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UNIVERSIDAD DE CANTABRIA

ENERGY MANAGEMENT, MARKETING OR NEED?

Improvement with Energy-Saving Building Automation

GESTIÓN ENERGÉTICA, ¿MARKETING O NECESIDAD?

Mejora con ahorros energéticos producidos por automatismos

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Master Final Dissertation

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As always, fighting for you.

Miguel Ribot Rodríguez

ABSTRACT

One of the problems that threaten the well-being of today's society is Climate Change. Climate Change occurs due to an increase in the level of emissions of greenhouse gasses, mainly CO^2, to the environment.

The industrial sector is one of the most significant contributors to this phenomenon due, among other factors, to the energy consumption. Hence, the interest in energy efficiency and in minimizing environmental impacts has increased. On this basis, it has been encouraged the use of tools or methodologies to know, evaluate and reduce the energy used for constructions.

This Final Dissertation seeks to be a continuation of the thesis that I developed one year ago, in which an attempt was made to answer whether **Energy Management is marketing or a clear necessity that all businesses and institutions should implement** and to identify the profitability (economic and financial), productivity and competitiveness of certified systems of energy management in order to obtain relevant information on the effects of its implementation in Spain, in which it was concluded that it was beneficial in both directions, a need to implement it for the savings achieved and an extra economic benefit reported by "green company" marketing.

The previous Master Thesis was developed using conventional methods of action, now it is intended to take the next step, trying to improve the results with the implementation of automatisms.

This thesis attempts to **investigate whether the implementation of automatisms in buildings is profitable or not.** To answer this question, a series of concepts such as the current state of energy, types of automatisms and smart cities are put in context and the reasoning for implementing an energy management system is explained. Next, the European regulations and legislations regarding efficiency and energy management are described.

After the introductory part of the subject matter, this thesis investigates through a case study in the city of Cañada del Hoyo, Cuenca, whether it is cost-effective to implement a system of energy management improvement with Energy-Saving Building automation or not. At last, in order to evaluate the energy performance and identify energy efficiency measures that have achieved a reduction in costs and environmental pollution through energy savings, this work identifies the potential energy savings and the investments on energy efficiency measures needed to achieve these savings.

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GLOSSARY

AC	Air Conditioning
BACS	Building Automation and Control System
BAS	Building Automation Systems
BCS	Building Control System
BEMS	Building Energy Management Systems
BRE	Building Research Establishment
BSRIA	Building Services Research and Information Association
COP	Conference Of The Parties
CTE	Código Técnico De La Edificación
EESC	European Economic and Social Committee
EMAS	Eco-Management and Audit Scheme
EMS	Energy Management System
EPA	Environmental Protection Authority
EPBD	Energy Performance of Buildings Directive
ESE	Energy Servies Company
EU	European Union
FD	Final Dissertation
GBCe	Green Building Council España
GHG	Greenhouse Gases
GPP	Green Public Procurement
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information And Comunnication Technology
IEA	International Energy Agency
IISBE	International Initiative on Sustainable Built Environment
INE	Instituto Nacional de Estadística
ISO	International Organization For Standardization
LEED	Leadership in Energy and Environmental Design
MIMO	Multiple Input – Multiple Output
MTOE	Million Tonnes of Oil Equivalent
NZEB	Nearly Zero Energy Building
PME	Power Monitoring Expert
SGEI	Service of General Economic Interest
SMEs	Small and Medium Size Enterprise
TBM	Technical Building Management
UPM	Universidad Politécnica De Madrid
USGBC	United States Green Building Council

Introduction

I CHAPTER

1. INTRODUCTION

Nowadays, the main concerns of the European Union's energy policies are the current financial and economic crisis, as well as the wider environmental pressures (climate change, security of energy supply, etc.). Towards this direction, the building sector has a key role in development of a viable strategic framework. Indeed, buildings are responsible for about 40% of the EU's total final energy consumption and greenhouses emissions, putting them among the largest end-use sectors globally (IEA, 2010). For example, energy savings of 10–40% are possible in commercial buildings by closely monitoring and supervising energy usage and related data.

The Directive 2010/31/EU (recast) is a new legislative instrument at EU level to achieve energy performance in buildings. Under this Directive, Member States shall ensure that:

- By 31 December 2020, all new buildings are nearly zero-energy buildings.
- After 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

In recent years, integrated building automation systems are applied to control lighting, cooling/heating, ventilation, etc. The role of building automation and control systems is a part of the whole problem. The majority of recent developments have followed the advances made in computer technology, telecommunications and information technology. Although these systems have become increasingly popular, the necessity for smart tools and methods, to provide remote control and real-time monitoring of building energy consumption, facilitating "green buildings" envelopment, remains.

Current buildings performance assessment tools are deficient in their ability to integrate and process building monitoring data to generate actionable information that can assist in achieving a higher level of building performance.

Building Automation Systems can be considered as a tool in the hands of building operations personnel that provides a more effective and efficient control overall building systems.

1.1. Objectives

The objective of this dissertation is the continuity of the TFM "Energy Management, Marketing or Need?" that I developed in the Master of Building Management at the Polytechnic University of Madrid, which deepens in the systems of energy management and in the implantation of one in a town hall, in Cañada del Hoyo, Cuenca.

In this project, conventional energy reduction measures were taken, such as changing luminaires, changing boilers, optimizing tariffs and uses...etc. The idea of this final dissertation is to continue improving the results with automations that can also help not only energy management, but also for the control of security, fires, installations and access.

Once again, it is tried to demonstrate if with these extra measures to those already implanted, **it is really cost effective to implant a EMS in an SME** or in this case in a city hall.

