sensors allow to measure the total luminosity in the application point; and based on that value and the brightness level set-point, the system acts on the charge to adequate the light and get the desired values.

The system works as follows:

1. The presence and lighting detector constantly evaluates the brightness level on the surface that is placed perpendicularly to it.

2. If the measured level is above the desired value, the sensor sends to the regulator the order to decrease the level of brightness.

3. If the measured level is below the desired value, the sensor sends the order to increase the level of brightness

4. If the sensor detects no presence in the room, once the set time has elapsed, all the lighting system turns off.5. If the amount of natural lighting is sufficient to achieve the brightness level set-point, all the lighting system turns off.

Defining Scenes

Scenes allow more complex control than just that of the ignition, or direct regulation of lighting. A scene permits a simple implementation, with either a push button or from a screen display, performing multiple actions, including timed and / or synchronized, among other options.

All actuators and sensors set scenes to be executed, as well as save a current state. In this way, a simple switch and an actuator, or a controller, may be implemented.

Programmed scenes have been defined suiting the brightness level to the activity taking place: lectures, practical classes or when a projector is to be used. These scenes can be reconfigured as needs vary, without replacing the components of the system.

This solution has been applied to areas where whiteboards are placed when they are used as a surface for video projections, transparencies, slides, etc… This allows to adapt the lighting level of the area, making it suitable for viewing projections without acting on all the lights in the classroom.

"Half Light" Feature

Switches that control the circuits that neither depend on occupancy nor on lighting sensors have been programmed, so that, when the system is activated, the lighting level will only be 30%. If a higher lighting level was necessary, it would have to be manually regulated.

The user's action to regulate the lighting level is, therefore, compulsory, becoming more comfortable keeping it to 30% if it is not indispensable to increase it.

This solution is to be applied in those rooms where there is no natural lighting or in those that have not incorporated presence or lighting detectors, as well as, when it has been found out that the tendency of users is to act on the switches; even when automatic control has previously been programmed.

Scheduling

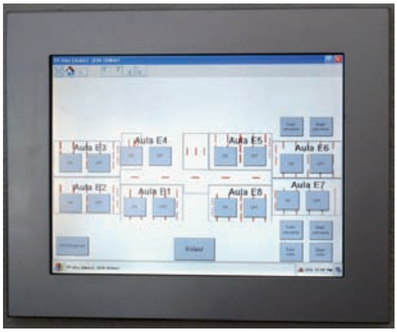
Through it, functioning can be programmed based on date and time, so that the facility can operate without the user taking direct action on any element of the system.

Once a certain time programmed after closing the building has elapsed, a general shutdown is forced, ensuring that the building lights are completely off outside school hours.

The switches have priority over scheduling, so that, if for any reason, someone needed to turn any circuit on or off; this possibility would be available. Display and control

The display and control of the system will be carried out in two different ways aimed at two different types of users.

Colour Touch Screen:



It allows certain users, who do not need to have computer skills, to access to the system settings in order to adjust some basic parameters such as:

- Switch-on and consumption control: to assess certain circuits, on/off-switches or status display.

- Regulated circuits control and display of lighting levels.

- Analysis of technical alarms and action on the necessary elements.

- Weekly and annual programming watches: fastly and intuitively programmable by the user.

- Control of some of the set-point values of the rooms and display of their status.

SCADA (Supervisory Control and Data Acquisition) Management and Programming:

Designed for qualified staff, it allows to obtain the maximum performance from the system; as it enables the analysis of all system parameters, adapting them to the best conditions for efficiency, based on the gathered and analysed information.

It makes it possible to have a record of any change in set-point parameters defined for the system, to prepare status graphics, and to use the recorded data to produce graphics of behaviour or consumption trends.

The results of each modification can be viewed by accessing to the system server through a PC.

Remote Control of the System:

The remote access to the system by using the Internet allows:

Remote Programming:

It lets the programmer to change parameters or to improve the system without moving, reducing costs and cutting down response times.

The staff responsible for maintaining the automation system can reprogram or adjust it from a PC, without having to connect directly to the KNX bus; facilitating, therefore, the programming and maintenance.

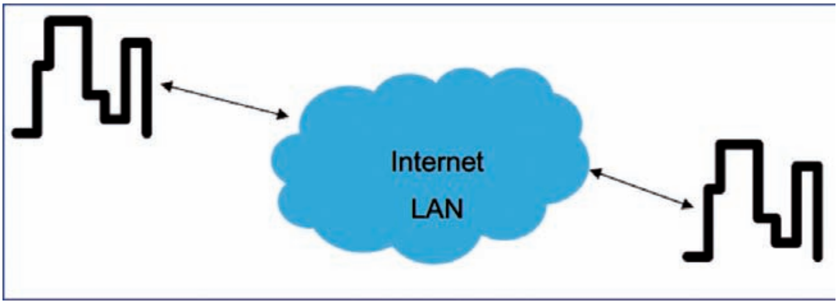
From an educational point of view, students can program from areas enabled for this purpose from computers used for practicing; without having to physically access to the system network.

Remote Management and Maintenance:

The option of remote maintenance and management of the system is undoubtedly one of its strengths; as it reduces the costs associated with maintaining and the resources needed for its management.

The system can, for example, report malfunctions, excessive consumption or misuse of facilities; allowing the management of incidences and the remote access to the registry of the system variables.

An access via VPN (Virtual Private Network) has been defined: this network technology can extend the properties of a LAN (Local Area Network) through the Internet or a public network.



It is a purely telematic method as, for the system, all the elements are connected to the same secure network; allowing the encryption of the data flowing through the VPN.

It allows interconnection between systems, easing the programming and diagnosis in corporate facilities through routers, switches and servers able to generate the VPN. This will allow in the future -if the option is necessary, appropriate and cost-effective- to interconnect FSV facilities and those of University of San Jorge, in order to manage both from a unique point as if they were a single building.

4.1.3.1. Work and Components Review

In order to implement the system described in a building with a history of more than 30 years as the present one, it was necessary to adapt the existing electrical system in each of the classrooms. Among other minor adjustments, the following modifications were carried out:

- Change of distribution panels and electric switchboards; and laying of new corrugated pipes and power lines for control and communication in KNX: sensors, actuators for lighting, blinds, etc…
- Relocation of luminaires to define scenes.
- Renovation of electrical power supply and of communication systems in the desks of students.
- Installation of new energy consumption meters in each floor, integrated within the KNX system.
- Adecuación de los sistemas de amplificación e imagen, para su integración en los nuevos cuadros eléctricos del aula y “escenas” definidas en el sistema.
- Replacement of lamps listed in the following tables for adjustable ones of high frequency (DALI), adapting the lighting level of each workspace to the regulations under the new configuration.

Floor "C"

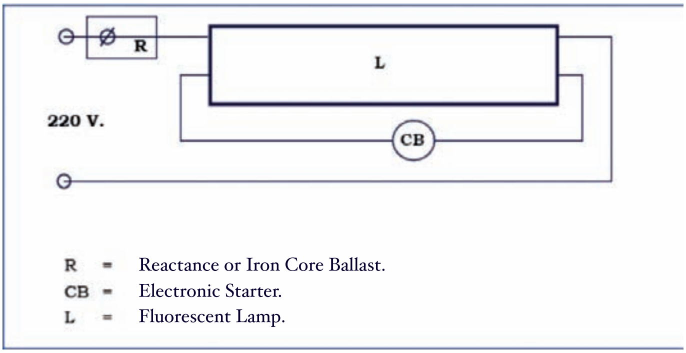
Old Installation						New Installation						
Units	Type	Unitary Power (W)	TOTAL Power (W)	Total kWH/year	Consumption kWH/day	Units	Type	Unitary Power (W)	TOTAL Power (W)		Total kWH/year	Consumption kWH/day
6	Powerstrip 2X58W AF (140W)	140	840,00	1.033,20	4,10	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	408,00	501,84	2,45
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
6	Powerstrip 2X58W AF (140W)	140	840,00	929,88	4,10	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	408,00	451,66	2,20
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.193,92	5,46	12	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	384	504,00	537,26	2,62
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.285,76	5,46	12	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	384	504,00	578,59	2,82
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
6	Powerstrip 2X58W AF (140W)	140	840,00	998,76	4,10	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	408,00	485,11	2,37
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
6	Wall mounted luminaires 2X58 AF (140W)	140	840,00	68,88	10,24	6	Wall mounted luminaires 2X58 AF (140W)	140	840	840,00	68,88	0,84
8	Powerstrip 2X58W AF (140W)	140	1.120,00	964,32	5,46	12	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	720	840,00	723,24	3,53
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.423,52	5,46	12	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	384	504,00	640,58	3,12
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.377,60	5,46	12	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	384	504,00	619,92	3,02
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
6	Powerstrip 2X58W AF (140W)	140	840,00	1.274,28	4,10	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	408,00	618,94	3,02
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
6	Powerstrip 2X58W AF (140W)	140	840,00	1.308,72	4,10	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	408,00	635,66	3,10
						2	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	120			
5	Powerstrip 2X58W AF (140W)	140	700,00	882,39	2,85	3	Surface mounted luminaire 1x54W HFDALI ASY (60W)	60	180	180,00	226,90	0,92
5	Powerstrip 2X58W AF (140W)	140	700,00	882,39	2,85	9	Surface mounted luminaire 1X28W HFDALI C6 (32W)	32	288	288,00	363,04	1,48
4	Powerstrip 2X58W AF (140W)	140	560,00	229,60	2,73	4	Powerstrip 2X58W AF (140W)	140	560	560,00	229,60	1,12
6	Powerstrip 2X36W AF (45W)	45	270,00	354,24	1,10	6	Powerstrip 2X36W AF (45W)	45	270	270,00	354,24	1,44
96,00			12.870,00	14.207,47	4,50	153,00			7.034,00	7.034,00	7.035,47	2,27

Floor "E"

Old Installation						New Installation						
Units	Type	Unitary Power (W)	TOTAL Power (W)	Total Kwh/year	Consumption Kwh/day	Units	Type	Unitary Power (W)	TOTAL Power (W) (W)		Total Kwh/year	Consumptio n Kwh/day
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.377,60	6,72	15	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	900	1020	1.254,60	6,12
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.377,60	6,72	15	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	900	1020	1.254,60	6,12
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
10	Powerstrip 2X58W AF (140W)	140	1.400,00	1.894,20	9,24	15	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	900	1020	1.380,06	6,73
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
3	Powerstrip 2X58W AF (140W)	140	420,00	516,60	2,52	4	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	240	360	442,80	2,16
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.331,68	6,50	15	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	900	1020	1.212,78	5,92
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
10	Powerstrip 2X58W AF (140W)	140	1.400,00	1.722,00	8,40	15	Surface mounted luminaire 1X80W HFDALI C6 (88W)	88	1320	1440	1.771,20	8,64
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
10	Wall mounted luminaires 2X58W AF (140W)	140	1.400,00	2.009,00	8,17	15	Surface mounted luminaire 1X80W HFDALI C6 (88W)	88	1320	1440	2.066,40	8,40
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
8	Powerstrip 2X58W AF (140W)	140	1.120,00	1.377,60	6,72	15	Surface mounted luminaire 1X54W HFDALI C6 (60W)	60	900	1020	1.254,60	6,12
						2	Surface mounted luminaire 1X54W HFDALI ASY (60W)	60	120			
2	Powerstrip 2X58W AF (140W)	140	280,00	137,76	1,12	2	Powerstrip 2X58W AF (140W)	140	280	280	137,76	1,12
5	Powerstrip 2X58W AF (140W)	140	700,00	936,34	3,81	3	Surface mounted luminaire 1X54W HFDALI (60W)	60	180	180	240,77	0,98
5	Powerstrip 2X58W AF (140W)	140	700,00	936,34	3,81	5	Surface mounted luminaire 1X54W HFDALI (60W)	60	300	300	401,29	1,63
4	Powerstrip 2X58W AF (140W)	140	560,00	229,60	1,12	4	Powerstrip 2X58W AF (140W)	140	560	560	229,60	1,12
3	Powerstrip 2X36W AF (45W)	45	135,00	94,10	0,38	3	Powerstrip 2X36W AF (45W)	45	135	135	94,10	0,38
84,00			11.475,00	13.940,41	5,02	142,00			9.795,00	9.795,00	11.740,56	4,26

Advantages of Using High Frequency Electronic Ballasts:

The standard system of fluorescent tubes with conventional reactance is schematically as follows:



The frequency at which the reactances or the ballast in fluorescent lamps normally work equals that of the electrical network, namely 60 Hz.

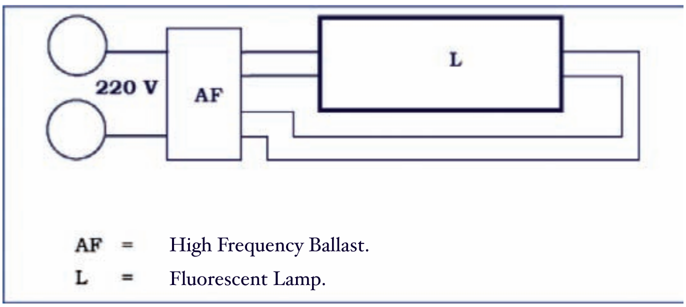
Running at this frequency value, the lighting efficiency (light output / power consumption) is less than the one that would be obtained if running at a higher frequency. Moreover, the conventional ballast consumes power and requires a compensation capacitor for improving the power factor of the whole system.

System with High Frequency Electronic Ballasts

Supplying a fluorescent lamp frequencies above 10 kHz, a significant increase in lighting efficiency is obtained. It is also convenient to work at a frequency value higher than the limit of human hearing, about 20 kHz, but lower than 50 kHz, from which losses in the ballast, as well as the possibilities of causing electromagnetic interference increase significantly.

In practice, the electronic ballasts available on the market work at a frequency of about 30 kHz.

Schematically, the system is as follows:



Each AF ballast can power a pair of lamps. Therefore, the consumption of the element itself is split between two light sources, which means a further increase in the efficiency of the system.

The main advantages of using high frequency ballasts are:

1. Energy saving; mainly produced by two effects:

Increased lighting efficiency of the lamp, as the electric current flows through it at high frequency (30 kHz), which allows to get the same lighting with 25% less power.

Minimal losses by induction, resulting in low losses by the Joule effect. The total energy saving over conventional systems can be of up to 40%.

2. High power factor, practically cos $\phi = 1$ or tg $\phi = 0$, which avoids installing compensation capacitors.

3. Instant start without flashing.

4. Absence of noise and mechanical vibration.

5. Low heat dissipation: in air-conditioned places the thermal load is reduced and therefore energy saving is obtained in air conditioning systems.

6. Easy installation: installation is not required along with the ballast, capacitors or other devices.

7. The investment cost is lower for new systems, as the system allows the conductor cross section to be smaller.

8. Reduction in contracted power for lighting.

9. The flow can be adjusted automatically or manually in a range from 100% to 25% of the rated flow.

During adjustment, the frequency varies up to 45 kHz. As the frequency increases, the power absorbed by the lamp decreases, and so does the light flow.

Besides, in the final phase of the project and in order to extend the scope of the tested technologies; luminaires of the “Strip 2x58 (140W)” type have been replaced by symmetric and asymmetric LED luminaires (50W); that have yielded excellent results.

The components that make up the KNX system, implemented among other small materials and devices; is briefly referenced as follows:

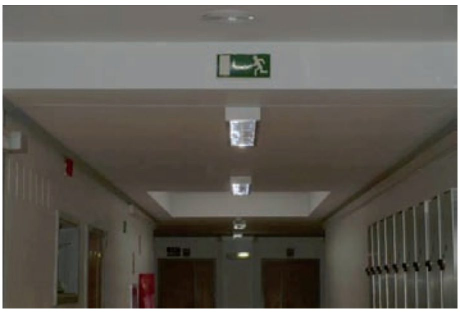
Componentes de la instalación KNX en FSV
NIESSEN 82204BA SENSORES DE 4 CANALES EIB SERIE ARC
NIESSEN 9619 SENSORES INTERFACE PARA PULSADORES 4C
NIESSEN 9620 ACOPLADORES AL BUS DE EMPOTRAR
NIESSEN 9641.3-BA DETECTORES PRESENCIA TECHO
NIESSEN 96891SBS5 ACTUADORES 4 SALIDAS, 10 A (AC1),
NIESSEN 9689SBS2 ACTUADORES 8 SALIDAS, 6 A (AC3), P
NIE9632PT9 PANTALLA TACTIL COLOR SIN MARCO 210 FU
NIESSEN 96371 EIB PORT LAN GATEWAY
NIE9637.1 PDA SOFTWARE DE VISUALIZACION PDA
NIE9637 DESK EIB-DESK PARA EIB PORT
NIE9637.3 IPR ROUTER IP EIB-KNX DIN 2 MOD
NIESSEN 9667 PROTECTORES CONTRA SOBRETENSIONES
NIESSEN 96801 FUENTES ALIMENTACIÓN C/FILTRO 640 M
NIESSEN 96803 FUENTES ALIMENTACIÓN AUXILIAR 12V
NIESSEN 96804 FUENTES ALIMENTACIÓN C/FILTRO 320M
NIESSEN 9686USB INTERFACES USB/EIB, DIN (2 MÓD.)
CONTACTORES EN 24-40 220V/50HZ(A)
NIESSEN 9653GD2 GATEWAY DALY, 1 CANAL, DIN (4 MÓD).

4.1.3.2. Graphic Review of Actions: “Lighting” in FSV

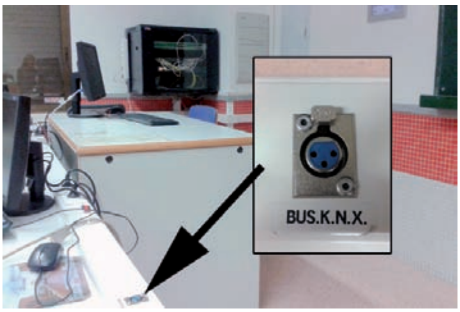
Views of the main facade of the Secondary Education and Vocational Training Centres in “San Valero Foundation” (FSV)

Installation work:

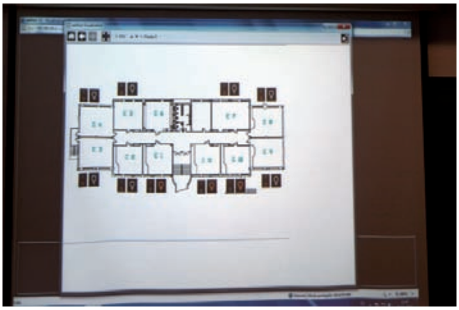
Result of lighting by presence detection in common areas:



Detail of devices: sensors, switches, consumption meters, touch screen, actuators and gateways:

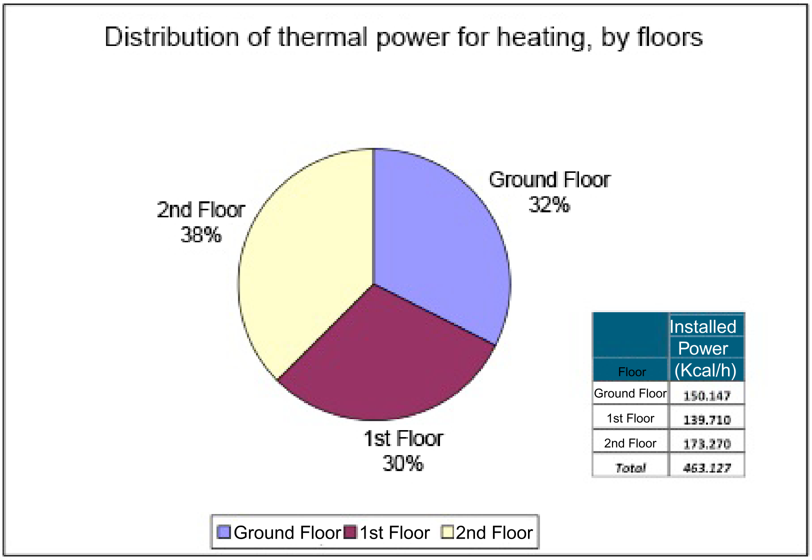


Programming, remote management and other reviews



4.1.4. Heating Control

There is only one heating circuit for the C and E floor whose consumption represents 36.4% of total diesel consumption.
The boiler room has three diesel boilers that start sequentially and were controlled by scheduling regulated with analogue clocks. The total installed thermal power is: 640 973 kcal / h, compared to a total thermal power installed for heating of 463 127 kcal / h; with the following distribution per floor:



It is observed that the thermal power generation (boilers) is 138% higher than the thermal power of the terminal elements (heaters). According to the information gathered in the project, this corresponds to the following percentages of increase:

- 20% oversizing due to boiler efficiency.
- 5% oversizing due to losses in pipes.
- 13% remaining, due to power available in the range of installed boilers.

Considering the age of the building, it was not feasible to tackle the segmentation and complete renovation of the system; so actions were focused on regulating the flow temperature of the water that feeds the radiators, taking into account the outside temperature, the inside temperature of two classrooms placed in opposite facades (NW-SE) that were taken as a sample, and the return water temperature; in order to adjust the system operation to the needs of indoor temperature at any time, according to the background environmental and climatic conditions.