To achieve this, partial objectives have been established:

- Know booming concepts such as the implementation of automatisms in buildings and see that more fields than energy can be useful.
- Respond to the issues raised.
- As a master project focusing on Europe, efforts will be made to focus on issues at European level.
- Know the legislation and regulations that regulate the automatisms in buildings.
- Put in a practical case the implementation of automatisms in buildings, which allows to prove with data if it is profitable and try to quantify the savings achieved.
- Make conclusions from what was initially proposed.

With the implementation of automatisms, a reduction in energy consumption in buildings is expected, as well as being beneficial to other parts of the building, as well as a reduction in maintenance costs by extending the useful life of the components and reducing emissions of CO^2.

1.2. Methodology

To achieve the objectives, briefly describe the methodology to be followed, distinguishing two phases work, and a previous phase of documentation:

Previous phase, Information gathering of previous research is the first step, relative to:

- Documentary research on the evolution of energy efficiency in recent years and the latest advances.
- Documentary search of building automations.
- Documentary search on management tools and software, indicators, impact assessment methodologies, simulations, etc.
- Legislation in force in the field of automation at European level.

Phase I, analysis and critical review of the information collected that includes the following points:

- Study of the energy situation in Europe.
- Analysis of the benefits and disadvantages of EMS.
- Analysis of the different types of automatisms that exist and how they help improve energy efficiency.
- Study of the standards and applicable legislation.

Phase II, application of implantation of a EMS with automations in the municipality of Cañada del Hoyo, Cuenca.

For its elaboration, the process that has been followed during the accomplishment of the practical case has been:

1. Contact with the municipality, its situation and characteristics
2. Collection of information on buildings and energy inventories
3. Compilation of actual consumption of each building
4. Interpretation of results

5. Analysis and summary of measures previously adopted
6. Development of possible improvement options
7. Selection of the most appropriate set of improvements for the town hall
8. Project feasibility analysis
9. Economic Analysis
10. Conclusions

Finally, conclusions are drawn from the results obtained.

So, it could be said that the research consists of three mains methodology protocols:

- Theoretical research
- Practical implementation of the Investigation
- Evaluation and interpretation of the results

State of the Art
Energy-Saving Building Automation

II CHAPTER

2. STATE OF THE ART - ENERGY-SAVING BUILDING AUTOMATION

As demonstrated in the TFM "Energy management, marketing or need?" With the action of small measures taken by man can realize large reductions in energy consumption, but what is the next step?

This section aims to show how the energy situation in Europe is, to know what energy management and new energy management systems, but mainly to analyze how the automatisms are breaking in the building sector and what benefits can bring us.

2.1. Energy Situation in Europe

2.1.1. Situation

Nowadays, natural resources are being reduced considerably, there is an increasing population in the world and a greater dependence on energy consumption. This consumption is considered essential for industry, commerce and also for personal comfort and mobility. But their production and consumption impose considerable pressures on the environment: emissions of greenhouse gases and air pollutants.

Most countries depend on fossil fuels (oil, gas and coal) to meet this demand. The combustion of these fuels when converted to energy also releases large amount of CO^2 that is transmitted to the atmosphere. As well as other atmospheric pollutants (sulphur dioxide, nitrogen oxides and particulates), which affect air quality, climate change, damage to natural ecosystems or human health.

In 2016, the European Union's Bureau of Statistics (Eurostat) presented a report entitled "Energy, transport and environment indicators", which gives us an overview of the state of the EU in terms of energy consumption. (Foro Europa Ciudadana, 2016)

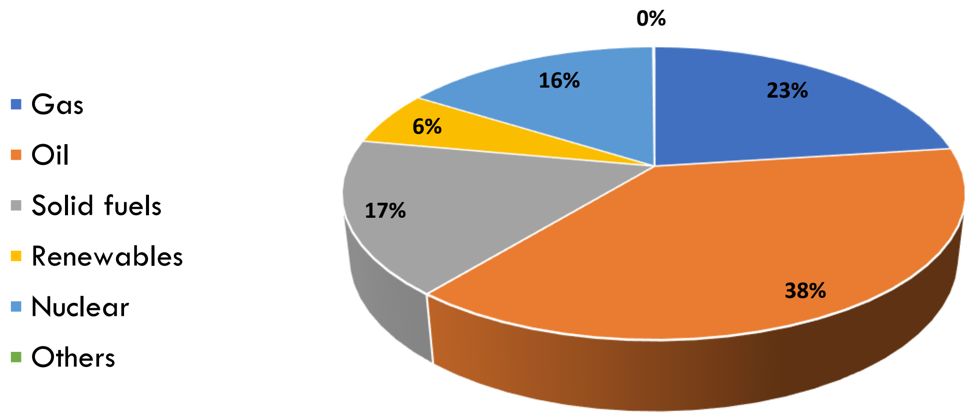


Fig. 1. Energy consumption 2004. Source EUROSTAT

The study states that in recent years there has been a decline in total energy consumption of 4% in relation to 1990. According to the type of energy there has been a 41% decrease in energy from coal, 15% of Petroleum. In turn, energy from renewable sources has increased by 180%, natural gas by 17% and nuclear by 10% compared to 1990. (European Comission, 2016)

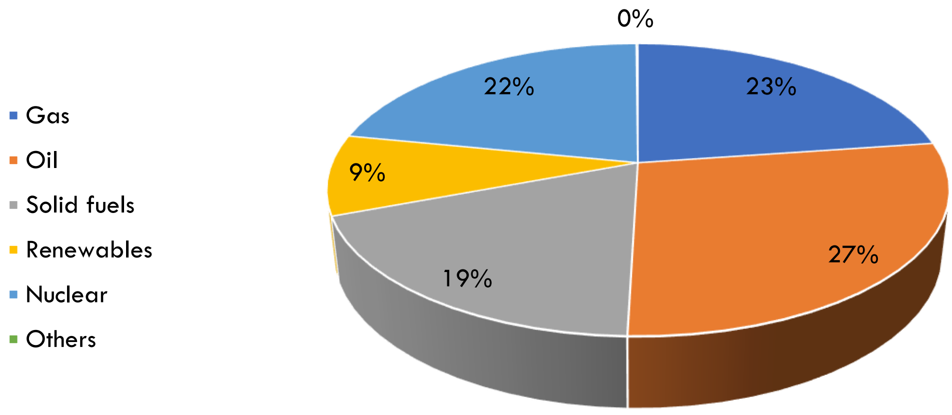


Fig. 2. Energy Consumption 2015. Source EUROSTAT

Regarding the emission of greenhouse gases, the report also comments on the decrease in the EU of 22.9% between 1990 and 2014. The countries with the highest number of emissions are Germany, the United Kingdom and France. Malta (+ 48.7%), Cyprus (+ 36.4%) and Spain (+ 16.9%) had the highest increases in gas emissions in the 1990s.

In general, we can distinguish the following sectors of consumption. In the US, the most important is the industrial sector, which consumes approximately two-fifths of the total electricity produced throughout Europe. Following the transport around 25% and the place that occupies us is the residential sector, consumes 14% of the world's energy, and it seems that in the future will continue to represent the same weight as the current.

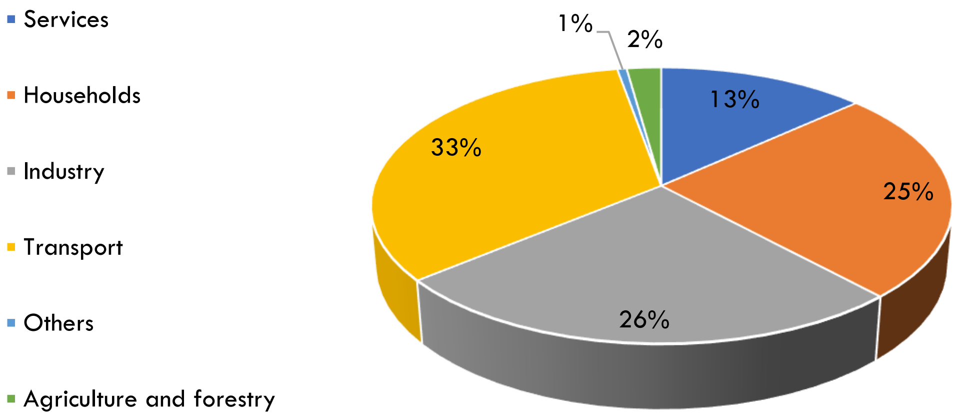


Fig. 3. Consumer sectors. Source: BSRIA

Within the residential sector, it is worth mentioning the different uses of these energies, since 34% is dedicated almost exclusively to luxury housing, 50% to shopping centers and hotels, and only 16% is destined for housing.

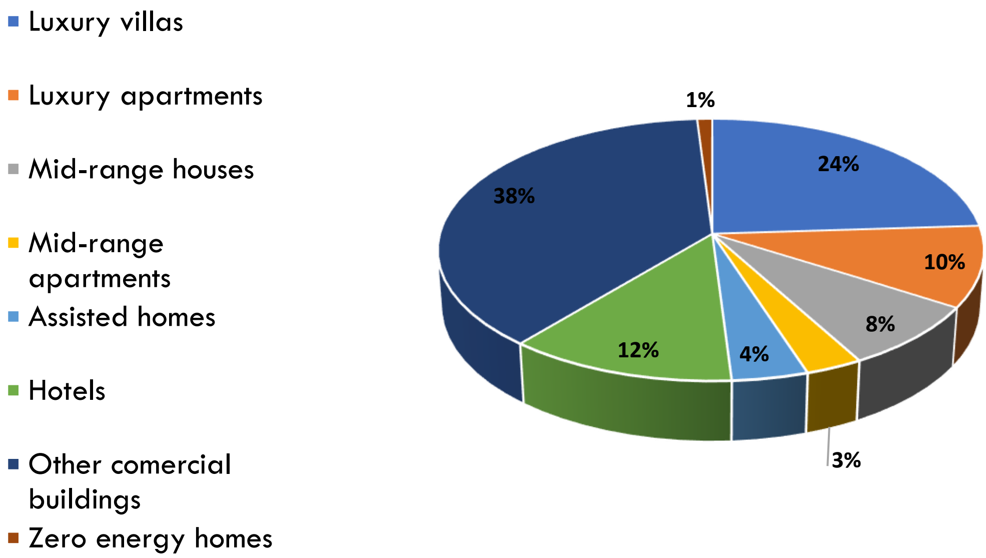


Fig. 4. Consumer sectors in the residential area. Source: BSRIA

Buildings applies that the hems are les called Smart homes.

As we saw in graphs fig3 and fig 4 is producing a small reduction in energy consumption. This began to be noticed in 2008 where we can observe a small reduction due to the global economic crisis, a technological advance in the residential area and a greater awareness on the part of the users.

It is worth mentioning the appearance of controls regarding the efficiency of appliances (energy label) replacing conventional light bulbs with more efficient ones (LED) or the installation of automated systems where the energy management in the Home (HEMS).

The HEMS provide updated Information on energy and budget to help optimize the use of energy in the home. They can provide an easy to use application that allows a utility company program demand to avoid peak periods, and you can integrate all components in the home (Including electric vehicles, energy storage and micro-generation).

The buildings to which the hems are applied are called Smart homes. (BSRIA, 2014)

2.1.2. Smart Homes

Smart Homes are buildings that use technology to communicate through a local network providing integrated control of two or more subsystems at home. If the Smart Home system can be accessed remotely over the Internet, BSRIA refers to it as a connected home.