The technical characteristics of the existing equipment are:

C1: ROCA BOILER TR-3-120

Location:	Boiler room in classroom building	
Make:	Roca	
Model:	TR-3 - 120	
Fuel:	C Diesel	
Construction Type:	Cast-iron	
Year of Production:	1.984	
Rated Power [kW] / [kcal/h]:	488 / 420	
Burner:	Make/Brand	Presomatic 60 GO
	Year of Production	
	Thermal Power [kWh]	355-710 KW
	Consumption [kg/h]	30-60
	Modulation	2 stages
	Electrical Power [W]	650 W (4,5 - 3,3 A)
Service provided:	Heating	
Control and Regulation:	Two-stage thermostat in water return circuit	
	Fixed flow temperature at 90 ° C	
	Individually programmed clock	
	No operating hours meter	
	No diesel/kWh electricity consumption meters available	
Measures:	Flow Temperature [ºC]	80
	Return Temperature: [ºC]	70
	Fumes Temperature: [ºC]	291
	Environment Temperature: [ºC]	23
	Combustion Efficiency[%]	88,1
	% O_2 [%]	3,1
	% CO_2 [%]	13,21
	Air Excess	1,17
	ppm CO	8
Energy Consumption	***Working Hours a Year [hours]***	***475***
	Thermal Energy Consumption [kWht/year]	***266.212***
	Electric Energy Consumption [kWhe/year]	***308***
	Thermal Energy Cost [€/year]	***12.592***

C2: ROCA BOILER TD-200

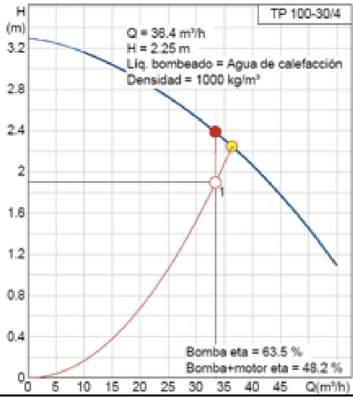
Name:	C2	
Location:	Boiler room in classroom building	
Make:	Roca	
Model:	TD-200	
Fuel:	C Diesel	
Construction Type:	Cast-iron	
Year of Production:	1.984	
Rated Power [kW] / [kcal/h]:	232,6 / 199,52	
Burner:	Make/Brand	Lamborghini ECO 30/2
	Year of Production	
	Thermal Power [kWh]	166-358 kW
	Consumption [kg/h]	14-30
	Modulation	2-stages
	Electrical Power [W]	750 W
Service Provided:	Heating	
Control and Regulation:	Two-stage thermostat in water return circuit	
	Fixed flow temperature at 90 ° C	
	Individually programmed clock	
	No operating hours metre	
	No diesel/kWh electricity consumption meters available	
Measures:	Flow Temperature [ºC]	80
	Return Temperature: [ºC]	70
	Fumes Temperature: [ºC]	
	Environment Temperature: [ºC]	
	Combustion Efficiency[%]	
	% O_2 [%]	
	% CO_2 [%]	
	Air Excess	
	ppm CO	
Energy Consumption:	***Working Hours a Year [hours]***	***475***
	Thermal Energy Consumption [kWht/year]	***125.122***
	Electric Energy Consumption [kWhe/year]	***214***
	Thermal Energy Cost [€/year]	***5.918***

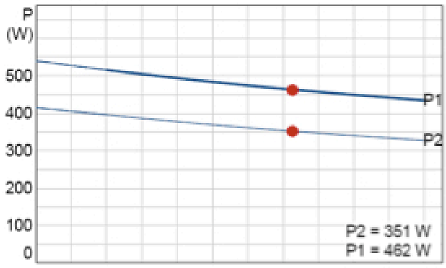
C3: ROCA BOILER AR-3

Location:	Boiler room in classroom building	
Make:	Roca	
Model:	AR-3	
Fuel:	C Diesel	
Construction Type:	Cast-iron	
Year of Production	1.984	
Rated Power [kW] / [kcal/h]:	34 / 29	
Burner:	Make/Brand	KADET tronic 3R
	Year of Production	
	Thermal Power [kWh]	
	Consumption [kg/h]	1,6-3 kg
	Modulation	Without Modulation
	Electrical Power [W]	90 W
Service Provided:	Heating	
Control and Regulation:	Two-stage thermostat in water return circuit	
	Fixed flow temperature at 90 ° C	
	Individually programmed clock	
	No operating hours metre	
	No diesel/kWh electricity consumption metres available	
Measures:	Flow Temperature [ºC]	80
	Return Temperature: [ºC]	70
	Fumes Temperature: [ºC]	
	Environment Temperature: [ºC]	
	Combustion Efficiency[%]	
	% O2 [%]	
	% CO2 [%]	
	Air Excess	
	ppm CO	
Energy Consumption	***Working Hours a Year [hours]***	***475***
	Thermal Energy Consumption [kWht/year]	***22.667***
	Electric Energy Consumption [kWhe/year]	***51***
	Thermal Energy Cost [€/year]	***1.072***

B1: GRUNDFOS UMT-100-3 PUMP (C1 PRIMARY)

Make:	Grundfoss	
Model:	UMT-100-30	
Tension [V]:	380 V	
Power [W]:	550	
Flow Rate for Calculation/Project [m3/h]:	33,4	
Head Calculation/Project [mca]:	1,9	
Performance Curves:		

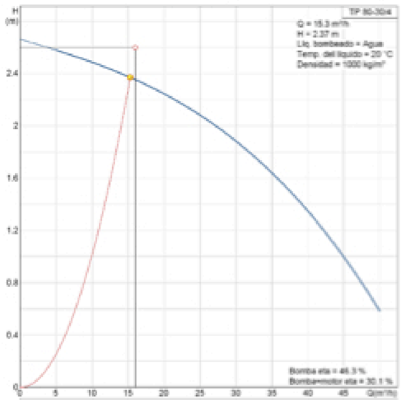


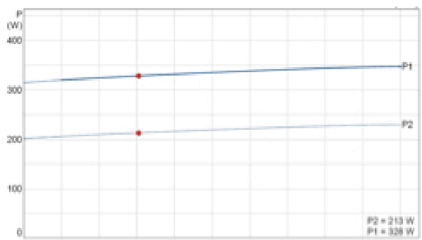


Flow Temperature [ºC]:	80	
Service:	Primary Pump C1 Boiler	
Control and Regulation:	Scheduling Same Performance as C1 Boiler	
	Pressure Gauge with Parallel Plug	
Measures:	Intensity [A]	
	Suction Pressure	
	Discharge Pressure	
Energy Consumption:	***Working Hours a Year [hours]***	***565***
	Electric Energy Consumption [kWhe/año]	***311***

B2: GRUNDFOS UMT-80-30 PUMP (C2 PRIMARY)

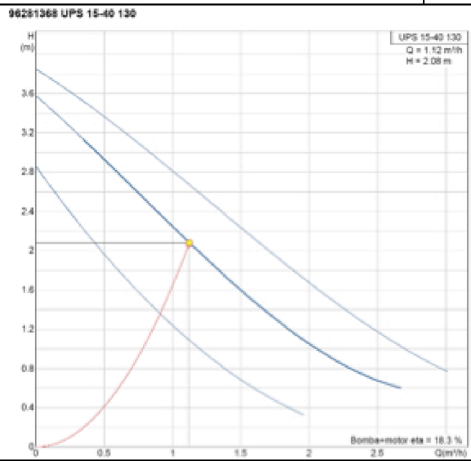
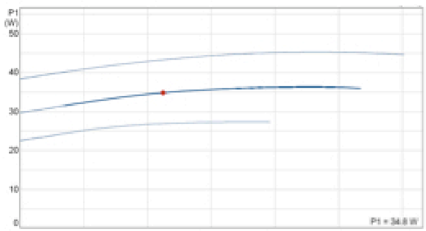
Make:	Grundfos	
Model:	UMT 80-30	
Tension [V]:	380 V	
Power [W]:	250	
Flow Rate for Calculation/Project [m3/h]:	16	
Head Calculation/Project [mca]:	2,6	
Performance Curves:		



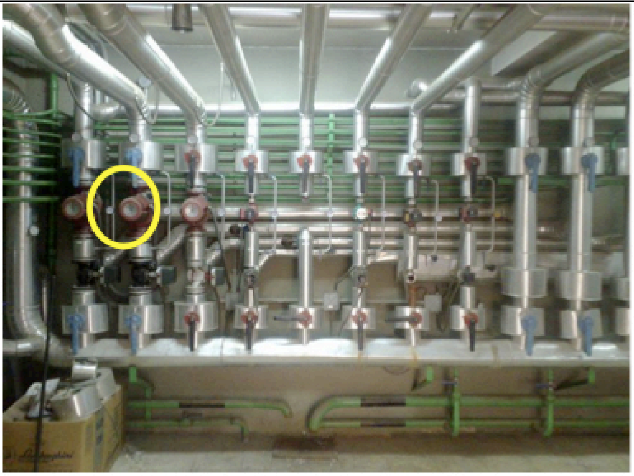


Flow Temperature [ºC]:	80	
Service:	Primary Pump C2 Boiler	
Control and Regulation:	Scheduling. Same Performance as "C" Boiler.	
	Pressure Gauge with Parallel Plug	
Measures:	Intensity [A]	
	Succion Pressure	
	Discharge Pressure	
Energy Consumption	***Working Hours a Year [hours]***	***565***
	Electric Energy Consumption [kWhe/año]	***141***

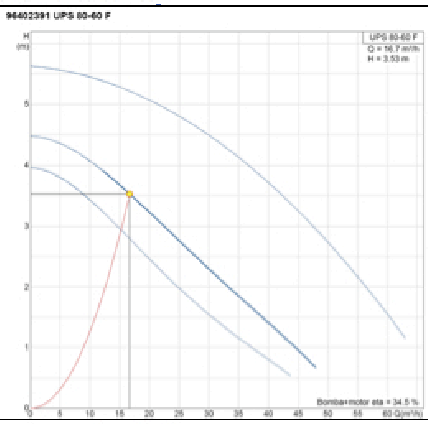
B3: GRUNDFOS UPS 15-35 PUMP (PRIMARY C3)

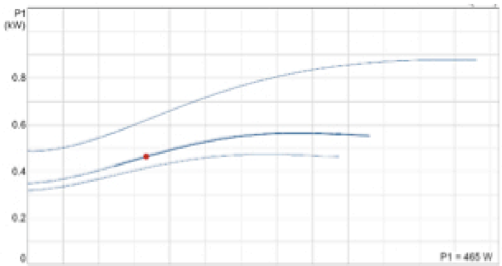
Brand:	Grundfos	
Model:	UPS 15-35	
Tension [V]:	230 V	
Power [W]:	65	
Flow rate for calculation/project [m3/h]:	2	
Head calculation/project [mca]:	1,1	
Performance curves:		
		
Flow temperature [ºC]:	80	
Service:	Primary Pump C3 Boiler	
Control and Regulation:	Scheduling. Same Performance as C3 Boiler	
	Pressure Gauge with Parallel Plug	
Energy Consumption:	***Working Hours a Year [hours]***	***565***
	Electric Energy Consumption [kWhe/año]	***37***

B5: GRUNDFOS UMS 80/60 PUMP (HEATING IN FLOORS 1 & 2 SOUTH)



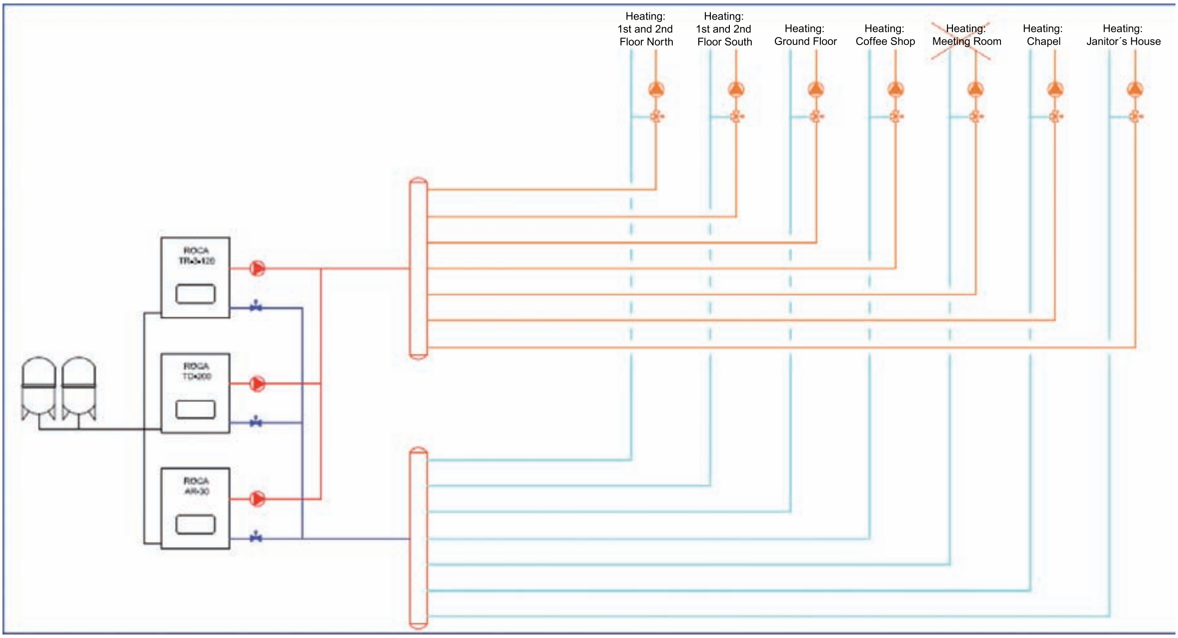
Make:	Grundfos	
Model:	UMS 80-60	
Tension [V]:	230 V	
Power [W]:	950	
Flow rate for calculation/project [m3/h]:	16,4	
Pump head calculation / project [mca]:	4,5	
Performance Curves:		





Flow temperature [ºC]:	80	
Service	Heating in 1st and 2nd Floors, South area	
Control and Regulation:	Scheduling.	
	Pressure Gauge with Parallel Plug	
Energy Consumption:	***Working Hours a Year [hours]***	***565***
	Electric Energy Consumption [kWhe/year]	***537***

Scheme of the Hydraulic Circuit of the Boiler Room



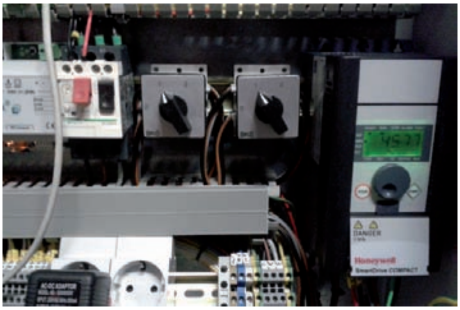
4.1.4.1. Implemented Measures and Components Review

Closure of radiators in passageways: according to the current Regulation on Thermal Systems in Buildings (RITE), heating/cooling systems must only be installed in areas with permanent occupation.

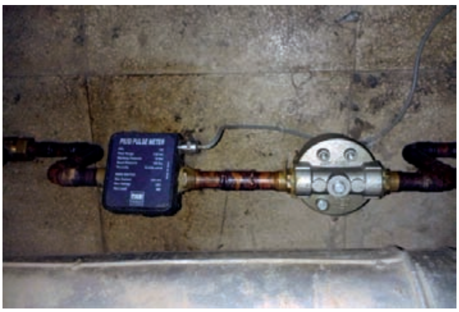
Since 18% of the thermal power installed in the building is intended to heat toilets and corridors, these radiators have been closed.

Regulation of flow by indoor temperature sensors and inverters: the heating circuit pumps in the 1st and 2nd floors of the South Building are turned on by scheduling, and drive heating water at a temperature of 90 ° to the radiators; without any additional type of regulation, as there are neither regulators nor heating cut-off elements inside the building.

After this action, the regulation of the circuit becomes dependent on the values provided by two KNX temperature sensors installed inside two "sample classrooms" located on opposite facades of the building; acting on an electronic inverter that controls the regulation of the flow that drives the pumps.



As the indoor temperature is monitored, the system detects when the set-point temperature (20°C) is reached, acting on the inverter to regulate the heat output that is to be sent from the boilers to the premises to be heated.
Flow temperature regulation by outdoor temperature sensor: depending on the outside temperature, the water in the flow circuit is mixed with that of the return circuit in order to regulate their temperature to a range between the current 90ºC and the set-point 75ºC.

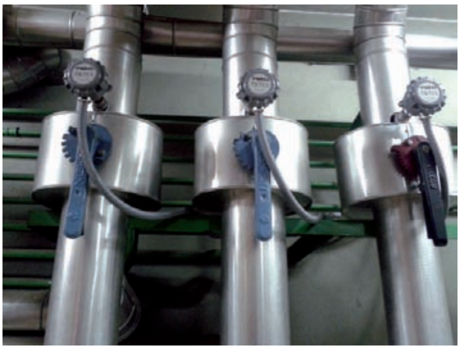


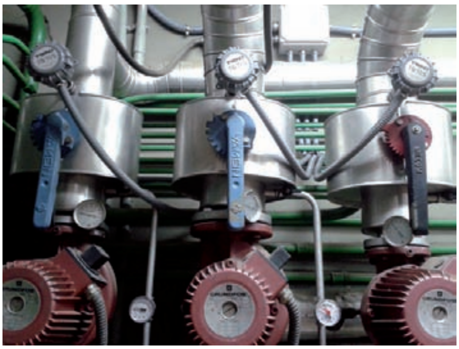
By propelling the water at a variable temperature, as it blends with the environment, losses due to pipe distribution are reduced, the operation of boilers is more continuous, as the number of starts and stops is reduced, and the combustion efficiency increases. Diesel consumption meter: to date, the fuel consumption was controlled by checking the amount of fuel displayed in the invoices by the supplier. This made it impossible to carry out a permanent monitoring of consumption and, thus, solve in real-time anomalies that may occur. There was therefore, a delay in the detection of excessive consumption.

The installation of a consumption meter integrated in the implemented automation system, enables an accurate and real-time monitoring of consumptions; which also allows an early detection of possible leaks and a correction of their cause.

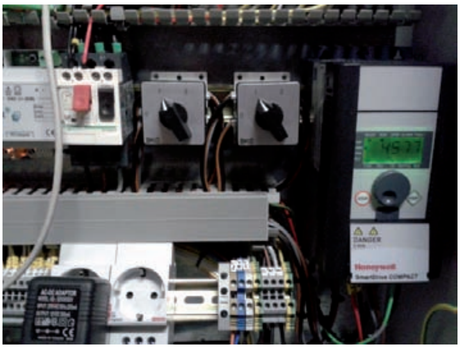
4.1.4.2. Graphic Review of Actions: “Heating” in FSV

Boiler room, timers, indoor and outdoor temperature sensors; and temperature sensors in flow and return water circuits:





View of the automation panel, time programmer, VFD, KNX gateway, etc ...



4.1.5. Results of Action 3a: San Valero Foundation

In the experimental period, the reduction in energy consumption and CO2 emissions achieved was as it is shown in the following table:

Consumptions and savings achieved [Centro ES y FP Fundación San Valero]							
CONSUMPTION	Energy Consumption (MWh/period...)		Energy Savings [MWh/Period...]				
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving by Lighting change	% of Saving by Regulation system	% of Saving	Period (months)
Electricity	95,80	45,75	50,05	37,51%	14,73%	52,25%	
Phase (I) Floor "C"	52,54	20,74	31,80	45,35%	15,18%	60,53%	34
Phase (II) Floor "E"	40,17	24,17	16,01	14,64%	25,21%	39,85%	22
LED Lamps	3,09	0,84	2,25	64,29%	8,43%	72,71%	2
Natural gas							
(**)Furnace Fuel Oil	1.019,05	811,36	207,69	Litres...:	19.504,00	20,38%	36
TOTAL	1.114,85	857,11	257,74			23,12%	
CO2 EMISSIONS	Emissions CO2		Emissions reduction [toe] [CO2 ton] / period				
Energy type	Final Energy CO2 [ton/Baseline]	Final Energy CO2 [ton/period]	Final Energy toe	Final Energy [CO2 ton/period]	Primary Energy toe	Primary Energy [CO2 ton/period]	
Electricity	33,53	16,01	4,30	17,52	9,81	39,94	
Natural gas							
Furnace Fuel Oil	268,17	213,52	17,86	54,65	20,00	61,21	
TOTAL	301,70	229,53	22,17	72,17	29,82	101,15	
ENERGY COST	Energy costs		TOTAL Differential cost				
Energy type	"Baseline" (€)	"Period" (€)	Economic savings (€)				
Electricity	16.010,88	7.654,88	8.356,01				
Natural gas							
Furnace Fuel Oil	84.580,92	67.343,03	17.237,89				
TOTAL	100.591,80	74.997,91	25.593,90				

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)
(*) Baseline: Projected to the experimentation periods.
(**) School year 2011-2012: Best Practices. Schools years 2012 to 2014: BPs + Domotic control

During the experimental period at the Secondary Education and Vocational Training Centres of San Valero Foundation the emission of 101.15 t/CO2 to the atmosphere and the consumption of 29.82 tonnes of oil equivalents (toe), in terms of primary energy, were avoided.