Although the early Smart Home systems tended to be stand-alone solutions, focusing solely on "lifestyle" needs such as lighting and entertainment, the current versions generally cover more energy management and are accessible via the Internet, Regular landlines or mobile phones. (Martín Martínez, 2013)

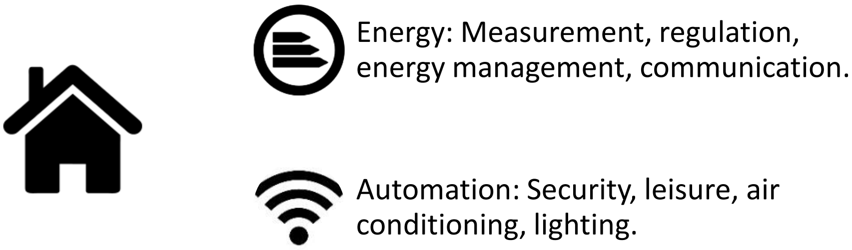


Fig. 5. Smart Home scope. Source: Own Work

Smart homes are able to control:

- The system of environmental control (heating, air conditioning and ventilation)
- Home appliances (clothes dryers, washing machines, refrigerators, freezers, dishwashers, ovens, coffee makers, microwave, etc.)
- Consumer electronics (TV, radio, audio-video equipment, consoles games, etc.)
- Components of construction (blinds, curtains, windows, doors, etc.).

The residential consumer awareness has increased throughout Europe, mostly due to the growing popularity of smartphones / tablets in solutions for smart homes. However, the high cost of a Smart Home solution prevents these systems to reach the mass market.

The European country that bets more on smart homes is Germany. Although in general the US residential sector sectors, while the commercial and hotel sectors are beginning to be implemented.

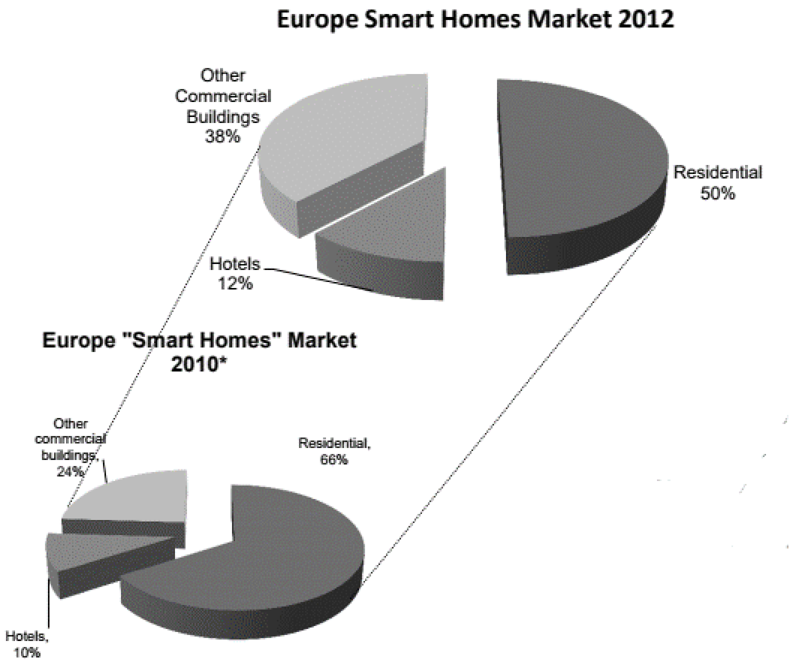


Fig. 6.Variation of the number of smart homes. Source: BSRIA

Lighting controls are the primary application for these systems, with environmental controls second, as customers have increasingly been concerned about their energy bills and the need to reduce energy consumption.

Studies report that using an automated lighting system can save up to 30% of electricity.

As well as a heating energy saving of 15% to 20% through automation heating in residential buildings.

The savings and energy efficiency that can be made by consumers will determine the future health of the planet. The future lies in a combination of energy savings through more efficient use of energy, alternative sources (especially renewable energies within the EU) and increased international cooperation. (Endesa, 2017)

Despite this meticulous improvement, it is clear the global need that the planet requires in reference to energy efficiency reducing energy consumption, improving energy efficiency and increasing the share of renewable energies are the main ways in which European countries are responding to the challenges of reducing GHG emissions, improving energy security, improving resource efficiency and reduce exposure to volatility of fossil fuels.

2.1.3. Smart Cities

The Smart City is to take the concept of smart houses to the next step.

When we talk about Smart City we are talking about urban environments where new technologies have a positive impact on the inhabitants and, through ICT solutions, promote sustainable mobility, energy efficiency in its streets (Smart Grids) or in its buildings (Smart Buildings).

But when we talk about Smart Cities we are talking about much more than this definition of smart cities. The concept of Smart City entails a change of mentality closely linked to the process of digital transformation that has already begun in many areas of our daily life and, at the same time, moves and extends to our urban environment. When we talk about cities of the future, in fact, we refer to the cities of the near present because of the need that we have at present of directing the future to a better destination.

And all this in a context of massive population growth in cities in which, according to an OECD report (Organization for Economic Co-operation and Development), more than 70% of the world's population is expected to live more years and therefore it is necessary to articulate measures that make them habitable and sustainable for their citizens and their environment, while generating wealth and professional opportunities. (Andalucía es digital, 2016)

This situation does not go unnoticed by the governments of the main cities of the world, nor by organizations such as the European Economic and Social Committee (EESC) or initiatives such as JPI Urban Europe, which, through programs such as the ERA-Net Smart Cities and Communities, promote Innovation in 12 EU countries, including Spain, to achieve the long-awaited Smart target within Horizon 20-20-20.

All this makes us focus the future on the need for a Smart City model

It is here where the Smart City objective becomes more than an option or a future approach is already a necessity in the present of the majority of the urban nuclei that, in a more or less imminent way, they face problems derived from that Constant increase of their populations that can lead to:

- Problems in the care and quality of public services that can't respond to overdemand in particularly sensitive aspects such as health, education, security or social services.
- Problems in the environmental quality resulting from overexploitation of resources with risk of shortages.
- Increased costs in services such as electricity, water and waste management.
- Slow attention to citizenship by an administration saturated with requests and efforts.
- Increased pollution of large cities.
- Mobility problems due to increased traffic and use of private vehicles.
- Saturation of the working market and of the classic models of occupation.

However, the benefits of implementing the Smart City be would be huge.

The problems of the above list are the objectives that seek to solve the Smart City where, through smart solutions and ICT solutions such as the Big Data and Internet of Things, promote a new way of understanding the relationships of citizens and its urban environment and drive these benefits in our environment (Sarkar, 2017):

- In smart cities, the quality of life of its citizens increases.
- A Smart City is committed to improving the quality of public services that become more efficient.
- The Smart city reduces CO^2 emissions and reduces the impact on the environment.
- In Smart City, there is a real communication between citizens and their city.
- It promotes transparency and trust in the administration that governs the life of Smart City.
- Smart cities reduce costs of services through Smart solutions.
- Smart City improves the city's relations with its citizens and makes the urban environment accessible, welcoming and sustainable, improving the quality of life of its inhabitants.

Key Elements for a Smart City.

When laying the foundations for the implementation of a Smart City model, the first requirement that cities have to bet on is the connectivity of the entire urban environment, from now on must be understood in a global concept which will have the following technological elements (Enerlis, Ernst and Young, Ferrovial and Madrid Network, 2012):

- E-administration and open access solutions to open platforms to encourage decision-making shared with the citizen at the center of decision-making.
- Smart Citizens or smart citizens who participate in decision-making processes and are aware of the benefits of being part of a smart city.
- Sensors (Smart Sensors) applied in public furniture that consistently report data for efficient waste management, lighting systems with photovoltaic panels, efficient traffic management with intelligent smart signals ... In short, connected cities

- Use of Big Data solutions for the collection, interpretation and response and constant interconnection with the citizens through interconnected networks (Smart Grid) or elements of the public furniture that allow to report any incidence, consultation or claim (Internet of Things)
- Smart buildings that focus on energy savings and the generation of their own solutions for energy self-sufficiency. These Smart City solutions are moved to homes through home automation systems that efficiently manage our homes.
- Sustainable transport in both public and private mobility systems through efficient vehicles (electric car, bicycle rental networks, efficient public transport)
- Management of urban planning and city planning based on the use of resources and efficient management through solutions such as super city blocks that have an impact on improving the quality of life of citizens.
- Elements and tools of Cybersecurity that guarantee the privacy in the communications and the management of the personal data that the citizens report and that guard the Administration.

One of the problems with these systems is that the current electrical system is not prepared to send instantaneous information about the cost of electric energy and that most companies set a price for electricity and do not distinguish when it is cheaper or More expensive which makes it impossible to apply it in real time. However, contracts are gradually emerging where more than one price is set, for example differ between night and day, and in the near future this division will be greater along with the arrival of Smart Grids until it is possible to do so in time real.

Another difficulty is that although the new houses may have energy management systems, most of them do not have systems that allow it so they require a change in their systems (plugs, controllers...etc), and therefore systems are needed Effective as well as cheap to increase your installation.

2.2. Energy Management and Energy Service Companies

Energy management consists of optimizing the use of energy, seeking rational and efficient use, without reducing the level of benefits.

To achieve this, we will need an Energy Management System (EMS), which is part of the management system of an organization dedicated to developing and implementing its energy policy, as well as managing those elements of its activities, products or services that interact with Use of energy.

A EMS is based on the PDCA (Plan-Do-Check-Act) continuous improvement cycle, also known as the Continuous Improvement Cycle or Deming Circle, compatible with other energy saving and efficiency measures. (Asociación Española para la Calidad, 2017)

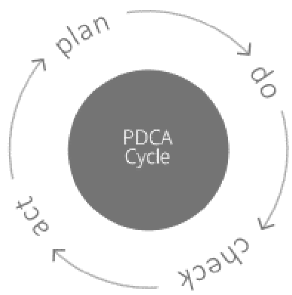


Fig. 7.Continuous improvement EMS. Source: Own work by Deming Circle

A EMS consists of a system parallel to other management models for the continuous improvement in the use of energy, its efficient consumption, the reduction of the energy consumptions and associated financial costs, the reduction of greenhouse gas emissions, The proper use of natural resources, as well as the promotion of alternative and renewable energies.

It is worth highlighting the ISO 50001: 2011 Standard, which establishes the requirements that an Energy Management System must possess, in order to make continuous and systematic improvements in the energy performance of the organizations.

Another fundamental tool for the correct Energy Management is the **energy audit.** (Jimeno Bernal, 2013)

In which an auditor who dominates the different measures of energy saving related to the existing technologies as well as their energetic implications from a point of view of the energy saving that would generate as well as from an economic point of view and of profitability record of the proper enforcement of the system to be audited.

As a result of the audit in the implementation of a EMS in the long run, the reduction of costs and improvement of the energy efficiency would start to be noticed with the consequent improvement of productivity and competitive advantage of the organization. Incorporation of new technologies linked to production systems and processes, with the consequent technological innovation and competitive advantage.

2.2.1. Energy services companies

Today, it would be desirable for all companies to be aware of the importance of having an energy policy based on the achievement of objectives such as improving energy efficiency, reducing consumption and protecting the environment. Through a correct energy management could reduce the costs associated with the use of this type of resources and would be a way to increase their competitiveness.