Electricity consumption for lighting was reduced by 52.25%; 37.51% of this amount was directly fulfilled by replacing conventional fluorescence lamps by high frequency fluorescence lamps and LED; the remaining 14.73% reduction in electricity consumption was achieved due to the regulation controlled by the implanted KNX system.

In the “C” floor, the installed power for lighting by change of luminaires (AF Fluorescence), was reduced by 45.35% while maintaining the same lighting levels: 12.8 kW to 7 kW; and by an additional 15.18% due to KNX regulation; consumption being reduced by 60.53% (31.80 MWh).

In the “E” floor, the installed power for lighting by change of luminaries (AF Fluorescence), was only reduced by 14.64%, as legislation enforces the rise of the lighting levels according the specific work carried out in classrooms, going from 9.8 Kw to 11.5; however, by KNX regulation, power consumption has been reduced by 39.85%; in premises which require, by law, very high lighting levels. The regulation by the KNX system, therefore, has reduced power consumption by 25.21% additional saving.

If conventional lamps are replaced by LED technology since the beginning, the reduction in electricity consumption is highly significant (64.29%). If, in addition, as it is the case, the facility has KNX regulation; the total potential reduction in consumption by application of these technologies exceeds 72%.

In view of the results, it is concluded than in rooms with high lighting requirements, the potential reduction in consumption due to the KNX system performance is greater than in rooms with lower lighting needs; and the potential savings by KNX regulation is inversely proportional to the reduction in electricity consumption achieved by changing luminaires.

Since the KNX regulation systems were implemented, the savings by lighting regulation have progressively increased, mainly due to awareness campaigns conducted among students and teachers and the effect of informational signs placed on the switches, which have changed the behaviour of users who now let the system act without neither switching the system on manually nor regulating lighting at full power.

As for the regulation of the heating system is concerned, the age of the building and its systems has limited the level of optimization of this system, mainly due to the high investment that would have been necessary to make in order to improve the currently obtained ratio.

Without renovating the system, but acting on the temperature and speed of flow and return water circuits from the boiler room, now regulated according to indoor and outdoor temperatures thanks to the KNX system implemented, diesel consumption has been reduced by 20.38% (19,504 litres in 36 months of experimentation). This is a very significant reduction for a building and systems, which because of their age, are far from having optimum potential for energy efficiency.

In an annual project, the results are as follows:

Consumptions and savings achieved
[Secondary Education Centre and VET San Valero Foundation]
(Annual calculation based on experimentation results)

CONSUMPTION	Energy Consumption (MWh/year)		Energy Savings [MWh/year]				
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving by Lighting change	% of Saving by Regulation system	% of Saving	Experimentation period (months)
Electricity	59,00	25,56	33,44	37,51%	19,16%	56,68%	
Phase (I) Floor "C"	18,54	7,32	11,22	45,35%	15,18%	60,53%	34
Phase (II) Floor "E"	21,91	13,18	8,73	14,64%	25,21%	39,85%	22
LED Lamps	18,54	5,06	13,48	64,29%	8,43%	72,71%	2
Natural gas							
Furnace Fuel Oil	339,68	270,45	69,23	Litres...:	6.501,33	20,38%	36
TOTAL	398,68	296,01	102,66			25,75%	

CO2 EMISSIONS	Emissions CO2		Emissions reduction [toe] [CO2 ton] / year			
Energy type	Final Energy CO2	Final Energy CO2 [ton/year]	Final Energy toe	Final Energy [CO2 ton/year]	Primary Energy toe	Primary Energy [CO2 ton/year]
Electricity	20,65	8,95	2,88	11,70	6,56	26,68
Natural gas						
Furnace Fuel Oil	89,39	71,17	5,95	18,22	6,67	20,40
TOTAL	110,04	80,12	8,83	29,92	13,22	47,09

ENERGY COST	Energy costs		TOTAL Differential cost
Energy type	"Baseline" (€ /year)	"Annual" (€ /year)	Economic savings (€/year)
Electricity	9.542,47	4.134,26	5.408,21
Natural gas			
Furnace Fuel Oil	28.108,72	22.380,06	5.728,66
TOTAL	37.651,19	26.514,33	11.136,87

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)
(*) Baseline: Projected to annual calculation.

In summary, on a yearly basis and according to the data recorded in the experimental stage; the San Valero Foundation facilities have proved the following potential reduction in energy consumption and emissions:

Savings in Energy Consumption and CO2 emissions "Annual Calculation"	
Reduction in Emissions (TOTAL):	47,09 t CO2/year
Reduction in Emissions (Electricity):	26,68 t CO2/year
Reduction in Emissions (Heating):	20,40 t CO2 /year
Reduction in Consumption (Electricity):	56.68% (33,44 MWh/year)
Reduction in Consumption (Diesel):	20.38% (6,501 l/year)
Cost Savings due to Reduction in Consumption	**11,136 €/year**

4.2. Action 3b: San Valero Foundation (University of San Jorge Buildings)

Location: **Autovía A-23 Zaragoza-Huesca km. 299**
50830 - Zaragoza (Spain)
GPS: 41.756797,-0.832250

4.2.1. Context for Action

Demonstration Of Models for Optimisation of Technologies for Intelligent Construction

Demostración de Modelos para la Optimización de Tecnologías para la Construcción Inteligente
[LIFE+ 09 ENV/ES/000493]

Context details of the building

BUILDING	Rectorado y Facultad de Comunicación de la USJ (FSV)			Date	18/08/14 0:00	
Date of construction	2.007	Address	Campus USJ, Autovía A-23Zaragoza-Huesca km. 299	Contact people	Dª Nieves Zubalez Marco (Dpto. Internacional)	
Built square meters	9.770	Postal code	50830	[Phone] [Fax]	00 34 976 466599	00 34 976 466590
Square meters audited	9.770	Locality/City	Villanueva de Gállego	Email	nzubalez@sanvalero.es	
Capacity (Users number	1.145	Province (Country)	Zaragoza (España)			

Types of energy used	Electricity
Uses of the building	Teaching: University education
Other relevant information	On the emergency lighting of buildings of the Rectorate and School of Communications; and integration into control system, of the existing lighting control of Faculty of Health.

Estimated average daily occupancy level	Monthly/Year	january	february	march	april	may	june	july	august	september	october	november	december
		60%	90%	90%	90%	90%	70%	10%	10%	90%	90%	90%	70%
	811	**687**	**1.031**	**1.031**	**1.031**	**1.031**	**802**	**115**	**115**	**1.031**	**1.031**	**1.031**	**802**

Time of use		january	february	march	april	may	june	july	august	september	october	november	december
Hours/day...:	**13**	13	13	13	13	13	13	13	13	13	13	13	13
Days/year-month...:	**186**	16	19	22	16	21	18	3	0	18	19	21	13
TOTAL (hours/year-month)...:	**2.418**	**208**	**247**	**286**	**208**	**273**	**234**	**39**	**0**	**234**	**247**	**273**	**169**

Monthly average temperature (30 years)		
Maximum	24,5	ºC
Minimum	6,4	ºC
Annual average	**15,45**	ºC

Average temperature in summer (30 years)		
Maximum	28	ºC
Minimum	15,2	ºC
Annual average	**21,6**	ºC
Yearly PV power	**1.540**	kWh/1kWp

Average temperature in winter (30 years: Oct-Apr)		
Maximum	14,9	ºC
Minimum	5,4	ºC
Annual average	**10,15**	ºC

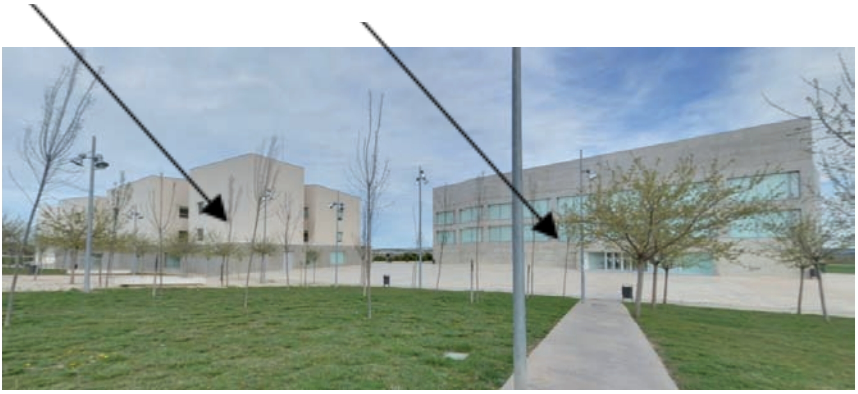
Altitude	**242**	Meters	http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php	Annual average rainfall [30 years]	**318**	liters/m2

With the actions developed at the University of San Jorge (USJ), the DOMOTIC project has demonstrated the potential that improving the domotics, inmotics and control systems for energy consumption have in their application to new buildings that might already have active and passive measures for efficiency.

By KNX, the permanent emergency lighting in the Chancellor´s and the Faculty of Communication has been regulated and the existing lighting control in the classrooms of the Faculty of Health Sciences has been integrated with the KNX system.

After the action and through a system of controlling consumption to improve energy efficiency and early fault detection; energy consumption of all campus buildings has been monitored; allowing to optimize consumption in HVAC, detect “phantom loads” and “faults” that remained concealed.

Edificios de Rectorado y Facultad de Comunicación



Buildings:

- The Chancellor´s and the Faculty of Communication Buildings whose construction ended in August 2007.
- The Faculty of Health Sciences, formed by newly built three buildings.

Being newly built buildings, they already have active and passive measures of efficiency; that have now been improved for demonstration.

The Campus of the University of San Jorge, in Villanueva de Gállego (Zaragoza), nowadays consists three In the first case the two buildings were equipped with a centralized climate control system, through which you can observe the temperatures of all the spaces within the building, change set-points, act on all equipment systems and program their operation.

In the case of lighting there is not a system of integrated automation control but, since it was built, it did have local regulation of light intensity in all spaces in the building; except for emergency lighting, which remained permanently on at full power.

In the second case, in the building of the Faculty of Health Sciences, in addition to what has already been mentioned in the previous section, there was a lighting control automation system for the entire building; which has now been integrated into the implanted KNX system.

The existing passive measures, such as building orientation, large windows and the white colour that prevails in the interior; now favours the implementation of systems that optimize the use of natural light and thermal inertia of buildings.

At baseline, the power consumption of the University, as the only energy source used, stands at around 1,400 MWh / year.

4.2.2. Technical Description: "KNX Standard System"

The general and technical characteristics described in 4.1.2 for the San Valero Foundation facilities in the Secondary Education and Vocational Training Centres are also valid for this action.

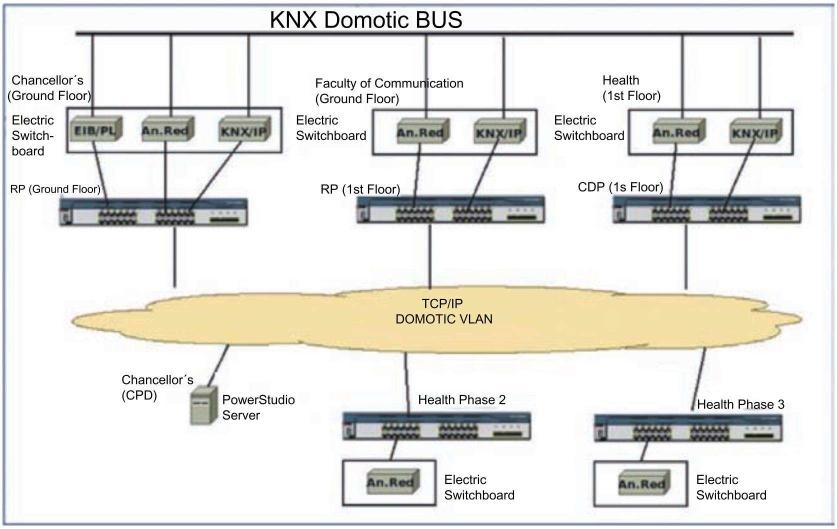
Since some of the buildings of the USJ already have isolated automation systems, it is especially relevant implementing an automation system with a robust and flexible design for communications to allow its integration into the existing network of the university, the interconnection with the other systems already implemented and with the ones that could eventually be implanted in other institutions of San Valero Foundation.

The defined design is basically approached as follows:

Needs:

- Integration of the KNX automation network in the Faculty of Communication, the Faculty of Health Sciences and the Chancellor´s buildings with the TCP / IP network of the University; using KNX / IP routers installed on the general electric switchboards which allow the KNX automation bus to be connected to the Ethernet network of the University.
- Implementation of a management system installed in the electric switchboard itself.
- Implementation, in each of the electrical panels, of RS485/IP network analysers that capture and submit information about consumption to the server.

Network topology:



Description:

Satisfying the described requirements, the implanted design to be implemented in new buildings in the future will fulfil the following specific characteristics:

The Automation Network of each building, integrated with the IP network, has the following components and wiring structure:

- In the electric switchboard of the Chancellor´s building, ground floor

  – KNX/IP router.

  – EIBLAN Port.

  – Network analyser.

From the electric switchboard Cat. 6 UTP cables are unfold to the electric distributor on the ground floor.

- In the electric switchboard of the Faculty of Health Sciences building (phase 1-1st floor)

  – KNX/IP router.

  – Network analyser.

From each electric switchboard two Cat. 6 UTP cables are unfold connected to the data centre of Phase1.

The electric switchboards of the Faculty of Health Sciences Building (Phases 2 and 3 - 1st floor) will have:

– Network analyser.

At least one Cat. 6 UTP cable will be unfolded from each electric switchboard, connected to each of the telecommunications room on the ground floor.

- In the electric switchboard on the ground floor of the Faculty of Communication building:

– KNX/IP router.

– Network analyser

As there was no simple way, without building work, to bring cable to the electric distributor on the ground floor and, besides, the distributor did not have power points for "electronic network"; a vertical canalization was used, attached to the electric switchboard, to unfold the cable to the electric distributor on the first floor; the cable being connected to two "foresight network" points available in Classroom 14.Each of the system components ("PowerStudio" server, network analysers, EIBPort/Lan and KNX/IP) are connected to the corresponding electronic network, creating a logical sub-network only accessible from USJ networks and through VPN.

A server to capture data from the analyser is located in the data centre of the Chancellor´s building. The server is integrated into the 'intelligent logical subnet. "

The automation systems and system of network analysers are integrated on the same subnet, in anticipation for future integrations.

The "smart home subnet" has become accessible to other infrastructure networks (cameras, alarms, climate), in anticipation for future integrations.

Access from Internet

At first, the "V-Lan Home Automation" is only accessible from the internal networks of USJ.

Access from external sites, is via a VPN system that enables access the "V-Lan Automation" devices.

4.2.3. Lighting Control

The solutions implemented in this area are as follows:

• Regulation of emergency lights according to the amount of natural light available and integration into KNX system.

Reach: Faculty of Communication and Chancellor´s buildings.

• Installation of presence detection systems in toilets.

Scope: Faculty of Communication and Chancellor´s buildings.

• Control of consumption by network analysers and installation of energy metres, as well as software for monitoring and data recording.

Scope: Faculty of Communication building and the University as a whole.

Situation in the Starting Point “Baseline”

• Emergency lighting comprises 1x49W with conventional ballasts with no possibility of regulation

(*) Characterization of lights for the treatment of data from “Emergency Lighting”

Power and Consumption at “baseline”					
Consumption and Rations at “baseline” year 2011	Type of lighting				
	Units	Type	Unitarian Power (W)	Total Power (W)	Consumption kWh/Year
Chancellor´s		Average (kW – kWh)...:		0,97	8.514,72
Ground Floor	20	Powerstrip 1X49W (54W)	54	1.080,00	9.460,80
1st Floor	19	Powerstrip 1X49W (54W)	54	1.026,00	8.987,76
2nd Floor	15	Powerstrip 1X49W (54W)	54	810,00	7.095,60
TOTAL	54		54	2.916,00	25.544,16
Comunicación		Average (kW – kWh)...:		1,49	13.560,48
Ground Floor	34	Powerstrip 1X49W (54W)	54	1.836,00	16.083,36
1st Floor	25	Powerstrip 1X49W (54W)	54	1.350,00	11.826,00
2nd Floor	27	Powerstrip 1X49W (54W)	54	1.458,00	12.772,08
3rd Floor	24	Powerstrip 1X49W (54W)	54	1.296,00	11.352,96
TOTAL	110		54	5.940,00	52.034,40

• The emergency lighting was permanently on at a maximum intensity to ensure the lighting level established by the regulations on evacuation of buildings; regardless the existing natural light level, with no possibility for regulation.Total power installed in luminaires: 8.8 / Kw.

• Operating time: 8760 hours / year (24 hours x 365 days / year).

• Annual consumption of luminaires: > 77,500 kWh / year.

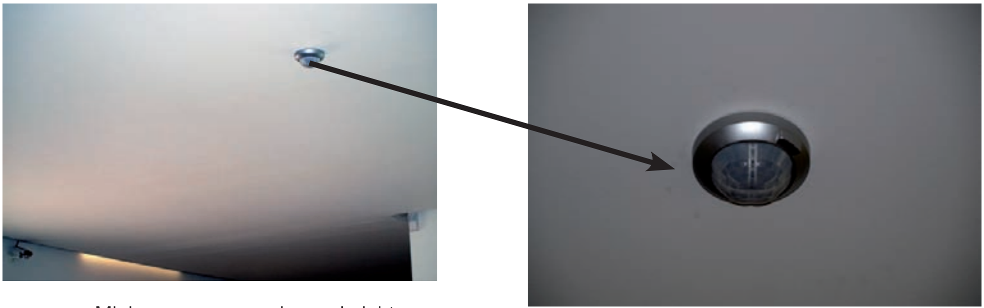
4.2.3.1. Implemented Measures and Components Review

Although the buildings are newly built and they have conduits for ICT, due to their building characteristics they lack “dropped ceilings” in some areas, making it difficult to remodel or expand facilities. This aspect is one that must be taken into account when designing new buildings.

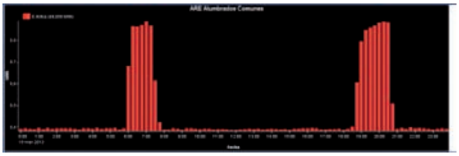
In short, the actions taken were as follows:

• Replacement of ballasts for emergency lighting in the Faculty of Communication and Chancellor´s buildings by high frequency regulating ballast.

• Installation of lighting detectors integrated in the KNX system that enable the modification of the flow in lamps; there are three modes depending on the amount of natural light detected by the sensor:

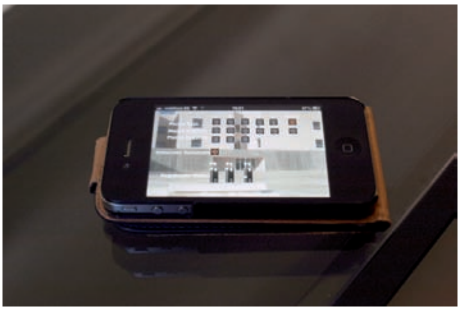


- Minimum: emergencies and night.
- Automatic: regulated according to the lighting level.
- Maximum: cleaning, special events, etc.

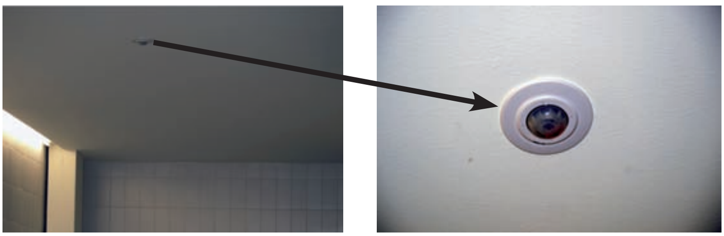


• Installation of an energy metre with software for monitoring in the Faculty of Communication, to record and quantifying the savings generated

• Implementation and programming of an "EIBPort-KNX" software that enables the lighting control within the system and the remote management of the intensity, activation and deactivation of lights; from a PC or mobile device (tablet, phone, etc.).



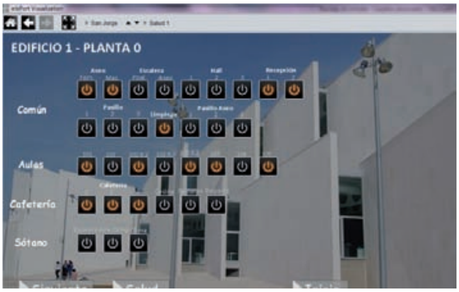
• Installation of presence detectors and timer light switches in the toilets, to avoid the light in these areas being on when they are not being used.



• Operating time: it varies depending on occupation, but corresponds to the actual use for consumption; instead of the 3220 hours / year previously recorded.

• The electric power supply lines in the toilets correspond to the common lighting areas on all floors of each of the two buildings. Therefore it has not been possible to take measurements from a main electric switchboard to record the initial and final consumption, although it is a standard solution with savings typified in 20% for this kind of buildings.

• Integration into the implemented "KNX System" of the existing automation system for lighting control at the Faculty of Health Studies; allowing remote control of the lights in the classrooms and in other rooms of the three buildings, preventing them from being on when these premises are not being used.



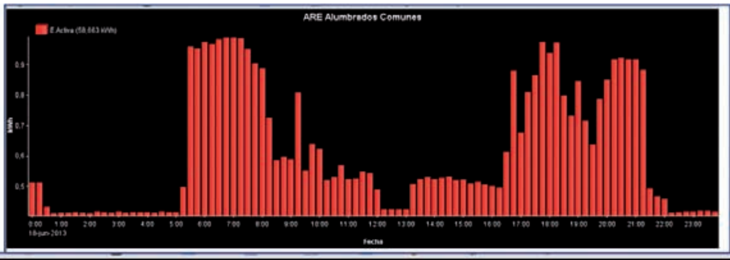
4.2.4. Consumption Control and Actions Derived from its Analysis

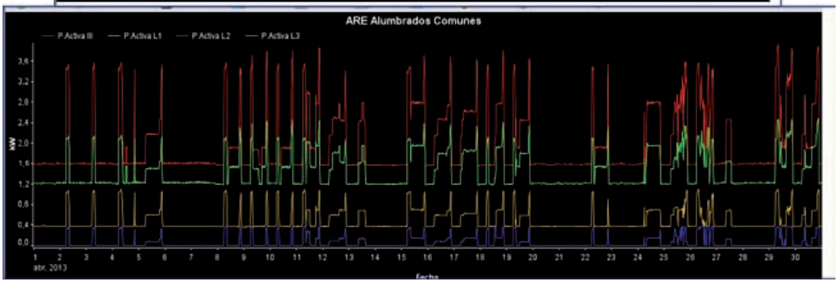
Any action seeking to reduce energy consumption is firstly to be based in the knowledge of the actual energy consumption and how it is distributed throughout the facilities. To do this:

• Electric metres have been installed in order to continuously monitor consumption in the major energy consuming systems within the premises: 6 new network analysers in the Faculty of Communication and the Chancellor´s buildings, which integrate with the existing ones in the Faculty of Health Sciences via "PowerStudio".

This now allows for regular monitoring of the consumption of almost all facilities, as well as, for the management of this consumption by days / weeks / months or years and for the statistic visualization of its progress.

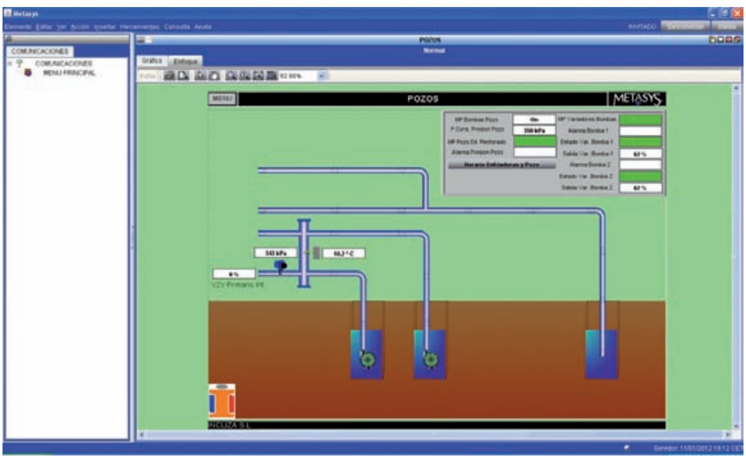
The implanted system to control consumption and its associated management software have so far allowed:





- To detect “phantom loads”: in new buildings, the initially established baseline for subsequent monitoring of consumption may be altered by the existence of this type of consumption that may go unnoticed for years; as that excessive consumption is considered as “normal”, being recorded in the allegedly “reliable” data collected from the beginning.
- To detect a “leak in the water conduction system” that supplies the water used by the HVAC system, which is extracted from the University well; and that made one of the pumps to be permanently working.

When analysing consumption data and put them in correlation with the graphic of the operating systems, it was observed that not even having water demand by the chillers (2V valves were closed), the pumps continued to operate; it was then detected that the cause was a leak in a section of the pipe inserted into the well.

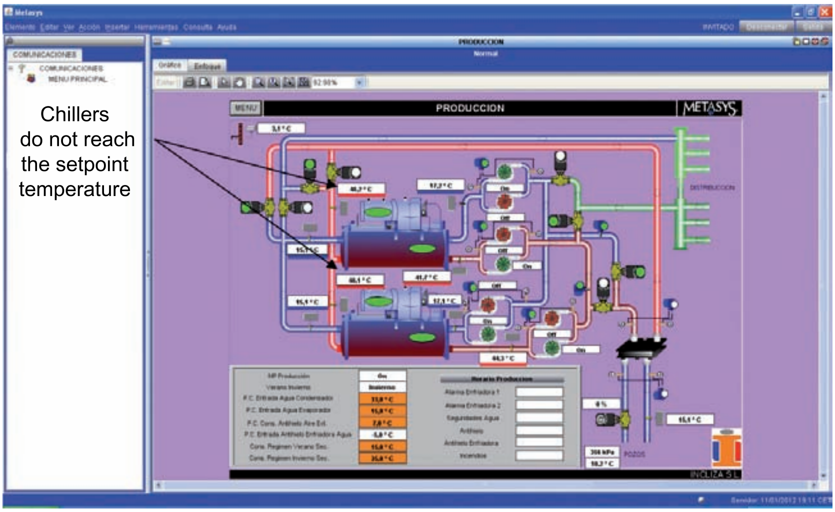


After correcting the fault, consumption was reduced by 50% (> 50,000 kWh / year).

- In the same line, a "failure of one pumps" of the Faculty of Health Sciences was detected. It made the pump to be in constant use.
- "To optimize the performance and efficiency of chillers" in the HVAC system, changing flow temperatures in the circuit for distribution to thermal units, according to the outdoor temperature.

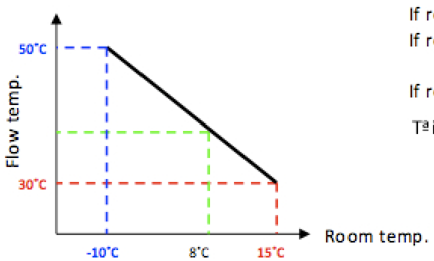
The flow temperature in this circuit was fixed (50˚C in winter, and 7˚C in summer).

Due to the circulating water flow, in many times of year chillers were unable to reach these temperatures and, as a result, the 3-way valves that mixed with the return flow were always 100% opened, so the mixture was not produced and the energy demand of chillers was high (initial consumption: 581,474 kWh / year).



The action involved programming the flow temperature of the chillers using a ramp that modifies the flow temperature depending on the outdoor temperature.

Heating Mode.

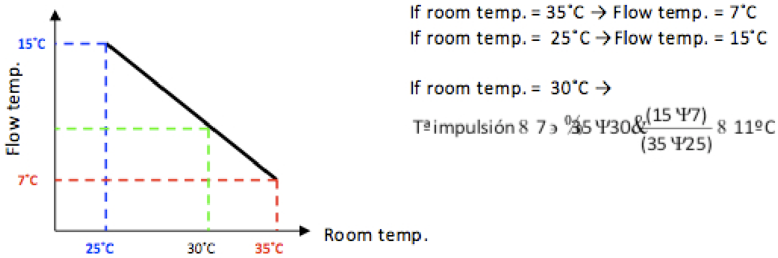


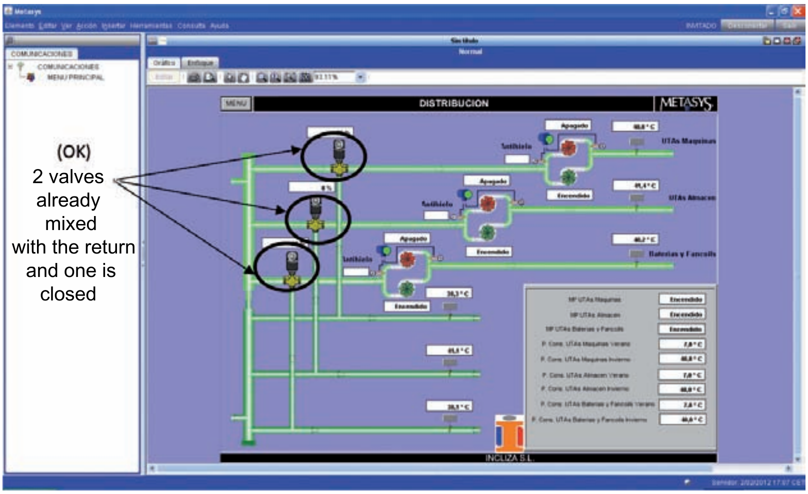
If room temp. = -10˚C → Flow temp. = 50˚C
If room temp. = 15˚C → Flow temp. = 30˚C

If room temp. = 8˚C →

$$T^{a}\,impulsión = 30 + (15 - 10)\frac{(50-30)}{(15-8)} = 44{,}3^{o}C$$

Heating Mode.

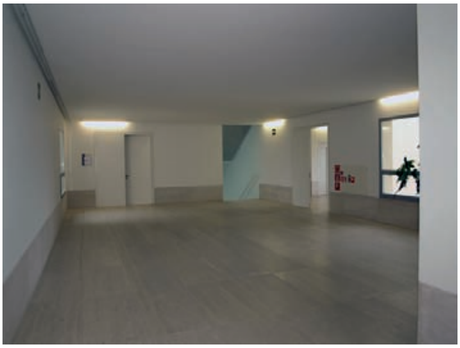




After the action, consumption has fallen by around 35%, which is >200,000 kWh / year saving.

4.2.5. Graphic Review of Actions in the University of San Jorge (USJ)

Emergency Lighting:



View of devices and systems for “regulating lighting”.

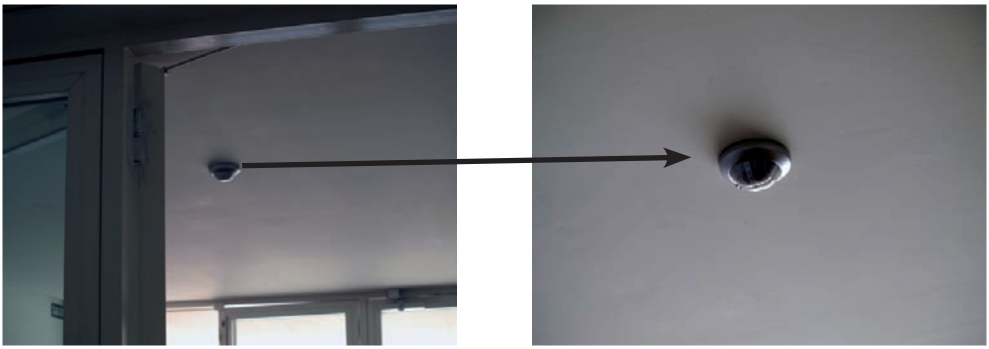
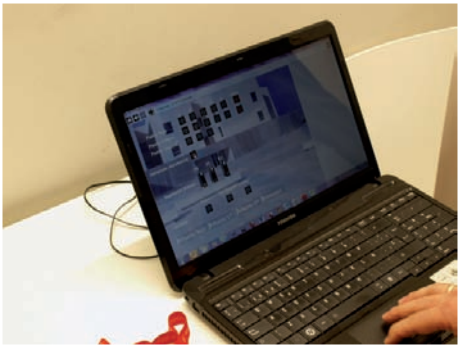
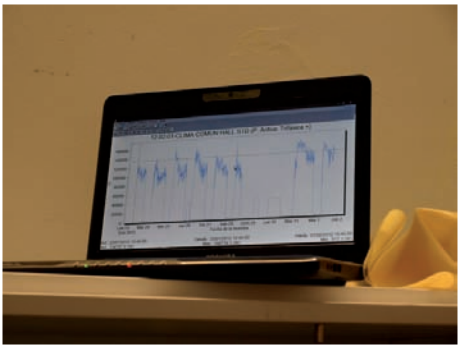



ABB
SA/S 12.10.1
ABB i-bus®
KNX

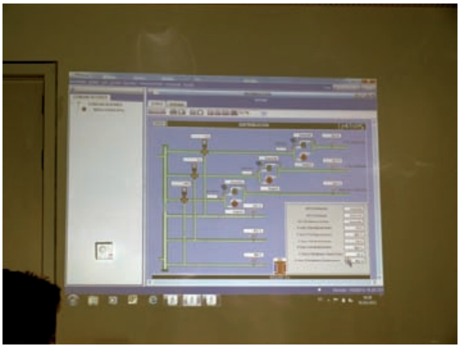
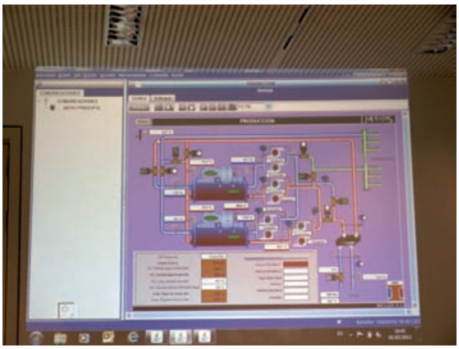
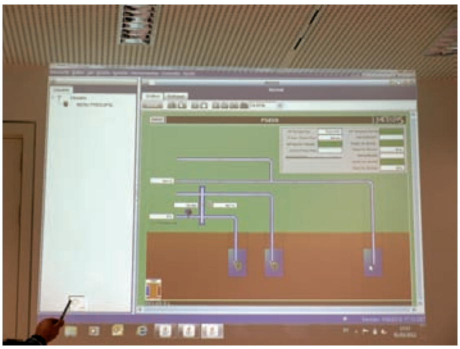


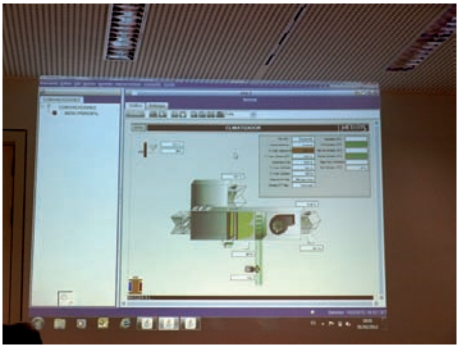


View of devices and work for “control consumption” and faults analysis:







Other graphic reviews:

4.2.6. Results of Action 3b: San Valero Foundation in “University of San Jorge”

In the experimental period, the reduction in energy consumption and CO2 emissions achieved was as it is shown in the following table:

Consumptions and savings achieved [San Valero Foundation in "San Jorge University"]						
CONSUMPTION	Energy Consumption (MWh/period...)		Energy Savings [MWh/Period...]			
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving		Experimentation period (months)
Electricity	890,26	495,65	394,61	44,33%		21
Emergency lighting adjustment...:	135,76	43,70	92,06	67,81%		
Control of consumption BMS...:	754,49	451,94	302,55	40,10%		
TOTAL	890,26	495,65	394,61	44,33%		
CO2 EMISSIONS	Emissions CO2		Emissions reduction [toe] [CO2 ton] / period			
Energy type	Final Energy CO2 [ton/Baseline]	Final Energy CO2 [ton/period]	Final Energy toe	Final Energy CO2 [ton/period]	Primary Energy toe	Primary Energy CO2 [ton/period]
Electricity	311,59	173,48	33,94	138,11	77,37	314,90
Emergency lighting adjustment...:	47,52	15,30	7,92	32,22	18,05	73,47
Control of consumption BMS...:	264,07	158,18	26,02	105,89	59,32	241,43
TOTAL	311,59	173,48	33,94	138,11	77,37	314,90
ENERGY COST	Energy costs		TOTAL Differential cost			
Energy type	"Baseline" (€)	"Period" (€)	Economic savings (€)			
Electricity	150.453,35	83.764,11	66.689,25			
Emergency lighting adjustment...:	22.943,86	7.385,43	15.558,43			
Control of consumption BMS...:	127.509,50	76.378,68	51.130,82			
TOTAL	150.453,35	83.764,11	66.689,25			
Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)						
(*) Línea base: Proyectada a los periodos de experimentación.						

During the experimental period at the University of San Jorge the emission of 314,90 t/CO2 to the atmosphere and the consumption of 77,37 tonnes of oil equivalents (toe), in terms of primary energy, were avoided.

Electricity consumption in emergency lighting was reduced by 67,81%, due to the automatic regulating device that controls the implanted KNX system, which takes into account the existing natural lighting in each of the rooms.

In testing phase, when analysing the system performance, it was detected that it could still be improved; so, in the final phase of the project, the minimum set-points established for lighting at night time were redefined, working now at 15% of their power. Therefore, it is very important to permanently monitor and evaluate the systems operation and performance.

Consumption of emergency lighting, for example, can sometimes be disregarded as a source of potential saving in consumption but, since they are systems which are constantly working, and although their momentary consumption may be low compared with the remaining sources of power consumption; they have a significant multiplying effect due to their working hours. In the case of the University of San Jorge, in 21 months of experimentation, this kind of consumption has been reduced in 92.06 MWh.

The tools that complement any home automation system of some complexity that might be implanted are the devices and programmes for monitoring and managing consumption. Both in combination, make up a “Building Management System” (BMS); they can provide significant savings even when the latter are not specifically aimed at controlling devices or systems.

The implanted system to control consumption, based on the “PowerStudio” software, has detected faults and incidents; enabling the possibility to make decisions that have generated savings of 40.10% on the affected devices and systems (302.55 MWh in the period of experimentation).

Reduction in consumption comes from the following actions.

Savings obtained by the implanted Building Management System (BMS) for “Control of Consumption”		
Detected Fault / Derived Action	**Reduction in Consumption MWh/period**	**Percentage of Improvement (%)**
HVAC: Leak detection in the well´s pump:	41,92 MWh/9 months	50.06%
Lighting: integration in KNX of classrooms in the Faculty of Health Sciences:	82 MWh/21 months	50.90%
HVAC: detection of continuous running of the recirculating water pump:	5,28 MWh/6 months	83.33%
Lighting: presence detection in toilets:	3,75 MWh/21 months	19.99%
HVAC: changing the setpoint temperature in chillers:	169,60 MWh/10 months	35%
TOTAL...:	**302,55 MWh/period**	**40.10%**

The above data show the importance of implementing systems and procedures for consumption control at the highest possible level of disaggregation. They also demonstrate the economic and environmental consequences that failure in an early detection of this type of incident would entail. It can be concluded that, without the support of these tools, incidents go unnoticed and it is not possible, due to lack of information, to make decisions to implement new systems or to adapt the existing ones in order to meet the same needs in the same conditions of comfort, but at a lower power and cost.

In an annual project, the results are as follows:

Consumptions and savings achieved [San Valero Foundation in "San Jorge University"] (Annual calculation based on experimentation results)						
CONSUMPTION	Energy Consumption (MWh/year...)		Energy Savings [MWh/year...]			
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving		Experimentation period (months)
Electricity	508,72	283,23	225,49	44,33%		21
Emergency lighting adjustment...:	77,58	24,97	52,61	67,81%		
Control of consumption BMS...:	431,14	258,25	172,89	40,10%		
TOTAL	508,72	283,23	225,49	44,33%		
CO2 EMISSIONS	Emissions CO2		Reducción de emisiones [tep] [t CO2] / año			
Energy type	Final Energy CO2 [ton/Baseline]	Final Energy CO2 [ton/year]	Final Energy toe	Final Energy [CO2 ton/year]	Primary Energy toe	Primary Energy [CO2 ton/year]
Electricity	178,05	99,13	19,39	78,92	44,21	179,94
Emergency lighting adjustment...:	27,15	8,74	4,52	18,41	10,32	41,98
Control of consumption BMS...:	150,90	90,39	14,87	60,51	33,90	137,96
TOTAL	178,05	99,13	19,39	78,92	44,21	179,94
ENERGY COST	Energy costs		TOTAL Differential cost			
Energy type	"Baseline" (€ /year)	"Annual" (€ /year)	Economic savings (€/year)			
Electricity	85.973,35	47.865,20	38.108,14			
Emergency lighting adjustment...:	13.110,78	4.220,25	8.890,53			
Control of consumption BMS...:	72.862,57	43.644,96	29.217,61			
TOTAL	85.973,35	47.865,20	38.108,14			
Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)						
(*) Linea base: Proyectada a cómputo anual.						