The general basis for establishing savings and energy efficiency policies entail a continuous system in which not only is it measured but managed by monitoring energy consumption, the application of management tools such as energy audits and energy management systems.

The main reason for implementing a EMS should be the need to ensure the supply of energy to future generations through responsible production and its use in an efficient way. The Certification of Energy Management Systems is aimed at those organizations that want to demonstrate that they have implemented an energy management system, make greater use of renewable or surplus energy, and/or have systematized their energy processes, seeking their coherence with energy policy of the organization.

An Energy Services Company (ESE) is a company that provides energy services in a specific installation or building, facing a certain degree of economic risk by conditioning the payment of the services provided to the actual obtaining of energy savings. These savings will be achieved through the implementation of measures to improve energy efficiency and save energy consumption, as well as the use of renewable energy sources.

In this way, for a client, the ESE manages to optimize the energy management and installation, recovering the investments through the energy savings achieved in the medium-long term.

The services provided by an ESE are of a wide variety. In fact, all services that allow energy savings and / or economic savings for an installation or building could be included in the scope of the services of an ESE. Thus, the simplest services, such as the temperature control of a building, to other more complex and technological measures that require greater investment, such as the installation of a renewable energy source of its own, would be within its scope.

Generally, the types of energy services that an ESE can develop are listed below.

Types of Energy Services of an ESE					
Energy Audit	Project design	Construction and installation	Exploitation	Operation and maintenance	Control, measurement and verification

Fig. 8.Types of Energy Services of an ESE. Source: Own Work

All these services can be independent of each other or developed jointly and complementary by the same ESE. The joint development is precisely one of the advantages of the service provided by an ESE, which allows the client to have a single partner and outsource all the services required in a single organization (Ribot Rodríguez, 2016).

2.2.2. Why Implement and Certify a EMS?

The reasons why a company or institution may become interested in implementing and certifying an energy management system are the following:

- To promote an energy policy that integrates the philosophy of energy efficiency in the organization, which in turn can be compatible with other existing management systems.
- To improve business results by identifying precise technical solutions thus improving the energy efficiency of processes in a systematic way. This entails a reduction of costs, optimization of the use of resources, reduction of energy intensity (energy consumption / GDP).
- To show a responsible and economically profitable attitude (cost reduction) through cost prevention, a suitable tool to facilitate the role of the Energy Manager and implementation of actions from energy audits.

- Knowing the current and future mandatory regulatory objectives on energy efficiency and GHG reduction.
- To demonstrate this conformity to others by certifying their energy management system by an external organization.
- Not to have the exclusive external energy dependence and the risks derived from the oscillations of the prices of the energy resources.

In addition, implementing and certifying with an energy management system we make sure to carry out the following objectives set out in ISO 50001:

- Fostering energy efficiency in organizations
- Encourage energy savings
- Encourage improvement in energy performance
- Reduce emissions of gases that cause climate change
- Ensure compliance with energy legislation
- Increase the use of renewable or surplus energy
- Improved demand management

Fulfilling all these points brings with it a series of environmental and energy benefits such as optimization of energy use (energy efficiency), reduction of CO^2 emissions to the atmosphere, reduction of environmental impacts, adequate use of Natural resources, and a boost to alternative and renewable energies.

The company would also be positively impacted by leadership and corporate image giving an image of commitment to sustainable energy development, committed to climate change and compliance with legal requirements.

2.3. Automation to improve energy efficiency

The best way to reduce costs is to consume less energy. And one of the best ways to achieve this is intelligent building automation or automation systems (BAS). BAS is concerned with improving the interaction between integrated systems and the inhabitants/users of buildings.

Historically, BASs were developed from automatic HVAC control (Heating, ventilation, air conditioning), improving human comfort and reducing energy costs. In the last years, they have been extended to other domains and the BAS added to systems of telecommunications, office automation, management of computer buildings, security, among others. Until today the field in which the researchers are dedicating more efforts is the one of energy consumption in buildings.

State-of-the-art intelligent buildings play a key role in advanced electrical networks known as smart grids. By expertly combining building technology with distribution transmission, smart grids can significantly improve efficiency.

Building automation is a fundamental part of energy management systems.

These are responsible for managing energy consumption through timers, programmed clocks, thermostats, etc. What allows to carry the programming and zoning of all type of electrical appliances, air conditioning or domestic equipment

They also allow the rationalization of electrical loads by disconnecting equipment of non-priority use in function of the electric consumption at a given time. The detection of opening windows and doors. And carry a lighting control with on and off of indoor and outdoor lights depending on degree of brightness, presence detection, etc. (National Science Foundation, 2013)