In summary, on a yearly basis and based and according to the data recorded in the experimental stage; the San Valero Foundation facilities at the University of San Jorge have proved the following potential reduction in energy consumption and emissions:

Saving in Energy Consumption and CO2 Emissions "Annual Calculation"	
Reduction in Emissions (TOTAL)...:	179,94 t CO2/year
Reduction in Emissions (Emergency Lighting)...:	41,98 t CO2/year
Reduction in Emissions (Actions by BMS)...:	137,96 t CO2 /year
Reduction in Consumption (Electricity)...:	44,33% (225,49 MWh/year)
Cost Savings due to Reduction in Consumption:	**38.108 €/year**

4.3. Action 3c: Natural Heritage Foundation (PRAE Building)

Location: **Cañada Real, 306**

47008 - Valladolid (Spain)

GPS: 41.60395. -4.7628

4.3.1. Context of Action

Demonstration Of Models for Optimisation of Technologies for Intelligent Construction

Demostración de Modelos para la Optimización de Tecnologías para la Construcción Inteligente
[LIFE+ 09 ENV/ES/000493]

Context details of the building

BUILDING	Centro de "Propuestas Ambientales Educativas" (PRAE-FPN)		Date	16/09/14 15:27
Date of construction	2008	Address: Cañada Real 306	Contact people	Jesús A. Díez Vázquez
Built square meters	3541,66	Postal code: 47008		Jorge Guerra Matilla
Square meters audited	3541,66	Locality/City: Valladolid	[Phone] [Fax]	983 345 850
Capacity (Users number	4500	Province (Country): Valladolid (España)	Email	jesus.diez@patrimonionatural.org
				jorge.guerra@patrimonionatural.org

Types of energy used	Electricity, biomass, photovoltaic solar energy and termal solar.
Uses of the building	Offices, environmental education (showrooms), rooms for events (meetings, conferences).
Other relevant information	Heating from biomass

Estimated average occupancy level	Annual average (people/month)	january	february	march	april	may	june	july	august	september	october	november	december
		21%	31%	48%	42%	45%	49%	40%	28%	48%	41%	38%	24%
	1.706	**945**	**1.395**	**2.160**	**1.890**	**2.025**	**2.205**	**1.800**	**1.260**	**2.160**	**1.845**	**1.710**	**1.080**

Time of use		january	february	march	april	may	june	july	august	september	october	november	december
Hours/day...:	**12**	12	12	12	12	12	12	12	12	12	12	12	12
Days/year-month...:	**361**	29	28	31	30	31	30	31	31	30	31	30	29
TOTAL (hours/year-month)...:	**4.332**	**348**	**336**	**372**	**360**	**372**	**360**	**372**	**372**	**360**	**372**	**360**	**348**

Annual average temperature (30 years)			Average temperature in summer (30 years)			Average temperature in winter (30 years: Oct-Apr)		
Maximum	21,7	ºC	Maximum	26,46	ºC	Maximum	11,14	ºC
Minimum	4		Minimum	13,03		Minimum	2,61	
Annual average	**12,85**		Annual average	**19,75**		Annual average	**6,88**	

Altitude	**689**	Meters	Yearly PV power [Average-Optimal]	**1.490**	kWh/1kWp	Annual average rainfall [30 years]	**435**	liters/m2

http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

Premises of PRAE: Proposals for Environmental Education; managed by the Natural Heritage Foundation of Castilla y León.

Environmental Resources Centre (CRA)

PRAE stands for “Propuestas Ambientales y Educativas” (Proposals for Environmental Education). It is a space dedicated to Environmental Education that consists of two elements: the Environmental Resources Centre (CRA for its acronym in Spanish) and the Environmental Park.

These premises are conceived for social, technical and educational use where people can enjoy, experience and sense environment, thus becoming environmentally aware. The centre is dedicated to transmitting the knowledge and attitudes necessary to achieve future sustainability.

The CRA (Environmental Resources Centre) building has a total floor area of 3,500 square meters and houses premises for environmental education and interpretation, administration, a multifunctional space for exhibitions and workshops, assembly hall and areas for research and documentation (CIDA). It is a reference centre for the dissemination of new trends in environmental management, sustainability, environmental education and citizen participation.

The building is eco-efficient and bioclimatic, as its design and construction are based on the principles of sustainability, applied to all phases of the project, from conception to construction and start-up. The energy saving and reduction in water consumption were mandatory principles from the beginning of the project.

The building is an emerging and transparent prism designed with a semi-underground floor that lessens its impact on the natural environment. The fact of being built semi-underground and the use of concrete walls, thermal clay and cellulose fibre from recycled paper for insulation, allow considerable initial energy savings, complemented with the overall HVAC system with heating-cooling floor that takes advantage of the solar thermal energy, providing significant savings in heating in winter and free cooling in summer. The building also has a heat pump, an absorption chiller and a biomass boiler.

The lighting comes from low consumption lamps and features a lighting management system that regulates the light output according to the needs.

The parking area is half hidden among native vegetation and pergolas with photovoltaic solar panels that provide electrical power to the building.

The surroundings of the building have a drainage system that enables the capture and collection of rainwater and its filtration through manifolds and pipes for it to be recycled for all kinds of uses other than human consumption.

The DOMOTIC project has successfully demonstrated that it is possible to optimize even the already excellent efficiency ratios that are present in buildings designed and built under strict sustainability guidelines.

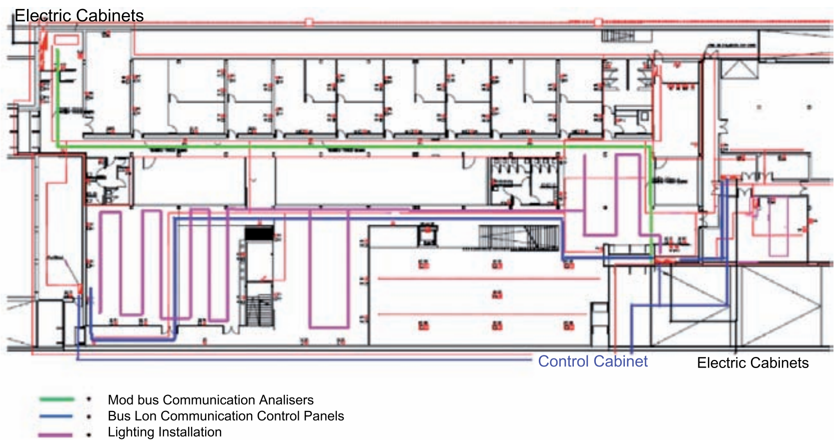
Reference Values in Baseline:

Environmental Park Area:	40.000 m2	Total PRAE Area:	10.743,15 m2
Type of Area for Action:	Indoors	Floor Area:	3.541,66 m2
Office Space:	1.180,55 m2	Exhibition Area:	2.361,11 m2
Hours of Facilities Use:	4.332 hours/year	Annual Power Consumption:	456.803 kWh / year
Generated Energy (Biomass):	857.543 kWh/year		
Solar Thermal Production:	66 collectors of 1,7 kW (2 tanks of 1.500 l)		
Photovoltaic Production:	540 FV panels of 130 Wp (50 kWh)		

4.3.2. Technical Description: Building Management System (BMS)

The project involved the implementation of a "Building Management System" (BMS) to monitor and centrally manage virtually all energy consumption; several regulating and measuring devices complement it.

The following plan shows the main areas of action within the building and the lines of communication and control of the implemented system:



The kind of software and hardware which forms a BMS, allows to manage almost all the services and facilities of a building or a set of buildings: electrical, lighting, HVAC, power generation, irrigation, etc.

4.3.2.1. Implemented Measures and Components Review

The BMS and the implanted devices allow to control the following four subsystems that are part of the main building of the PRAE premises:

- Lighting network.
- Computer network.
- HVAC network.
- Energy production network. In this subsystem the contributions of solar (thermal and photovoltaic) and biomass energy production are also specified.

Among other measures applied in each of the identified subsystems, they following ones can be highlighted:

- Monitoring: Installation of three-phase and single-phase network analysers.
- Lighting: installation of motion detectors and daylight sensors to control the switching on or off of the lights.
- HVAC: installation of air quality sensors to optimize the operation of the AHU (Air Handling Unit).
- Production: Installation of instrumentation for monitoring the energy values provided by alternative energy available in the building and of signs for their control and regulation.
- Public information display with relevant project figures and information.
- Integrating the DEXCell and Sedical systems into a single one through gateway.

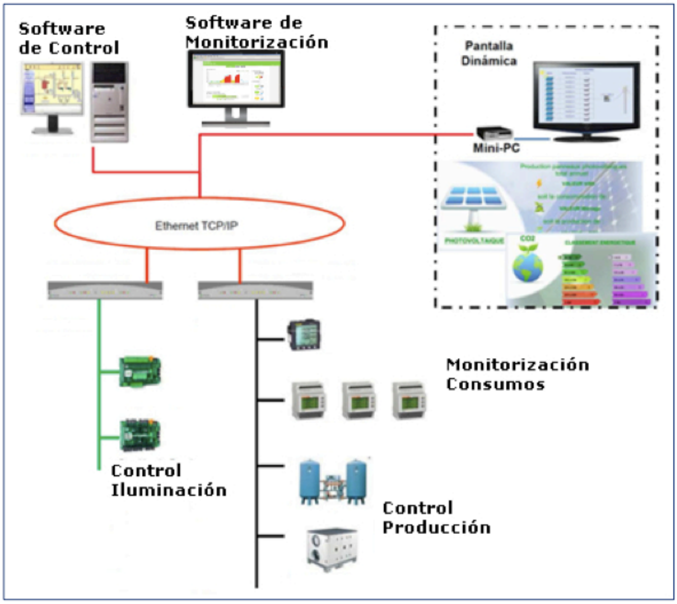
On the one hand, the DEXCell application allows treating the information of the network analysers. On the other hand, the Sedical system integrates everything related to the HVAC system, including the installed sensors.

While the integration of both systems facilitate the work done on data analysis and decision making, the coexistence of both does not devalue their usefulness; as it is evidenced by the results achieved.

In summary, the adopted solution incorporates the monitoring of energy consumption to determine the levels of energy efficiency of the building, make consumption and behaviour patterns and define the actions to be taken in order to improve the energy saving rates.

To improve the consumption parametres, actions have been focussed on lighting in the building and improving the HVAC system and cold and heat production efficiency, not only by adding an optimal control to the system; but also by installing sensors to improve the air quality in the building.

The system architecture is open, without proprietary protocols; and according to the following scheme:



The monitoring system manages the data obtained by the installed field elements.

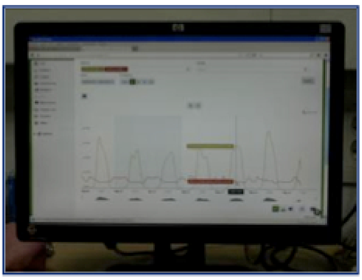
The field elements are connected to the PLC power management system by the field network that supports the MODBUS protocol.

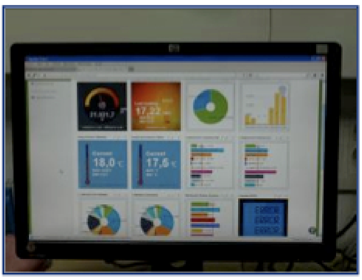
The hub is vertically connected via TCP / IP connection.

The hub is connected to the DEXCell Energy Manager, Web Server application that resides on an external server.

The implemented **monitoring system** allows:

- To obtain statistical reports on energy consumption.
- "Remote" programming of the operation of the facilities for its best performance.
- To receive "remote" alerts for malfunctions and breakdowns in facilities.
- To disseminate advances in energy efficiency for educational purposes, through an installed screen that displays, in real time, the most representative figures of the project.





To do this the following devices have been installed, among other elements of the monitoring network detailed below:

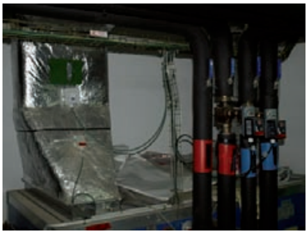
- 21 network analysers, installed in switchboards, to measure the phases by toroidals, sending information upstream from the communication bus based on the standard Modbus protocol.


- To structure the collection of data about consumption the following areas have been defined: hall (Lighting + Power), offices (L + P), 1st Floor (L + P), systems building (L + P), exterior light (L), left climate control (P), right climate control (P), climate control facilities (P), computer sockets (P), employee cafeteria (L + P), lift (P), emergency lighting (P), safety features (P) and café-restaurant environmental Park (L + P).

The readings of the existing network analysers have also been included. They not only report on the total power consumed but also on the power generated by the photovoltaic panels; that is the reason why these devices can also communicate with the system throughout the communication bus, hub and gateway for data collection.

- 12 sensors for the AHUs (Air Handling Unit) control (10 for controlling air quality and 2 for controlling temperature and humidity).

The building has an air conditioning system comprising 10 AHUs, which are responsible for renewing and conditioning the air of the building, both for cooling and for heating.


In order to improve the regulation of the HVAC system, optimising the energy required to achieve the desired set-point temperature, since the AHUs did not have air quality sensors, 10 air quality sensors and 2 temperature and humidity sensors have been installed and connected by communication cables to the two AHUs control panels, which I/O modules had previously been expanded. Likewise, the existing PLC and the corresponding SCADA have been programmed.

- 35 presence detectors in halls, hallways, corridors, toilets and kitchen (24 passive infrared and 11 ultrasonic). The passive infrared detectors are activated in the presence of energy sources, such as the human body in motion, in the infrared band. Analysing the difference between the energy emitted by these sources and that emitted by the surrounding environment, the devices detect the presence of people and activate the loads if necessary. To function correctly and efficiently, PIR detectors need to have a field clear of obstacles in the coverage area.

The ultrasonic sensors emit sound waves (Doppler) that collide with objects that are in their scope and measure the time it takes for them to return. When moving within this scope, the sound waves return with different wavelengths and so the devices detect the presence of people and activate the lighting loads if necessary. Ultrasonic detectors are ideal in places with obstacles or where the activity level of people is extremely low.

- 2 energy metres (solar thermal and HVAC).
- 1 pulse metre (biomass pellets boiler room).

In more detail, among other small equipment and wiring necessary for integration; actions and components needed to implement the system are as follows:

ENERGY MONITORING

- Energy monitoring software.
- Computer application.
- Three-phase and single-phase modbus network analysers.
- 40A a 600ª toroidals.
- IP/Modbus communications hub and gateway.
- Integration of metres for electricity generation through solar panels.
- Integration of metres for electricity generation through solar thermal panels.
- Integration of metres for electricity generation through biomass boilers.

PUBLIC INFORMATION STAND

- 60" LCD screen for public information.
- PC control of the screen for public information.
- Wireless sensor hub.
- Wireless temperature and humidity sensor

ADAPTATION OF THE LIGHTING SYSTEM

- Motion detectors including a natural light detection sensor with PIR technology.
- Motion detectors including a natural light detection sensor with us technology.

SCADA SOFTWARE AND CONTROL STATION

- Computer, screen and keyboard for the control station.
- SCADA software development for the expansion of new signals and field elements.
- PLC software development of each control cabinets.

LIGHTING CONTROL PANELS

- /O modules for the lighting control panels in the ground floor and outdoors, comprising control CPU, I/O cards and control cabinet.

- I/O modules for the lighting control panels in the first floor, comprising control CPU, I/O cards and control cabinets.

PRODUCTION CONTROL PANEL

- Control panel associated to the main production control panel that consists of control CPU, I/O cards and control cabinet, with the necessary I/O cards to control the biomass boilers and solar thermal system.

- Flow metres and temperature sensors.

HVAC CONTROL PANELS

- I/O modules for the AHU control panels consisting of control CPU, I/O cards and control cabinet.

- Air quality sensors in AHUs.

ELECTRIC BILLS:

- Details about the contracted electricity tariff have been introduced in the DEXCell application, including the actual costs of power, energy, taxes and discounts per term; allowing visualization of consumption and costs by hours, days, weeks and months, as well as comparison with the invoices issued by the electricity company in order to detect possible variations and to be aware of the evolution of energy costs in real time.

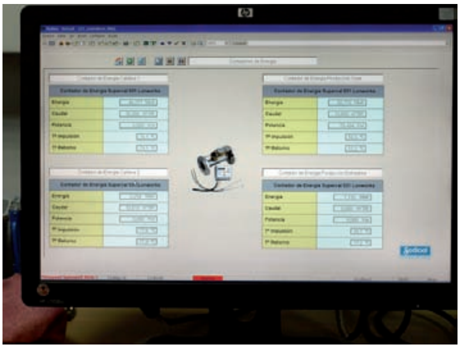
4.3.3. Graphic Review of Actions in PRAE:

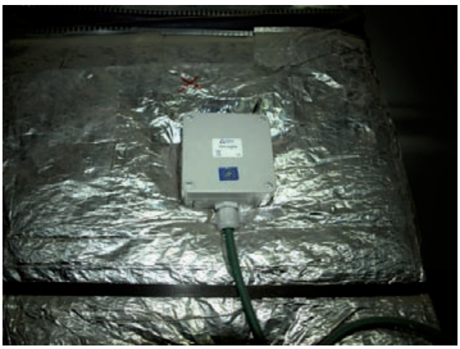
View of facilities in the Environmental Resources Centre within the PRAE premises.

Renewable energy in PRAE premises: biomass boiler, photovoltaic cells for solar energy and wind turbines, solar thermal panels and charging point for electric vehicles

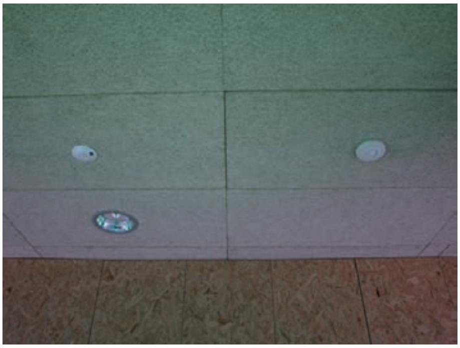
Devices installed in the Environmental Resources Centre and in the PRAE premises: network analysers, control panels, metres, sensors for air quality and lighting control.


888
00000254
Sedical
Supercal
531










View of various Sedical and DEXCell screens for programming and control devices and consumption.

4.3.4. Results of Action 3c: Natural Heritage Foundation in "PRAE"

In the experimental period, the reduction in energy consumption and CO2 emissions achieved was as it is shown in the following table:

Summary of consumptions and savings achieved [Centro de Propuestas Ambientales Educativas (PRAE-FPN)]					
CONSUMPTION	Energy Consumption (MWh/period...)		Energy Savings [MWh/Period...]		
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving	Experimentation period (months)
Electricity	1.103,94	636,23	467,71	42,37%	29
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass in equivalent fuel	2.072,40	1.052,43	1.019,97	49,22%	
		Litres...:	95.786,32		
TOTAL	3.176,34	1.688,66	1.487,67	46,84%	
CO2 EMISSIONS	Emissions CO2		Emissions reduction [toe] [CO2 ton] / period		
Energy type	Final Energy CO2 [ton/Baseline]	Final Energy CO2 [ton/period]	Final Energy CO2 [ton/period]	Primary Energy toe	Primary Energy CO2 [ton/period]
Electricity	386,38	222,68	163,70	91,71	373,23
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass in equivalent fuel	545,37	276,96	268,41	98,24	300,62
TOTAL	931,75	499,64	432,11	189,95	673,85
ENERGY COST	Baseline		TOTAL Differential cost		
Energy type	"Baseline" (€)	"Period" (€)	Economic savings (€)		
Electricity	176.326,09	77.815,94	98.510,14		
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass	136.420,85	51.763,64	84.657,21		
TOTAL	312.746,94	129.579,59	183.167,35		

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)

(*) Baseline: Projected to the experimentation periods.

(**) Reference prices 2011: Electricity (0,14 €/kWh). Fuel-oil (0,082 €/kWh). Natural Gas (0,058 €/kWh). Pellets (0,021 €/kWh).

During the experimental period at the PRAE premises, the emission of 673,85 t/CO2 to the atmosphere and the consumption of 189,95 tonnes of oil equivalents (toe), in terms of primary energy, were avoided.

Electricity consumption was reduced by 42,37% (467,71 MWh), by rationalizing use. This rationalization has been achieved due to the implanted devices for regulation and to decisions based on the information provided by the BMS through which consumption in facilities is controlled

The results of this action have confirmed the importance of the devices and programs that aim at monitoring and managing consumption.

These systems, coupled with the introduction of home automation devices (e.g. presence detectors, weather sensors, etc.); form an “integrated system for energy management in buildings” (BMS: Building Management System); allowing substantial savings, even when the BMSs do not directly generate savings and are not specifically targeted for controlling devices or systems.

The implanted consumption control system, based on the “DEXCell” and “Sedical” programs, detected excessive consumption and allowed making decisions that have generated savings on the affected devices and systems, by 46.84% (1487.67 MWh in the period of experimentation); with an estimated savings by reducing consumption of 180,000 euros over 29 months of experimentation.

In an annual project, the results are as follows:

Summary of consumptions and savings achieved [Centro de Propuestas Ambientales Educativas (PRAE-FPN)] (Annual calculation based on experimentation results)					
CONSUMPTION	Energy Consumption (MWh/year...)		Energy Savings [MWh/year...]		
Energy type	(*) Final Energy "Baseline"	(*) Final Energy "Experimentation"	Savings Final Energy	% of Saving	Experimentation period (months)
Electricity	456,80	263,27	193,53	42,37%	29
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass in equivalent fuel	857,54	435,49	422,06	49,22%	
		Litres...:	39.635,72		
TOTAL	1.314,35	698,76	615,59	46,84%	
CO2 EMISSIONS	Emissions CO2		Emissions reduction [toe] [CO2 ton] / year		
Energy type	Final Energy CO2 [ton/Baseline]	Final Energy CO2 [ton/year]	Final Energy CO2 [ton/year]	Primary Energy toe	Primary Energy CO2 [ton/year]
Electricity	159,88	92,14	67,74	37,95	154,44
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass in equivalent fuel	225,67	114,60	111,07	40,65	124,40
TOTAL	385,55	206,75	178,80	78,60	278,84
ENERGY COST	Baseline		TOTAL Differential cost		
Energy type	"Baseline" (€ /year)	"Annual" (€ /year)	Economic savings (€/year)		
Electricity	72.962,52	32.199,70	40.762,82		
FVP Renewables					
Renewables: Thermal solar					
Renewables: Biomass	56.450,01	21.419,44	35.030,57		
TOTAL	129.412,53	53.619,14	75.793,39		

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)

(*) Baseline: Projected to the experimentation years.