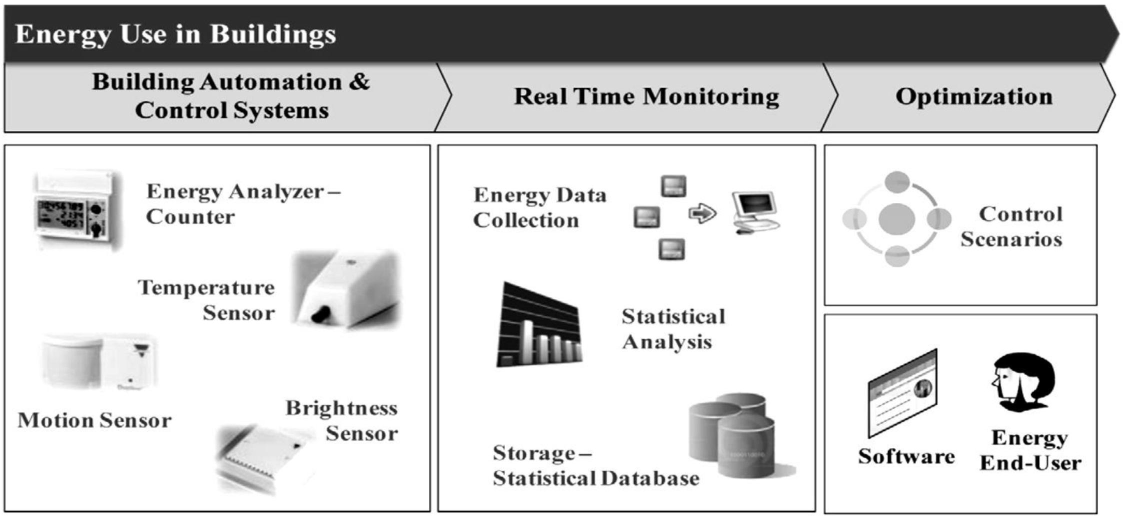


Fig. 9. Tools Philosophy Source: www.elservier.com

Carrying out all these measures ends up producing a reduction in contracted power. Where the electric tariffs are managed by running the operation of some appliances at reduced tariff hours, or by using them through charge accumulators.

The automation of buildings also creates transparency since all the data of the installation are available at the moment. Through personalized visualizations integrated to the analysis of the operation of the building that help to its continuous optimization

To implement an energy management system through automation is necessary to make a large initial investment that will feed back with the profits produced. (Asociación Española de Domótica, 2008)

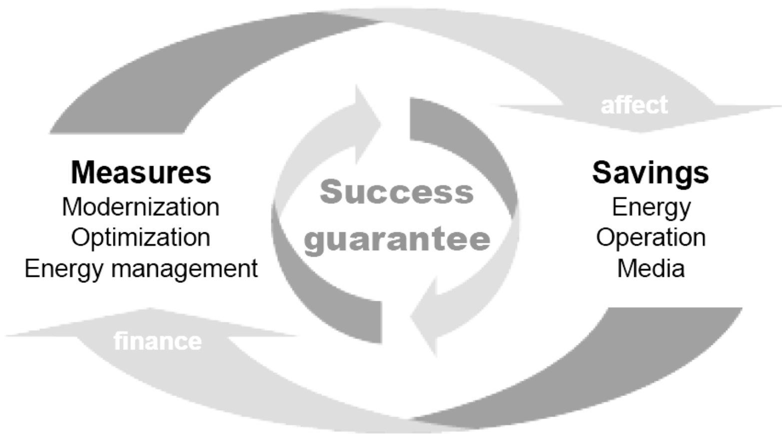


Fig. 10. Performance contracting. Source: Siemens

Tap existing energy saving potential in your customer's building technology with targeted renovations and optimization. Resulting in lower operating costs and increased values. The required investments pay for themselves from savings in energy and operating costs throughout the contract period. A savings guarantee ensures your customer's business success. Updating technical plants and guaranteeing functions during the contract period also increases operational security.

And we make a valuable contribution to the environment together with our customers by saving energy. (Morales Barroso & Gómez Moreno, 2006)

A win-win situation for the building operator with performance contracting consist of:

- Added value through modernization
- Savings pay for investments
- Risk-free thanks to success guarantee
- Function guarantee during the contract period
- Sustainable quality assurance by energy management
- Secured financing

2.3.1. Fields of application

In general, you can distinguish two types of buildings depending on whether the building is oriented to housing or services. Residential buildings or residential buildings, where applications are more oriented towards comfort and safety, and large non-residential buildings, where services are more oriented to energy saving and improving the working environment.

- Housing of new construction: In this case it is recommended the placement of a specific wiring that transmits the necessary information between the different elements of the system.
- Reform of existing housing: In this case, a non-wired solution is recommended where the installation requirements are minimal since it is possible to take advantage of either the own electrical network of the dwelling or the radiofrequency technology as a means of transmission. In any case, they are simple to use and their cost has been significantly reduced in recent years.
- Non-residential buildings: Non-residential buildings are classified according to their purpose or specific use, and may be designed for various purposes. This way you can differentiate the following types of building:
    - Hotels, hostels, hostels and similar buildings.
    - Properties for offices and buildings dedicated to the wholesale and retail trade.
    - Buildings for transport and communications.
    - Industrial buildings, warehouses and for farms.
    - Buildings of cultural, recreational, educational or sanitary use, and dedicated to worship and religion.
    - Monuments declared of artistic or historical interest.

- Other buildings not included in other items.

Depending on the intended use of the building, the most suitable power grid will be designed.

You can also differentiate the dwellings depending on the type of user that inhabits them. It is not desirable to think of the same model of intelligent house for the whole population. In other words, the concept of intelligent house should not be univocal. For this, three specifications are taken into account that determine the type:

- Size and composition of the home.
- Division of labor.
- Age and status in the family life cycle.

2.3.2. Classification of Automated Systems of Housing Environments

Depending on the configuration used to implement its functions, it is possible to differentiate between centralized systems and decentralized systems. (Cortés, 2016)

- ***Centralized systems:*** These are systems in which the elements to control and monitor (sensors, lights, valves, etc.) are connected in a single point, generally to the central control unit, which contains the intelligence of the whole system. In centralized configuration systems, the communication between elements passes through the central unit. This system is widely used, for example, in security management or in energy management. Centralized systems have two drawbacks:
    - The control system is the heart of the house, which means that if it is missing, everything stops working.
    - In addition, the easiest way to supply products that operate with this design is by producing the complete system. This creates a dependency on a single brand, since it does not ensure that elements of one manufacturer can communicate with those of others.
- ***Decentralized systems:*** In this type of systems there are different control elements, each of them has the capacity to treat the information that it receives and to act accordingly in an autonomous way. In these systems, the control elements are as close as possible to the elements to be controlled.