(**) Reference prices 2011: Electricity (0,14 €/kWh). Fuel-oil (0,082 €/kWh). Natural Gas (0,058 €/kWh). Pellets (0,021 €/kWh).

In summary, on a yearly basis, according to the data recorded in the experimental stage, the Natural Heritage Foundation of the Autonomous Government of Castilla y León facilities in the PRAE premises, have proved the following potential reduction in energy consumption and emissions:

Savings in Energy Consumption and CO2 Emissions "Annual Calculation"	
Reduction in Emissions (TOTAL)...:	**278,84 t CO2/year**
Reduction in Emissions (Electricity)...:	154,44 t CO2/year
Reduction in Emissions (Biomass, fuel equivalent)...:	124,40 t CO2 /year
Reduction in Consumption (TOTAL)...:	**46.84% (615.59 MWh/year)**
Reduction in Consumption (Electricity)...:	42.37% (193,53 MWh/year)
Reduction in Consumption (Biomass)...:	49,22% (422,06 MWh/year) 39,635 litres of diesel
Cost Savings due to Reduction in Consumption:	**75,793 €/year**

The above data, as had been detected in the actions carried out at the University of San Jorge and San Valero Foundation; demonstrate again the importance of implementing systems and procedures to control consumption, at the highest possible level of disaggregation. They also demonstrate the economic and environmental benefits of the computerized control of energy consumption in places receiving large amounts of visitors, as it is the case, with over 25,000 people / year.

In addition, the action of showing to the public in real time the savings that are being generated and the specific awareness campaigns, based on the proven results, generate important synergies between people in regard to environmental awareness and sustainability of our surroundings.

Renewable Energies in the PRAE complex:

As its name suggests (PRAE: Proposals for Environmental Education), is a space specifically dedicated to education and to raise public awareness on sustainability and the environment. Therefore it has, among its facilities, photovoltaic systems for solar energy production, solar thermal energy production, biomass boilers and even wind generators; although the latter have not been monitored during the experimental period.

The application of control systems for renewable energy generation and the measures for efficiency in consumption carried out under the project has allowed calculating, demonstrating and showing to the public that visit the Environmental Park, the environmental benefits and the enormous potential that this type of generation systems have; if their production is considered from the point of view of the environmental impact that fosil fuels and energy consumption they replace would represent.

The following table shows, on a yearly basis, the generating potential of renewable energy production systems within the PRAE premises. The energy generated is completely consumed in their own facilities, thereby substituting equivalent conventional energy that would otherwise be consumed.

It is also shown the reduction in terms of environmental impact and costs that using this energy means; compared to equivalent conventional energy.

Paragraphs on "Total emissions savings" and "Total cost savings" display the potential for reducing CO2 emissions and saving in costs within the PRAE facilities, considering the already mentioned savings and emissions reductions due to the decrease in consumption and to the replacement of conventional energy for renewable energy.

Summary of Production and Consumption of Renewable Energy
[Centro de Propuestas Ambientales Educativas (PRAE-FPN)]
(Annual calculation based on experimentation results)

CONSUMPTION	Renewable Energy [MWh/year]				
Renewable generation System	Renewables production	Equivalent fuel	Final Energy	Primary Energy	Litres Fuel-oil
			In projection to equivalent fuel		
FVP Renewables	46,71	Electricity	46,71	106,50	
Renewables: Thermal solar	28,95	Fuel-oil	28,95	32,43	2.719,10
Renewables: Biomass in equivalent fuel	435,49	Fuel-oil	435,49	487,75	40.897,25
TOTAL	511,15	TOTAL	511,15	626,67	43.616,35

CO2 EMISSIONS	Emissions reduction [Renewables: Equivalent fuel]				Primary Energy TOTAL CO2 [ton/year]
Energy type	Final Energy toe	Final Energy CO2 [ton/year]	Primary Energy toe	Primary Energy CO2 [ton/year]	
Electricity					154,44
FVP Renewables	4,02	16,35	9,16	37,27	37,27
Renewables: Thermal solar	2,49	7,62	2,79	8,53	8,53
Renewables: Biomass in equivalent fuel	37,45	114,60	41,95	128,35	252,75
TOTAL	43,96	138,57	53,89	174,16	453,00

ENERGY COST	Differential cost by Energy source		Economic savings TOTAL (€/year)
Energy type	Equivalent fuel-Fuel Oil (€)	Economic savings - Renewables (Equivalent fuel) (€/year)	
Electricity			40.762,82
FVP Renewables	8.127,36	8.127,36	8.127,36
Renewables: Thermal solar	2.374,22	2.374,22	2.374,22
Renewables: Biomass	35.710,04	26.564,78	61.595,35
TOTAL	46.211,62	37.066,37	112.859,75

The potential for reducing GHG emissions (Greenhouse Gas) owing to the use of renewable energy is 174.16 CO2 t/year; abstaining from consumption of 106.50 MWh / year of electricity from conventional power and 43,616 litres of diesel; that is to stop using 53.89 toe.

would have been avoided.

The cost savings due to replacing conventional energy (electricity and diesel) is 37,066 €/ year.

If we also consider the reduction obtained by implementing the energy efficiency measures described in previous sections, the total potential for emissions reduction is 453 CO2t/year, and 112,859€ / year for costs reduction. This indicates an excellent economic and environmental cost / benefit ratio.

The following table summarizes the potential for emissions reduction and cost savings in the PRAE complex, calculated annually; considering the reduction in consumption due to the efficiency measures applied and to their potential for generation and consumption of renewable energy within the own premises:

In the experimental period, the reduction in energy consumption and CO2 emissions achieved was as it is shown in the following table:

Potential for Cost Savings in Energy Consumption and Reduction in CO2 Emissions (Efficiency Measures + Consumption of Renewable Energy) "Annual Calculation"	
TOTAL Reduction in Emissions:	**453 CO2t/year**
Due to Efficiency Measures:	278.84 CO2 t/year
Due to Generation and Use of Renewable Energy:	174.16 CO2t/year
TOTAL Reduction in Consumption:	**94.55% (1.242.26 MWh/year)**
Due to Efficiency Measures:	46.84% (615.59 MWh/año)
Due to Generation and Use of Renewable Energy:	47.68% (626.67 MWh/año)
Reduction in Consumption (Diesel Equivalent):	**83,251 litres/year**
Due to Efficiency Measures:	39,635 litres/year
Due to Generation and Use of Renewable Energy:	43,616 litres/year
Reduction in Consumption (Natural Gas Equivalent):	**69,378M3/year**
TOTAL Potential for Cost Savings:	**112,859 €/year**

5. PROJECT RESULTS

5. Project Results

The information and data shown below reflect the results achieved in each of the actions during the experimentation stage, as far as they are considered effective for calculation purposes.

Those records or periods in which the information collected could affect the validity of the results due to several technical reasons (e.g., adjustments, maintenance and revisions...) have been discarded.

The results are additionally displayed on a yearly basis, according to the recorded data, in order to calculate projection, when this is required, and to make comparison between different actions easier.

5.1. Summary of Characterization

Three systems for building automation and energy management have been modelled and implemented.

For the benefit of transfer and aiming at the reproducibility of the project, elements of variability have been introduced in the selection of buildings, areas of action and home devices and systems, so that the tested models can be replicated virtually in any building of any of the European Union countries.

Building features:

The variability criteria introduced in the selection of buildings are related to their age and structural characteristics (FSV vs. USJ and PRAE) as well as to their efficiency (USJ) and sustainability (PRAE) applied since the building design and construction stages.

Implanted automation systems:

They have been used: isolated home devices (e.g. motion detectors in FSV, USJ and PRAE), action systems and integrated control of lighting, heating and HVAC (KNX Standard in FSV and USJ), BMS for consumption control and management, and renewable energy production systems (Sedical and DEXCell in PRAE premises).

Priority areas of action:

Action has been taken on:

- Lighting control at different scopes, approaches and purposes (FSV: versatility through sectorisation, defining scenes and integrating lighting control in general; USJ: control of intensity and emergency lighting activation and deactivation in classrooms; PRAE: sectorisation with controlled activation / deactivation in workspaces).
- Heating: in FSV through integrated flow and return water temperature control in boilers, using KNX and analysing the indoor and outdoor temperatures.
- HVAC: control of the setpoint temperature of chillers in USJ; and integrated control of systems in PRAE.
- Control of production performance vs. renewable energy consumption within the PRAE premises.
- Integrated consumption control through Business Management System (BMS): specifically and in an integrated way in the PRAE premises, with lesser level of integration in the USJ buildings, and in isolated areas for action in the FSV building.

Summary of environmental and economic benefits achieved by areas of action and systems:

Levels of Energy Consumption Reduction and Environmental Improvement		
San Valero Foundation		
Rationalisation and integrated lighting control:	**Change of Luminaires, DALI and KNX...:**	**52,25%**
Change of Luminaires (AF) and Regulation:	Fluorescence (High Frequency), DALI and KNX integrated control system:	51,56%
Change of Luminaires:	Fluorescence (High Frequency):	30,82%
Regulation:	KNX + DALI integrated system:	20,74%
Change of Luminaires (LED) and Regulation:	Fluorescence (LED), DALI and KNX integrated control system:	72,71%
Change of Luminaries:	Fluorescence (LED):	64,28%
Regulation:	KNX + DALI integrated system:	8,43%
Isolated Devices for Lighting Activation/Deactivation:	Presence Detectors:	20%
Heating:	**Flow and Return Water Temperature Control in Boilers According with the Indoor and Outdoor Temperatures:**	**20,38%**
University of San Jorge (FSV)		
Regulation and Integrated Control of Emergency Lighting:	**KNX + DALI integrated regulation:**	**67,81%**
Consumption Control (BMS)...:	**"PowerStudio" Software + Network Analysers (ARES) and integration of lighting control within classrooms through "EIBPort":**	**40,10%**
Isolated Devices for Lighting Activation/Deactivation:	Presence Detectors:	20%
Environmental Resources Centre and PRAE		
Rationalisation of use and Integrated Lighting and Energy Consumption Control:	**BMS Control: Sectorisation and Control of Selective Activation/Deactivation According to Consumption Analysis (ARES + DEXCell):**	**42,37%**
HVAC Control and Performance of Biomass Boilers:	**BMS Control: ARES, Control Panels, Energy Metres, Air Quality Sensors and "Sedical" and "DEXCell" Software:**	**49,22%**
Monitoring and Control of Production of Renewable Energy:	**BMS Control: Energy Needs Covered by Renewable Energy (Solar PV, Thermal, and Biomass):**	**73,15%**
Isolated Devices for Lighting Activation/Deactivation:	Presence Detectors:	20%
190 toe/year	**680 CO_2 t/year**	**€162,000 /year**

5.2. Reduction in Consumption and CO2 Emissions (Experimentation Period)

The following reductions in energy consumption and CO2 emission were recorded during the experimental period:

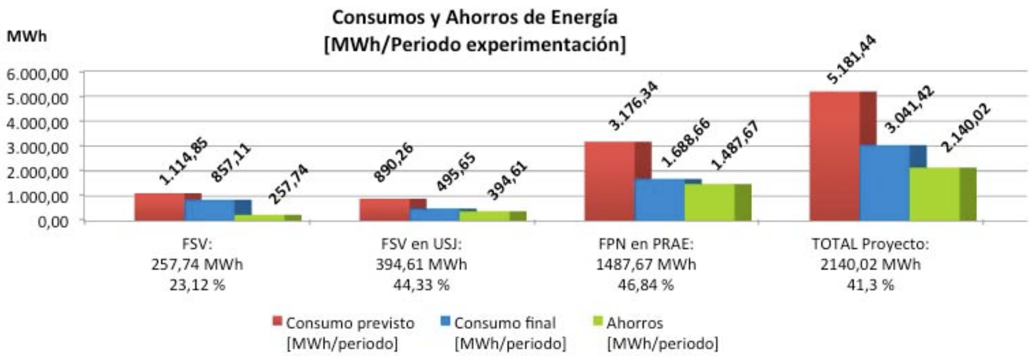
Summary of Consumptions and Savings; and CO2 Emissions Reduction [Experimentation period]							
Energy type	Energy Comsumption [MWh/Period...]		Energy Savings [MWh/Period...]		CO2 emissions reduction [toe & CO2 ton/period]		Economic Saving (€)
	(*) Final Energy Expected consumption	Final Energy "Experimentation"	Final Energy Savings	% of Saving	Primary Energy toe	Primary Energy CO2 [ton/period]	
Electricity	2.090,00	1.177,63	912,37	43,65%	178,90	728,07	173.555,39
Training Centre (FSV)	95,80	45,75	50,05	52,25%	9,81	39,94	8.356,01
University (FSV_USJ)	890,26	495,65	394,61	44,33%	77,37	314,90	66.689,25
Interpretive Centre (FPN)	1.103,94	636,23	467,71	42,37%	91,71	373,23	98.510,14
Furnace Fuel Oil (FSV-FPN)	3.091,44	1.863,79	1.227,65	39,71%	118,25	361,83	101.895,10
Litres TOTAL...:	290.321,33	175.031,02	115.290,32				
In Natural gas projection (M3)...:	241.972,56	145.882,16	96.090,40				
Training Centre (FSV)	1.019,05	811,36	207,69	20,38%	20,00	61,21	17.237,89
Interpretive Centre (FPN)	2.072,40	1.052,43	1.019,97	49,22%	98,24	300,62	84.657,21
TOTAL...:	5.181,44	3.041,42	2.140,02	41,30%	297,14	1.089,91	275.450,50
Reduction of CO2 emissions [Renewable production in "Equivalent fuel"]...:					130,24	420,89	89.577,05
TOTAL reduction of CO2 Emissions, Renewables included...:					427,39	1.510,80	365.027,55

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)
(*) Baseline: Projected to the experimentation periods.
(**) Reference prices 2011: Electricity (0,14 €/kWh). Fuel-oil (0,082 €/kWh). Natural Gas (0,058 €/kWh). Pellets (0,021 €/kWh).

In the experimental period, and in the whole project, there was a reduction of 43.65% in electricity consumption and 39.71% in diesel consumption (912 MWh of electricity and of natural gas); and generating more than €275,000 savings.

In terms of primary energy, the consumption of 297.14 toe and the emission of 1,090 CO2 t to the atmosphere was prevented.

If to all the previously mentioned it is added the fossil fuel that has been replaced by renewable energy (solar thermal and biomass) generated in the PRAE premises; the consumption of 427.39 toe and the emission of 1,511 CO2 t has been avoided; generating over €365,000 economic saving.



On average, the three actions undertaken have shown a potential for reducing energy consumption of 41.3% (2,140 MWh).

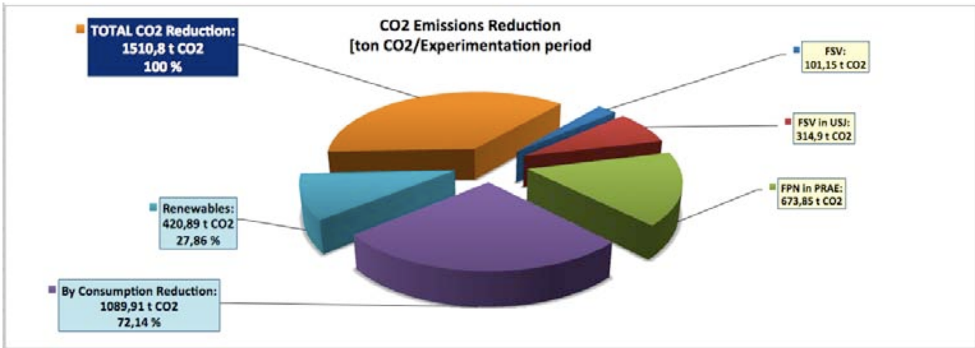
Por lo que a la reducción del consumo de electricidad se refiere, todas las actuaciones superan el 40% de ahorro; destacando la actuación de FSV en iluminación, que ha demostrado que combinando el cambio de luminarias, con una regulación integrada mediante KNX, pueden lograrse ahorros que superan el 50% (52,25%).

As the reduction in electricity consumption is concerned, all actions exceed 40% saving. The performance of lighting in FSV should be emphasized, as it has shown that, combining change of luminaires with an integrated regulation through KNX, savings of over 50% (52.25%) can be achieved.

It is also evident that, even without change of luminaires, but carrying out a thorough control of consumption at the highest possible level of disaggregation through BMS and acting on the detected critical points, the savings generated exceed 40% (USJ: 44.33% and FPN: 42.37%).

This potential of BMS, but taken to the field of fossil fuels or even biomass consumption, referred to saving on "equivalent fuel"; is evident in the reduction ratio achieved by FPN in the PRAE premises, close to 50% (49.22%).

It has also been highlighted the difficulty of achieving similar savings when the building on which actions are taken is older, due to the scale of the investment needed to bring facilities at optimum efficiency parameters, since sometimes it would be necessary to carry out a full renovation of the whole system. Nevertheless, power consumption was reduced by 20.38% through the application of the implemented KNX control system, which takes into account the outdoor and indoor temperature in order to regulate the flow and return water temperature from the boilers room.



Of the total avoided emissions (1,511 CO2 t), 72.14% come directly from the reduction in energy consumption achieved by applying "home automation solutions"; and the remaining 27.86% come from replacing the consumption of electricity from conventional electrical grid and fossil fuels with renewable energy generated in the PRAE premises in Valladolid.

5.3. Reduction in Consumption and CO2 Emissions (Annual Results)

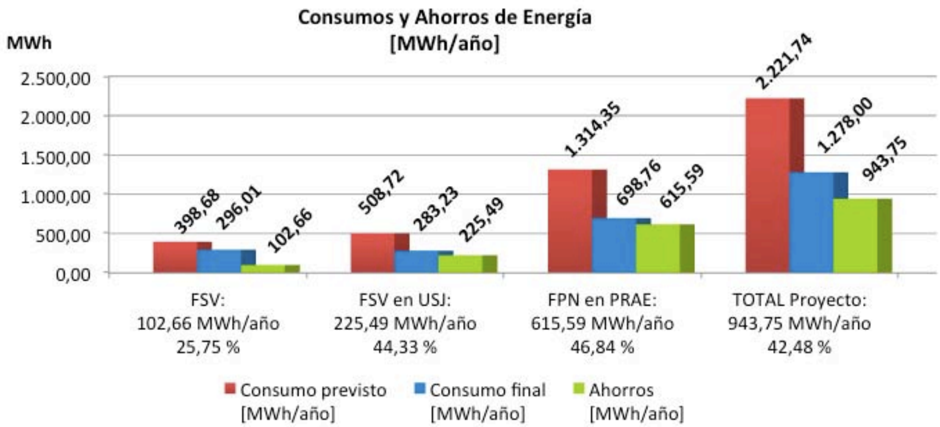
In annual plan, the results of the experimentation produce the following outcomes:

Summary of Consumptions and Savings; and CO2 Emissions Reduction
[Annual calculation based on experimentation results]

Energy type	Energy Comsumption [MWh/year...]		Energy Savings [MWh/year...]		CO2 emissions reduction [toe & CO2 ton/year]		Economic Saving [€/year]
	(*) Final Energy Expected consumption	Final Energy "Experimentation"	Final Energy Savings	% of Saving	Primary Energy [toe/year]	Primary Energy CO2 [ton/year]	
Electricity	**1.024,52**	**572,05**	**452,46**	**44,16%**	**88,72**	**361,06**	**84.279,17**
Training Centre (FSV)	59,00	25,56	33,44	**56,68%**	6,56	26,68	5.408,21
University (FSV_USJ)	508,72	283,23	225,49	**44,33%**	44,21	179,94	38.108,14
Interpretive Centre (FPN)	456,80	263,27	193,53	**42,37%**	37,95	154,44	40.762,82
Furnace Fuel Oil (FSV-FPN)	**1.197,23**	**705,94**	**491,28**	**41,04%**	**47,32**	**144,80**	**40.759,23**
Litres TOTAL...:	**112.432,97**	**66.295,91**	**46.137,05**				
In Natural gas projection (M3)...:	**93.708,90**	**55.255,30**	**38.453,60**				
Training Centre (FSV)	339,68	270,45	69,23	**20,38%**	6,67	20,40	5.728,66
Interpretive Centre (FPN)	857,54	435,49	422,06	**49,22%**	40,65	124,40	35.030,57
TOTAL...:	**2.221,74**	**1.278,00**	**943,75**	**42,48%**	**136,04**	**505,86**	**125.038,40**
Reduction of CO2 emissions [Renewable production of electricity and "Equivalent fuel"]...:					**53,89**	**174,16**	**37.066,37**
TOTAL reduction of CO2 Emissions, Renewables included...:					**189,93**	**680,03**	**162.104,76**

Conversion factors PE/FE and Emissions calculation: IDAE (November, 2010)
(*) Baseline: Projected to the experimentation years.
(**) Reference prices 2011: Electricity (0,14 €/kWh). Fuel-oil (0,082 €/kWh). Natural Gas (0,058 €/kWh). Pellets (0,021 €/kWh).

Based on the experimental results, the implemented home automation solutions have the potential for reducing power consumption to 42.48% (943.75 MWh / year), and will reduce emissions to 506 CO2 t per year and generate economic savings of over €125,000/ year.



On average, the three actions undertaken have shown a potential for reducing energy consumption of 42.48% per annum (944 MWh / year).

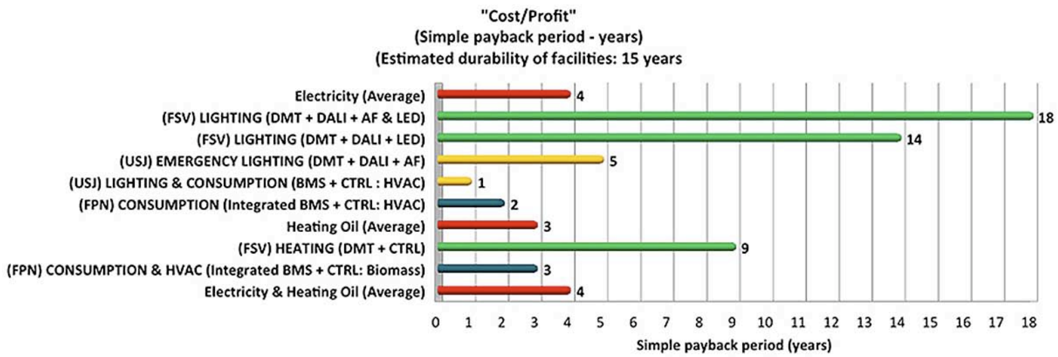
Of the potential emission reduction, calculated annually (680 CO2 t per year), 74.39% comes directly from the reduction in energy consumption that, on average, can be achieved by applying home automation solutions; and the remaining 25.61% comes from the potential for replacing electricity from conventional electrical grid and fossil fuels with renewable energies generated in the PRAE premises in Valladolid.

6. COST / BENEFIT RATIO (SIMPLE PAYBACK PERIOD)

6. Cost / Benefit Ratio (Simple Payback Period)

As reflected in the approved proposal, throughout this section an analysis of the cost/environmental and economic benefit ratios of the “sample facilities” will be carried out in order to control energy consumption in buildings that allow to display, based on the developed tested actions, simple payback periods of investment, both regarding home automated systems or integral BMS and those that, even without covering the entire facilities, target specific areas of consumption.

Simple payback periods are less than four years on average, both in the systems aimed at reducing electricity consumption, and in those targeting the consumption of fossil fuels (diesel or biomass in fuel equivalent); as shown in the following chart.



“Sample facilities” that include both isolated automation devices, which have a generally accepted standard performance (e.g. detectors, with a potential saving of 20%); and integrated automation systems which, in the experimentation period, have allowed to record the actual savings that such devices can obtain under normal conditions of use, have been considered for calculations in the benefit of the transfer potential.

The criteria for the calculation of the obtained ratios are as follows:

COSTS:

The design, integration, testing and modelling costs corresponding to demonstrative actions carried out in the project were excluded in order to establish the approximate actual cost of a standard neither experimental nor demonstrative installation, likely to be reproduced according to the validated models.

Maintenance, review, adjustments, corrections, monitoring and evaluation costs required by the demonstrative action to validate the actions and technology have also been excluded.

In order to establish the implementation costs, the progressive price reductions that this type of technology is experiencing has been taken into account, as it is becoming widespread and competition is gradually increasing (e.g. the significant drop in price that the LED technology is experiencing).

Costs associated with all the standard implementation process: draft, licenses, permits, labour and business profit have been considered and those costs related to the functional and management control, maintenance, repairs and replacement, typical of installations in operation, have been projected to an estimated durability period of 15 years.

FINANCIAL INCENTIVES:

Atendiendo a la inseguridad jurídica existente, que afecta al coste de la propia "energía", al mercado Considering the current legal uncertainty, which affects the energy cost, the renewable energy market and the promotion of energy efficiency that may have existed in the past, and also taking into account that legislation regarding this matter is under constant, even retroactive, changes; no financial incentive has been included within the estimated savings, as it is not possible to determine how "incentives" or "tolls" would modify the present energy market due to the existing need of sorting out the "tariff deficit" in Spain, among other reasons.

As it has been previously mentioned, a moderate downward trend in the prices of some components for this kind of technology has been detected; as a result of an increase in its market volume and of a reaction that could prevent its "fall" within the current economic recession framework.

However, in response to the rising price of energy, the widespread need to reduce energy consumption is causing a gradual, though still slow, spontaneous increase of demand for such hardware and software systems, which implies that their implementation costs are not falling as fast as expected in a time of economic recession, due to their generalized use and market competition. Nevertheless, a short-term adjustment of this market is expected. It will be favoured by such widespread use of these systems and by the active participation of Energy Service Companies (ESCOs) in the implementation of this technology

ECONOMIC BENEFITS:

The cost savings derived from direct reduction in consumption of "electricity", "diesel" and "biomass"; calculating the saving on the latter in terms of oil equivalent; have exclusively been considered.

In this regard, it is worth noting that the calculated payback periods are expected to be reduced in a medium and long term; as a consequence of a foreseeable decrease in the price of the devices and an also predictable increase in energy prices.

VAT is excluded in both the implementation costs and the reference prices.

Simple Payback Periods:

As it has been mentioned, in the energy areas of action (electricity and diesel) "simple payback periods" are less than 4 years on average; these periods are well below the estimated durability for the installed systems (15 years).

Moreover, except for the action carried out in San Valero Foundation, the economic profit obtained after the payback period would cover the cost of at least a whole new system installation.

Paradoxically, that facility (San Valero Foundation in its Secondary Education and Vocational Training Centre) stands out because of its high potential for reducing electricity consumption (56.68%), as well as its long simple payback period, exceeding the estimated durability for the installed system.

This is due to the following reasons:

- Extra implementation cost: as it is a building older than 30 years that did not have the structural features, facilities and pipes of modern buildings.

- Lighting time of use in classrooms: which is 12.39% of the total hours in a year (1,085 vs 8,760 hours); economic performance is, therefore, far below its proven actual potential for reduction.

In this regard and as an example, if the facility was used for 50% of the hours in a year; the result would be as follows:

24.35 Kw * 4,380 hours = 106,653 kWh/year consumption

106,653 kWh/year * 56.68% = 60,451 kWh/year reduction.

60,451 kWh/year * €0.1617/kWh = €9,776/year savings.

Simple payback period: €98,187 / €9,776 / year = 10 years.

Economic profit after payback period: € 48,880

There is a fact confirming this approach: the simple payback period in the action developed by San Valero Foundation in the University of San Jorge building is less than 5 years, acting on similar luminaires with the same automated system, with a total installed power of 8,856 kW but that, as being "Emergency Lighting", are permanently on.

At the end of the project and considering the significant price reduction that LED technology has experienced over the years, San Valero Foundation has tested this technology by replacing the "AF fluorescent lamps" with "LED tubes". With the same configuration and implemented automation system to manage the classroom lighting, consumption has been reduced by up to 72,71%, with a simple payback period of 14 years, less than the estimated durability of the installed system; and an economic performance after payback period of €6.560.

It is very significant that in every action partially or completely using a BMS (Building Management System) to target consumption control, the simple payback period is less than 3 years.

It is also important the fact that the potential saving related to the regulation of the heating system in the Secondary Education and Vocational Training Centre of San Valero Foundation is of 20.38%; well below the average achieved in the other actions.

The cause is again to be found in the age of the premises, where it would have been necessary to carry out a previous renewal of the entire heating system in order to achieve a grade of efficiency consistent with the potential average economic saving obtained with the automated systems that control HVAC.

By contrast, the intervention implemented in this area for action has proven possible to reduce diesel consumption by more than 20%, with a simple payback period of less than 9 years and a profitability, after payback period, of over € 36,000 even in old heating systems and with just a moderate investment in automation technology.

ENVIRONMENTAL BENEFITS:

Detailed in the table below, the reduction in energy consumption and emissions with reference to the "Spanish energy mix" (Spanish Institute for Energy Diversification and Saving - IDAE 2010); in projection to 15 years estimated durability of the installed systems.

The reduction in CO2 emissions is expressed in terms of "primary energy" to highlight the actual environmental impact of uncontrolled energy consumption, as well as to raise awareness on this issue and benefit transfer.

Following the same approach, the "Balance of Environmental Improvement" of the different types of tested premises is also detailed in terms of percentage of achieved reduction in emissions.

Averaging the results of the actions undertaken and tested technologies; it has been found out that a single action implementing "automation control and BMS" in the areas of "lighting" and "HVAC", would avoid the emission of more than 2,200 CO2 t in 15 years.

Once again, it is very significant the fact that in every action partially or completely using a BMS (Building Management System) the potential for reducing emissions in 15 years is around 2,000 CO2 t.

In the area of "lighting", all the actions will reduce emissions by over 400 CO2 t in 15 years; with an average potential for reduction of over 1,100 CO2 t.

In the areas of "HVAC and Heating", the average reduction potential exceeds 1,000 CO2 t in a projected 15-year durability of the installed systems.

The following table details the results described above, arranged by actions and areas of action:

"Cost/Profit" Ratios Based on Results
(Estimated durability of facilities: 15 years

Acronyms...:	DMT...:	Integrated domotic control	BMS...:	Building management system (Consumption control)
	DALI...:	Digital Addressable Lighting Interface	AF...:	Fluorescents "High frecuency"
	LED...:	Fluorescents "LED Technology"	CTRL...:	Automatic control of HVAC, Heating or Renewables

Basis action for calculation Intervention field Facilities type	Implementation costs...				Costs by consumption...	
	Implementation Cost (€)	Extra charges by implementation dificults (%)	Maintenance costs (€/15 years	TOTAL Cost (€)	Average annual consumption (MWh/year)	Cost by energy consumption (€/year)
Electricity	**55.188**	**2.657**	**11.218**	**69.063**	**217**	**40.254**
(FSV) Scope: LIGHTING "Lamps change" (DMT + DALI + AF & LED)	75.820	5.307	17.060	98.187	59	9.542
(FSV-Projection) Scope: LIGHTING "Lamps change" (DMT + DALI + LED)	79.930	5.595	11.990	97.515	59	9.542
(USJ) Scope: EMERGENCY LIGHTING (DMT + DALI + AF)	38.114	1.143	8.576	47.833	78	13.109
(USJ) Scope: LIGHTING & CONSUMPTION (BMS + CTRL: HVAC)	20.876	626	4.697	26.199	431	72.864
(FPN) Scope: CONSUMPTION (BMS Integrated + CTRL: HVAC)	61.200	612	13.770	75.582	457	96.213
Heating Oil	**52.870**	**1.610**	**15.861**	**70.341**	**599**	**49.642**
(FSV) Scope: HEATING (DMT + CTRL: Flows and temperatures)	36.040	2.523	10.812	49.375	340	28.109
(FPN) Scope: CONSUMPTION & HVAC (BMS Integrated + CTRL: Generation with Biomass)	69.700	697	20.910	91.307	858	71.176
TOTAL...:	**108.058**	**4.267**	**27.079**	**139.404**	**815**	**89.897**

Basis action for calculation Intervention field Facilities type	Savings and Simple payback period...			"Emissions reduction" and "Environmental profit"		
	Economic saving [€/year]	Simple payback period (years)	Profit after amortization (€/15 years)	Primary Energy (Baseline) CO2 ton/15 years	TOTAL] CO2 Reduction CO2 ton/15 years	Environmental improvement balance [CO2 Primary E.] (%/year)
Electricity	**17.776 €**	**4 years**	**197.581 €**	**2.594**	**1.146**	**44,16%**
(FSV) Scope: LIGHTING "Lamps change" (DMT + DALI + AF & LED)	5.408 €	18 years	-17.064 €	706	400	56,68%
(FSV-Projection) Scope: LIGHTING "Lamps change" (DMT + DALI + LED)	6.938 €	14 years	6.560 €	706	513	72,71%
(USJ) Scope: EMERGENCY LIGHTING (DMT + DALI + AF)	8.889 €	5 years	85.508 €	929	630	67,81%
(USJ) Scope: LIGHTING & CONSUMPTION (BMS + CTRL: HVAC)	29.218 €	1 year	412.078 €	5.161	2.070	40,10%
(FPN) Scope: CONSUMPTION (Integrated BMS + CTRL: HVAC)	40.763 €	2 years	535.860 €	5.468	2.317	42,37%
Heating Oil	**20.371 €**	**3 years**	**235.222 €**	**2.646**	**1.086**	**41,04%**
(FSV) Scope: HEATING (DMT + CTRL: Flows and temperatures)	5.729 €	9 years	36.555 €	1.502	306	20,38%
(FPN) Scope: CONSUMPTION & HVAC (Integrated BMS + CTRL: Generation with Biomass)	35.031 €	3 years	434.152 €	3.791	1.866	49,22%
TOTAL...:	**38.147 €**	**4 years**	**432.803 €**	**5.240 €**	**2.231**	**42,48%**

(**) Reference prices 2011: Electricity (0,14 €/kWh). Fuel-oil (0,082 €/kWh). Natural Gas (0,058 €/kWh). Pellets (0,021 €/kWh).

7. TRANSFER POTENTIAL

7. Transfer Potential

During the development of the project and final validation phase, it was possible to verify the scalability and versatility of the defined models.

The excellent reproducibility and transfer potential of the project is supported by:

- The technological maturity of the implanted devices and their availability in the market.

- The modularity of systems, equipment and components used.

- The possibility that most of the devices have of being implanted in isolation, or as part of an integral "Home Automation System", to reduce consumption.

- The scalability of the "Models for a Smart Building" defined and validated as part of the project, which has been demonstrated by the performance achieved in each and every one of the demonstrative actions executed in its various configurations:

  - FSV: integrated lighting control.
  - FSV: water flow and heating temperatures control.
  - FSV in USJ: integrated emergency lighting control.
  - FSV in USJ: integration of lighting control and consumption analysis.
  - FPN: integrated consumption control (BMS).
  - FPN: BMS of renewable energy generation and HVAC consumption.
  - ALL: implementation of sensors and isolated actuators in public areas.

- The versatility and adaptability of the "Models" that have been demonstrated by the project in every one of the tested configurations and areas of intervention:

  - Old buildings: lighting and heating
  - New buildings: lighting, emergency lighting and HVAC
  - New bioclimatic buildings: lighting, consumption and renewable energy generation

- The excellent results achieved: despite the current economic recession, the project has fulfilled all expectations; and demonstrated significant environmental benefits.

- The excellent cost/benefit ratios and the short periods of ROI (Return on Investment), calculated according with the results of the project.

- The excellent acceptance that the project had among its targeted public (authorities, technology manufacturers, architects, engineers, installers, specialized press and the general public); evidenced by the high level of support received and of attendance to events related to it, as well as by its dissemination in both specialized and general media.

Finally and concerning transfer, it is worth noting that previous and periodical "Energy audits", along with the implementation of "Systems for Consumption Control - BMS" (devices and software: ARES, consumption metres, SCADA, etc.), are highly recommended complements to any "Home Automation System" implemented; as they exponentially multiply savings and simple payback periods.

8. SUMMARY OF RESULTS:

8. Summary of Results:

A table below presents a summary of the main results obtained versus the expected results.

An objective related to natural gas consumption had been considered in the draft of the project. However, in its execution, none of the tested premises consumed this kind of fuel, therefore, in order to show the savings that would have been achieved if natural gas was consumed in HVAC systems, savings on diesel have been extrapolated to their equivalent in natural gas.

The renewable energy production systems in PRAE were either inactive or clearly inefficient according to the performance considered to be normal for this type of premises. The analysis based on the information provided by the BMS and the measuring devices implanted under the project has actually allowed a proper management of the energy production and consumption associated with such systems.

Expected Results vs. Obtained Results

Type of Result	Expected Result	Obtained Result (Experimentation)	Obtained Result (Annual Calculation)
Reduction in Energy Consumption:	50%	41.30% Electricity: 43.65% Diesel: 39.71%	42.48% Electricity: 44.16% Diesel: 41.04%
		With Renewable Electricity: 49.05% Diesel: 76.02%	With Renewable Electricity: 49.63% Diesel: 78.56%
Reduction in Electricity Consumption:	750,000 kWh/year	912,000 kWh	452,000 kWh/year
		With Renewable 1,025,000 kWh	With Renewable 508,004 kWh/year
Reduction in Diesel Consumption:	30,000 litres/year	115,290 litres	46,137 litres/year
		With Renewable 220,696 litres	With Renewable 89,753 litres/year
Reduction in Natural Gas Consumption:	40,000 m3/year	96,090 m3	38,454 m3/year
		With Renewable 183,942 m3	With Renewable 74,807 m3/year
Reduction in CO2 Emissions:	400 CO2 t	1,090 CO2 t	506 CO2 t/year
		With Renewable 1,511 CO2 t	With Renewable 680 CO2 t/year

(*) In the PRAE premises in Valladolid, the BMS implanted by FPN allowed to operate and manage, for optimization, production systems for renewable energy generation and consumption; as the generated renewable energy (Biomass, Solar PV and Thermal) is used within these premises.

TOTAL Project "Without BMS of Renewable Energy"		
136 toe/year	506 CO2 t/year	€125,000 /year
TOTAL Project "With BMS of Renewable Energy"		
190 toe/year	680 CO2 t/year	€162,000 /year

9. LESSONS LEARNED:

9. Lessons Learned:

Energy Audits and BMS (Building Management System):

Prior to the implementation of any building management and automation system, it is advisable to carry out an energy audit to:

- Establish a baseline of energy consumption regarding, at least, energy type and physical and functional areas of use and performance.

- Compare the consumption of different areas with similar classification or functional purpose, to detect deviations from usual consumption that may indicate, for example, an equipment malfunction or abnormal use routines.

- Identify priority areas for action, based on the consumption recorded.

- Evaluated over time the usefulness and performance of the implemented systems implemented.

It is important to design, from the beginning, "data collection sheets" (digital or paper) to allow monitoring of the information over time.

It is also important to define a balanced level of disaggregation of information, to identify the physical or functional areas where deviations from usual consumption may occur (e.g.: excessive consumption can be detected in a particular building, but if disaggregation is not accounted for by floor, and within each floor, by "power" and "lighting", it may take longer to identify the specific point of incidence).

The BMSs provide continuity, complement the audit and allow, in practice, a permanent monitoring and audit the energy consumption of the building. Under the project potential savings of between 40% and 50% have been proven; significantly improving the efficiency ratios provided by the building automation systems in those buildings where both solutions have been implemented.

These systems are, therefore, highly recommended for their implementation, either coexisting with other automation systems to be implemented or on their own.

New buildings:

- In the first months of occupation and in the establishment phase of the "baseline of energy consumption", it is very important to verify that the recorded consumption values actually correspond to those expected from the implemented and defined equipment, systems and applications.

It is sometimes assumed that a "baseline" is correct when, in fact, it may be hiding over-consumption that, having "always" been there, may be considered "normal" in the future, going on over time and generating significant accumulated over-costs.

- When buildings already have networks of communications, even if they serve other functions, it is necessary to analyse how these networks can be used by the building automation systems or the implemented management and control systems of the building (BMS), expanding or restructuring the type of networks and redefining their functionality; so duplication of network cabling can be avoided.

Old buildings:

- Sometimes actions aimed at optimization of complex systems in buildings, such as heating or HVAC as a whole, are rejected or postponed, as they require investments that may be difficult to cope with, in a given situation.

In such situations it is possible, by “building automation control”, to improve the efficiency of these systems by more than 20%; with a moderate investment and a “simple payback period” below the estimated period of durability for the system on which action is taken.

- Such buildings do not usually have electrical wiring previously integrated within their structure, which makes the installation required to implement comprehensive building automation control systems more difficult, and may generate significant cost overrun.

This problem can be minimized by using radiofrequency devices already available in the market, which reduce significantly the scale of work to be performed, protecting elements in buildings with high architectural or heritage value without losing functionality.

Lighting:

- The implanted and tested systems for lighting control in the buildings of San Valero Foundation, combining KNX Bus + DALI + AF/LED Fluorescence + Light sensors + Scene definition; have shown potential savings of 40% to 70%, depending on use of rooms and type of luminaires installed.

- In the tested systems, consumption savings obtained by lighting regulation are inversely proportional to those previously obtained by the more efficient technological renovation of lamps and luminaires (e.g. DALI + AF fluorescence vs. LED tubes...).

- The isolated devices, as may be the detectors, although initially offer less savings (e.g. 20%) are widely accepted by the sector and have a good cost/benefit balance and a short simple payback period, given their low cost.

- By regulation and depending on the type of task to be performed in each of the premises, the high minimum level required for lighting in some public buildings determine the minimum power of lamps to be installed.

In premises requiring a high lighting level and, consequently, high lighting power installed, control systems and the use of natural light are particularly relevant; and can reduce consumption by up to 25%.

- In the definition phase of the domotic/inmotic automation system to be implemented, it is important to establish precisely the intensity of use of the lighting system (hours/year); because it is very relevant to calculate the system performance, profitability and the simple payback period of the investment.

Occasionally, if the intensity of use is low, except for reasons of convenience, comfort, sensibility or teaching; a mere replace of lamps and luminaires with more efficient and properly diversified ones may be sufficient to achieve good levels of profitability and optimal return on investment, without having to implement more complex regulatory systems that would break the cost/benefit ratio.

- It is important to attend to the correct location, orientation and number of light sensors that will provide the signal that the controller will use to adjust the light output to the real needs of the premises depending on the amount of daylight in order to:

- Prevent one single sensor from controlling different areas of action where, due to the building orientation, arrangement of windows or other causes, the brightness is different from the one that may be detected at a given time (e.g. the sensor installed inside the east facade of a building would receive natural light in the mornings, and would get to control lights located on the west facade, where the afternoon sun would be received).

- Avoid false readings due to the effect of reflective surfaces or objects towards which sensors may be oriented. If they are facing the windows, it is very important to take into account their location and distance from them in order to ensure an adequate measure of daylight.

- The automation of blinds, combined with the lighting management systems, simplifies the scene definition to increase visual comfort and gives the system greater versatility; allowing, for example, the darkening of a room with a single action and taking advantage of the dim light when needed.

HVAC:

- As it was the case with lighting systems and in combination with them; blinds automation, preferably external to avoid the thermal effect of solar radiation, and integrated within the HVAC management system; allows, when necessary, to reduce or even eliminate thermal loads from the windows of the room, generating significant savings.

- Once again, the BMSs, as tested on the action carried out in the PRAE by the Natural Heritage Foundation (SEDICAL + DEXCELL + Measuring and control devices), have proven to be effective tools to ensure comfort in the premises, optimising the performance of the renewable energy generation systems and reducing consumption by up to 50%.

- The usefulness of the BMSs is also confirmed by the result of 35% reduction in HVAC consumption obtained by FSV in San Jorge University; modifying the setpoint temperature in chillers, based on the preliminary analysis of the information provided by the system.

The conclusions outlined here as a “lessons learned” are but a small sample of the extensive list of benefits that could be listed; arising from the implementation of devices, home and building automation systems and consumption and building management systems (BMS) tested under the project.

As an end to three years of experimentation and testing of devices and systems for building automation favouring “smart building” and benefiting the environment, the fight against climate change and the economy; the following conclusions and final considerations must be mentioned:

1. The average potential reduction in energy consumption provided by the “automation and building control and management systems” tested exceeds 40%; with results of up to 70% in some cases and configurations.

2. The average potential reduction of CO_2 emissions has exceeded 500 t CO_2 / year.

3. Based on the obtained results, the average simple payback period for this type of facilities, is about 4 years.

4. The continuous monitoring of consumption and the combined action of building automation and BMSs have been key factors to obtain the proven environmental and economic benefits.

5. Without the active and committed participation of users, any automation system could fail in its results. Consequently, to plan and conduct regular awareness campaigns and training for the users of the facilities is of vital importance.

Regarding transfer, this project will also generate synergies for efficiency and savings that will favourably affect the behaviour of people towards their environment; with a clear multiplying effect for the benefit of the environment and the fight against climate change.

6. In response to the constant increase in the price of energy, it is very important to check and adjust the electrical power contracted to the actual consumption needs; based on the information provided by the BMS installed.

7. Contracting Energy Service Companies (ESCOs) that address the maintenance and optimization of systems for renewable energy production and consumption to generate savings is an ideal way to boost the market for home automation, building automation and BMS technologies, based on reducing energy consumption, improving efficiency ratios and proven return on investment (ROI) periods.

10. A PROJECT IN PICTURES

10. A Project in Pictures

10.1. Sites of Action and Development

Below there are some images of the sites of action and development...

In the Secondary Education and Vocation Training Building – San Valero Foundation

In the University of San Jorge Building – San Valero Foundation

In the PRAE Building – Natural Heritage Foundation of Castilla y León

10.2. Partnership Meetings and Visits to Actions

The meetings of the Project consortium enabled the monitoring of the implementation of the Project, of its objectives and its results.

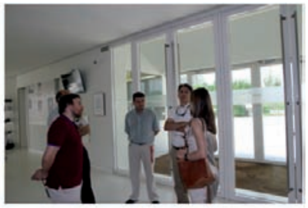
In addition to the consortium coordination meetings, other meetings with the external assistance of the European Commission were held, as well as inspection visits of the desk officer and of the financial unit of the European Commission. These meetings were as follows:

25/10/2010	Launch of the Project meeting in Zaragoza
02-04 /11/2011	Meeting of partners and external assistance with visit to the Valladolid and Zaragoza premises.
15-16/05/2012	Meeting of partners with visit to the Valladolid and Zaragoza premises.
10-11/12/2012	Meeting of partners with visit to the Zaragoza premises.
17-19/06/2013	Meeting of partners with visit of the desk officer and the financial unit of the European Commission to the Zaragoza premises.
14-15/05/2014	Meeting of Partners and Final Conference with visit to the Valladolid premises.
09-11/07/2014	Meeting of Partners and visit of the external assistance of the European Com mission in Logroño.

Transnational meetings and Monitoring and Desk Officer visits to the San Valero Foundation.

Visits to the University of San Jorge.






Transnational meetings and Monitoring visits to the PRAE building of the Natural Heritage Foundation of Castilla y León.







10.3. Dissemination Review

Project and Partners Websites

http://www.lifedomotic.eu

http://www.sanvalero.es/fsv/proyectos_europeos

http://www.patrimonionatural.org/ver_proyecto.php?id_proyecto=72

http://praecyl.es/prae.php?fija_id=69

http://www.grazer-ea.at/cms/projekte/domotic/content.html

http://www.adesos.org/index.php/proyectos

http://eid.com.es/Domotic.html

http://www.casadomo.com/tags/life-domotic

Informative Materials.

Among other informative materials the following have been developed:

- Project Brochure (various editions).
- L-Banner.
- Roll-up.
- Flyer.
- Poster.
- Panels.
- Information plaques on network models of energy efficiency.
- Notepads with pen.
- USB pendrives.
- Laser pointer.
- Smart pen.
- Digital glove.

Seminars and Conferences

- 06/09/2010 Presentation of the Project due to the final meeting of the Eco-Diagnostic LdV Project for sustainability and efficiency in SMEs, held in Zuera (Zaragoza-Spain).
- 20/09/2010 Presentation of the Project in the course of the transnational meeting and training day provided by EID for “Efficient Energy Management in Municipalities” in Teruel, in the framework of the “Minus 3%” Intelligent Energy for Europe (IEE).
- 30/09/2010 Presentation of the Project because of the transnational meeting in which the EID participated as a member of the LIFE + POWER Project, in Zaragoza (Spain).
- 04/11/2010 Presentation of the Project because of the transnational meeting in which the EID participated as a member of the LIFE + CONNECT Project, in Zaragoza (Spain).
- 08/11/2010 Presentation of the Project in the events of the 15th Anniversary of the Leonardo da Vinci Programme.
- 17-19/02/2011 Presentation of the Project at the Education, Training, University and Employment Fair that, as its name suggests, is divided into four sections: education, training, college, and employment. This meeting was held at the Zaragoza Trade Fairs Venue (Feria de Zaragoza).
- 22/02/2011 Presentation of the Project in the Natural Gas Foundation Meeting, Valladolid.
- 30/09/2011 Seminar on home automation taught by SEAS (Open College) in San Valero Foundation.
- 17-20/10/2011 Presentation of the Project at the Conferences on Energy and Environment, Zaragoza.
- 24-31/10/2011 Presentation of the Project at the Workshop on energy efficiency as new source of job opportunities made in collaboration with the Employment Service of the Autonomous Community of La Rioja.
- 24/11/2011 Presentation of the Project at the Workshop on energy efficiency in Leisure Centres, Zaragoza.
- 29/11/2011 Presentation of the Project within the framework of the Regional Forum held in the city of Valladolid, in the PRAE building, where the DOMOTIC Project on “innovation and sustainability in the field of information technology and communication: Green-ICT “ is being developed.
- 20/12/2011 Presentation of the Project at a meeting with a target group of hospitals and schools in Klagenfurt, Austria.
- 16/02/2012 Presentation of the Project at the Symposium Energieinnovation (Technical University Graz, Austria).
- 13-14/03/2012 Presentation of Communication of the “DOMOTIC” Project: “Exemplary Performance of the Potential to Reduce Energy Consumption and CO2 Emissions in Existing Buildings” at the II Congress of Energy Services held in Barcelona.
- 15/03/2012 Presentation of the “DOMOTIC” Project at the conference held at the premises of San Valero Foundation (FSV) about the “ARDUINO” free hardware.
- 20/04/2012 Presentation of the Project at the Commemoration day of 20 years of LIFE in Castilla y León.
- 21/04/2012 Presentation of the Project at EUREM (European Energy Manager), Graz.
- 25/04/2012. Presentation of the Project at Grazer Energiegespräche (Graz, Austria).
- 02/05/2012 Presentation of the Project at THINK GREEN! Brussels, Conference of the European Economic and Social Committee on the Opportunities of Sustainable Development and the Green Economy.

- 07/05/2012 Presentation and publication of the Project´s communication in the plenary of the First Congress of Nearly Zero Energy Buildings.
- 22-25/ 05/2012 Presentation of the “DOMOTIC” Project by communication during the GREEN WEEK in Brussels.
- 23/05/2012 Technical Presentation on Home Automation, Logroño.
- 30-31/05/2012 Presentation of the Project in II Spanish Congress on Domotics CED2012.
- 19/06/2012 Presentation of the Project in the Sustainable Energy Week, Zaragoza.
- 09/2012 Inclusion of the Project in the Strategy for Sustainable Energy Management of the city of Zaragoza - 2010/2020.
- 27-30/11/2012 Presentation of the Project in POLLUTECH 201, Lyon (Francia).
- 26-30/11/2012 Presentation of the Project at the National Congress on the Environment (CONAMA), Madrid.
- 13/02/2013 Networking Meeting. Partner Construction21 Project Intelligent Energy Europe, Valladolid.
- 26-28/02/2013 Presentation of the Project in GENERA 2013, Madrid.
- 10-12/04/2013- Presentation of the Project in II Smart Energy Congress, Madrid
- 10-11/04/2013 Presentation of the Project at the Congress on Comprehensive Building Rehabilitation (RIED), Madrid
- 17/04/2013 Networking. Partner: INNOVAge Project. INTERREG IVC, Valladolid
- 23/04/2013 Presentation of the Project in Ausbildung für Energiebeauftragte - Seminar for Energy Managers. Graz, Austria
- 03-06/06/2013 Presentation of the Project in Green Week 2013, Brussels.
- 05/06/2013 Presentation of the Project in Optimierungspotenziale mit GLT in öffentlichen Gebäuden – Workshop on Optimization Potential with BMS in Public Buildings. Telepark Bärnbach, Austria,
- 17/06/2013 Presentation of the Project in OPTISOL Project meeting, Zaragoza.
- 19/09/2013 Presentation of the Project at a Training Course for Public Employees on Environmental Management Systems, Valladolid.
- 24-26/09/2013 Wind PowerExpo, Zaragoza.
- 14/05/2014 DOMOTIC Final Conference, Valladolid.
- 04/06/2014 Presentation of the Project at the Energy Efficiency and European Regions Conference, Brussels.
- 06/06/2014 Presentation of the Project at the Casadomo-Smart Buildings Workshop, Madrid.
- 11-13/06/2014 Stand and Project Presentation in the 17th edition of TECMA, the Urban Development and Environment International Trade Show, Madrid.
- 12/06/2014 Annual Award for “Energy Efficiency” of the Spanish Association of Energy Agencies (EnerAgen) to the DOMOTIC Project, Oviedo.

Institutional Presence.

05/02/2011 Press Conference of the Minister of Environment of the Autonomous Government of Castilla y León on the implementation of the "Natural Areas against Climate Change" programme, including the DOMOTIC Project among the main priorities of the programme.

8/09/2011 Visit of the Minister of Innovation of the Autonomous Government of Aragon to the San Valero Group premises

Presence in Television.

TV spots edition (20”, 60”, 4’).

Broadcast on TV:

RtvCyL Castilla y León (from 12th to 22nd February).

15 20”-spots, 22 60’-spots and 10-minutes interview.

Zaragoza local TV (from 4th March to 4th April).

25 20’-spots, 7 60”-spots and 2 4’-spots

Popular TV La Rioja ((from 4th March to 4th April)

TV Magazines: “Marcador”, “Punto de Vista”, “Que quede entre nosotros”, “La Rioja y Cia” “Pelota”.

Articles and Publications.

Digital Bulletin: Sustainable Development in Castilla y León. No. 0, September 2010.

Newsletter of the Association of Information Technology Companies of Castilla y León. AETICAL 17/02/2012.

Nearly Zero Energy Buildings Congress Conference Book, May 2012.

Digital publication “20 years of LIFE in Castilla y León”, May 2012.

National Congress on the Environment (CONAMA) Conference Book, October 2012.

Article in CYL Digital Magazine, April 2014.

Article in the special “e-volution” section within the supplement about innovation in “El Norte de Castilla” regional newspaper, May 2014

Article in the special “cutting edge” section within the supplement about innovation in “El Mundo” regional newspapel, May 2014.

Special section LIFE DOMOTIC in Casadomo digital media, June 2014.

Article in “Futurenergy” web magazine, June 2014.

Article in “Electroeficiencia” specialized journal, number 16, June 2014.

Article about the Project in KNX Spain Newsletter, number 22 and in KNX web, August 2014

Proyecto europeo LIFE DOMOTIC:
Sistemas de control y monitorización de consumos energéticos en tres edificios

LA DOMÓTICA
al servicio de la EFICIENCIA ENERGÉTICA en los EDIFICIOS PÚBLICOS

La automatización, la informática y la tecnología permiten un ahorro energético de los edificios sin reducir la comodidad y la seguridad de los usuarios.

PANORAMA
Proyecto domótico

Sistemas de control y monitorización domótica de consumos energéticos, en tres edificios

Proyecto europeo
LIFE DOMOTIC

PROYECTO EUROPEO LIFE DOMOTIC: MODELOS DE CONTROL Y MONITORIZACIÓN DOMÓTICA DE CONSUMOS ENERGÉTICOS

EUROPEAN PROJECT LIFE DOMOTIC: DEMONSTRATION OF MODELS FOR OPTIMISATION OF TECHNOLOGIES FOR INTELLIGENT CONSTRUCTION

10.4. International Conference

The Final Conference of the European Project LIFE DOMOTIC took place on the 14th May 2014 in Valladolid, at the Proposals for Environmental Education Centre of Castilla y León (PRAE).

Besides presenting the results of the project, more than 70 managers and designers of buildings met, mainly belonging to the fields of Management and Education, as well as industry professionals, to discuss and disseminate the economic, environmental and social aspects of home automation.

On this day the latest developments in software and applications for energy management in buildings (KNX, and DexmaTech) or in certification of buildings using building automation (CEDOM) were presented.

Specific domotic applications for the elderly and disabled were also presented (Industrial Technology Centre of Extremadura and University of Burgos), as well as applications for historical and heritage buildings, (Santa María la Real Foundation), and applications for blind control and lighting in offices (Luxmate).

The important role that the dissemination and training services play for the development of the automation industry, such as Casadomo Communication Website (Tecmared Group) was also analysed.

The presentation of the project results was carried out by the architecture department of the Natural Heritage Foundation of Castilla y León and by the Alvarez Beltran group, San Valero Foundation technical assistance for the development project.

Conclusions:

- Ongoing monitoring of consumption, in the context of “Provision of comprehensive services for Energy Management”; should be included in contracts entered into with the “Maintenance companies”, if the sustainability of the systems over time is to be ensured.

The incorporation of this “new service” (control of energy production & consumption) will make these companies different from those just offering maintenance services, giving them a “competitive advantage” that will strengthen customer confidence and promote their inclusion in the emerging market for Energy Service Companies (ESCOs).

- The choice of “open systems” for device management and energy production and consumption control versus “proprietary systems” is key to reducing dependence on third parties, ensuring the durability of the facilities, the compatibility between devices and reducing future costs by adapting them to new settings.

- The “Energy Management” systems should now be considered as part of “a whole” that goes beyond the traditional consumption measurement and control of facilities; in an orientation that allows forming a harmonized network of “Smart cities”, based on the development and integration of “Smart homes”, “Smart buildings”, “Smart metering”, “Smart grids” and “Smart mobility” plans.

- Audits and procedures for energy production and consumption monitoring should not be limited to compare the results of measurements made in time; but they also have to consider other external factors affecting energy production and consumption such as the “weather”, “occupancy levels”, “change of use of the facilities” and the possible evolution of users “behaviour and conduct”, among others; that is, a “deviation factors control” must be added to ensure the homogeneity of the data to be compared and, ultimately, the validity of audits.

- Home and building automation control systems have evolved in concept and exceed the pure and simple automation devices, a concept that has to take into consideration the characteristics, the physical environment of the building where the systems are being implemented as well as its bioclimatic conditions. It is therefore

necessary to consider very carefully and from a multidisciplinary perspective, the areas of control, measurement methodologies and automation systems to be implemented.

For example, for lighting control it will be necessary to evaluate whether to implement heliometers to control the performance of the motorized exterior building blinds and interact with the DALI (Digital Addressable Lighting Interface) and with the information provided by light sensors. Regarding the latter, their location and orientation will have to be studied in detail to ensure that they do not provide values based on internal illuminance. On the other hand, from the point of view of measurement, derived deviation factors will have to be considered, for example, the influence of climate and its relation with the structural characteristics and orientation of the building.

- The programs (software) designed for the "energy rating of buildings" should allow to discriminate the influence and the savings generated by the implementation of the "automation systems" (for control and automation) from those generated by the mere introduction of a number of other efficiency measures, or by the substitution of the existing equipment for a more efficient one; considering the implementation of the standard UNE-EN 15232 "Energy performance of buildings"; that integrates the calculation methods of energy efficiency improvement through the application of integrated building management systems.

- The "historical heritage" buildings, with high architectural value, or those containing masterpieces with high artistic value, have enormous potential for improving energy efficiency; but also have the limitation imposed by their structure or works of art, which cannot be affected by any implemented action. There are minimally invasive monitoring systems (machine to machine), created ad hoc for this type of control (e.g.: Heritage Monitoring System: a project for environmental, structural and safety parameters monitoring that has been designed as a tool to implement a preventive conservation methodology, which has developed and uses devices that are specifically adapted to the "Historical Heritage").

In this field, there is technology that can be installed without any major building work, that is maintenance free and versatile to be adapted to future changes in the interior layout of the building (e.g.: EnOcean that combines miniaturized energy harvesters with very low power consumption radio technology; its wireless networks of sensors can operate for decades without any maintenance whatsoever, they are flexible and ensure significant cost reduction and energy saving).

- "Negative marketing": it is very important not to devalue the proven usefulness of home and building automation control systems by, for example, misusing or underusing the already installed systems. An example of "negative marketing" is what occurs in some installations where a high percentage of the implanted lighting control system is deactivated.

- Automation systems applied to "Social Services" are especially relevant as future field of development and implementation of these technologies; as they not only aim to improve the energy efficiency ratios, but also put automation at disposal for the "elderly", the "disabled" and the people in "dependent care".


DEXMA
Herramientas de gestión
DOMOTIC


www.lifedomotic.eu
DOMOTIC


DOMOTIC


www.lifedomotic.eu


Universidad de San Jorge


DOMOTIC

11. FIRST EUROPEAN NETWORK OF MODELS FOR ENERGY EFFICIENCY (MEMBER ENTITIES)

11. First European Network of Models for Energy Efficiency (member entities)

Within the DOMOTIC project, a network of organizations committed to the smart management, energy saving and efficiency of buildings was created in order to promote the exchange of experiences of organizations committed to energy efficiency of buildings and the use of domotics and inmotics. All this in order to promote the European strategy to fight against climate change through measures that can be easily carried out.

This on-line network tries to gather together entities that are aware of environment and committed to it and that already have or are planning to install home automation applications and energy management systems for buildings. This network is visible on the project website. www.lifedomotic.eu

In addition, member entities can submit and share their experiences in this field, becoming public in the website of the European Network for Best Practices.

The network member entities may use a plate or badge designed for this purpose that will allow them to identify themselves as members of the Network of European Energy Efficiency Models.

Miembros de la Red

- SANVALERO
- Grazer ENERGIEAgentur
- Patrimonio Natural de Castilla y León
- ADeSOS
- ALVAREZ BELTRAN
- ESCI
- termoservicio
- Instituto Aragonés del AGUA
- ase ingenieros
- Zaragoza
- Binder Lern:werk
- SIEMENS
- Instituto de la Construcción de Castilla y León
- arquitectura
- Fundación cidaut
- LUXMATE
- Ayuntamiento de Valladolid
- UVa
- Sphera
- Instituto de E.S. Inventor Cosme García
- pirener instrumentación equipos de medida
- ENACE
- Universidad de La Rioja
- adra
- biosar
- Open Domo services
- DEXMA Energy Management
- otc
- Sarmentero
- acma
- Ayuntamiento de Logroño
- Bioma
- ifor-net
- Colegio Oficial de Ingenieros Técnicos Industriales de La Rioja
- ecotelia
- PROLUS s.d.l. S.L.
- EMESA
- proenergy
- cenitsolar
- ECO WORLD STYRIA
- reprise print or screen?
- KNX
- arquidomo estudio
- CALENAE
- AP Control
- aeice Construcción Eficiente

Team members who have sent their best practices in energy efficiency

Example:

University of La Rioja (UR):

- Study of thermal energy optimization for the Polytechnic Building at the UR.

- Definition of installations needed to efficiently cover the needs of the Higher Technical School of Industrial Engineering premises at the University of La Rioja.