  This method eliminates the two problems mentioned in the centralized system. There is no central control unit, and therefore, the user does not depend on a single manufacturer; On the other hand, the failure of any element does not affect the operation of the rest.

  In addition there are other advantages, such as the ease of reconfiguration of the system, which directly affects the degree of flexibility, and especially in the wiring savings of the installation. Being more expensive systems are also more powerful systems, which allow to implement a large number of applications and services to the user. As an inconvenience, this system implies a standardization of the messages and the way in which they are to be transmitted: all the equipment must be able to receive and understand the messages sent by other elements. On the other hand, the greater cost of the elements of the system also entails another drawback.

(Observatorio Industrial del Sector de la Electrónica, Tecnologías de la Información y Telecomunicaciones, 2010)

Proprietary Systems: In a distributed system, the communication protocols can be opened or closed (denominated also proprietary) (Wicaksono, et al., 2012).

- Closed or proprietary systems are those in which control nodes use a closed communication protocol, that is, a protocol that has been created solely to communicate the products of a manufacturer. Generally, these equipments are more economic although they have a great dependence of a single manufacturer and high costs of maintenance.
- Open systems are those in which control nodes use a standard communication protocol. These systems offer more viable solutions and the different protocols have evolved enormously. They originate in the 1990s, and are presented with more complete solutions than proprietary protocols, and with the ability to integrate products from different manufacturers. Its maintenance has lower costs, there is a wide range of products, and it has a lot of flexibility and extensibility.

A domotic system can combine several of the previous systems, having to fulfill the requirements applicable in each part of the system.

Here are some SOFWARES management platforms highlighted for power automation:

- **ISOTools** helps you automate your ISO 50001 system, it is a perfect tool to accompany your company in the process of implementation, maintenance and automation of ISO 50001, making it a simple system to handle. ISOTools is a fully parameterizable and adaptable tool that guides the implementer to meet the requirements of the standard and facilitates communication among the people of the organization thanks to a scalable alerts system.
- **Desigo System - siemens**, helps reduce operating costs and reduce energy consumption while maintaining, providing a rapid and flexible response to changes. Taking into account the use of the building, and the life cycle. The stations can also be programmed to measure. Switches, sensors and actuators for lighting and are integrated and allow to monitor and operate multiple disciplines in the building.

  The automation system used is the Dupline system. The Dupline decentralized building automation system combines heat, lighting, A / C and other building monitoring procedures that provide high standards of comfort, safety and energy-saving potential.

  Where energy users have the ability to control energy consumption and control the operation of building appliances without their active participation in different parts of the building installation. The proposed tool offers energy-efficient automation functions, maximum comfort for the user and energy savings at the same time.

  Other software for automation of siemens is SIMATIC, which reaches new levels of efficiency thanks to our uniform and integrated platform and the use of open interfaces and reusable modules.
- **Power Monitoring Expert 7.2 -Schneider** is a complete power monitoring and management solution that can integrate measurement of electricity and other inputs

such as water, air, gas and steam. PME delivers the right information to the right person anytime, anywhere.

The monitoring module of the PME software allows to monitor in real time and remote to the conditions of the energy system providing the reports and the information that you require, of the form in which you need it

Its application is fully scalable and the information that it provides is adapted to its needs to give timely follow-up to its indicators related to its energy inputs, whether electrical or not (water, air, gas, electricity and / or steam).

- **SMARKIA 50001** is a cloud tool to automate and simplify energy management with the aim of achieving great energy and economic savings. Based on ISO 50001.Smarkia, it allows to test the platform with a few measurement points and increase as needed. Continuous information, monitoring and control of consumption (electricity, water, steam, diesel, natural gas ...) and the many factors that affect it. Detection of consumption deviations from the trend thanks to automatic calculation.

  Create alerts and configurable tasks according to the user profile. Allocation of the energy cost per work center, production line, measurement equipment or unit produced. Accessible from anywhere and at any time. It does not need specific infrastructure to obtain the consumptions of the organization. Smarkia is a multifederation, multiprotocol and multienergy tool. Security in all processes, access, encryption, backup and recovery of data.

2.3.3. BACS

Building Automation and Control Systems (BACS) are sets of hardware and software that are networked to monitor and control environmental systems in industrial and commercial buildings. These environmental systems include mechanical and electrical services such as lighting, heating and air conditioning.

BACS generally consist of several sensors and controllers, a centralized web server and at least one UI device. Controllers are basically small computers designed to control the devices or subnets of other controllers. The Web server monitors the drivers and UI device, often a desktop or handheld computer, allows the person to receive information about the system from the Web server.

The advantages of installing a BACS in a new building or upgrading an old system are that they are vastly more energy efficient than structures without such a system. This is because the BACS can be adjusted to adjust lighting systems and heating and cooling equipment when the building is vacant, thus reducing energy costs. This can also help qualify a building for EPA Energy Star or LEED process to give a title.

BACS can notify building managers and maintenance personnel of any problems, allowing them to react immediately and appropriately to the situation (Siemens, 2016).

Since the BACS takes care of all these functions, with only the building manager assisting the main user interface device and possibly some controllers could take all the maintenance, so the maintenance costs are also reduced.

Problems are constantly monitored, so that issues can be addressed as they arise. For these reasons, installing a BACS in a new structure or upgrading a system in an older building is a worthwhile investment.

BACS are the brain of the BAS building as they monitor, optimize, interconnect and control. The fields of application and the BACS are (Fraunhofer Institute for Building Physics IBP, 2015):

- Heating systems
- Air conditioning systems
- Cooling systems
- Lighting systems and blinds
- Fire and security systems
- Elevators

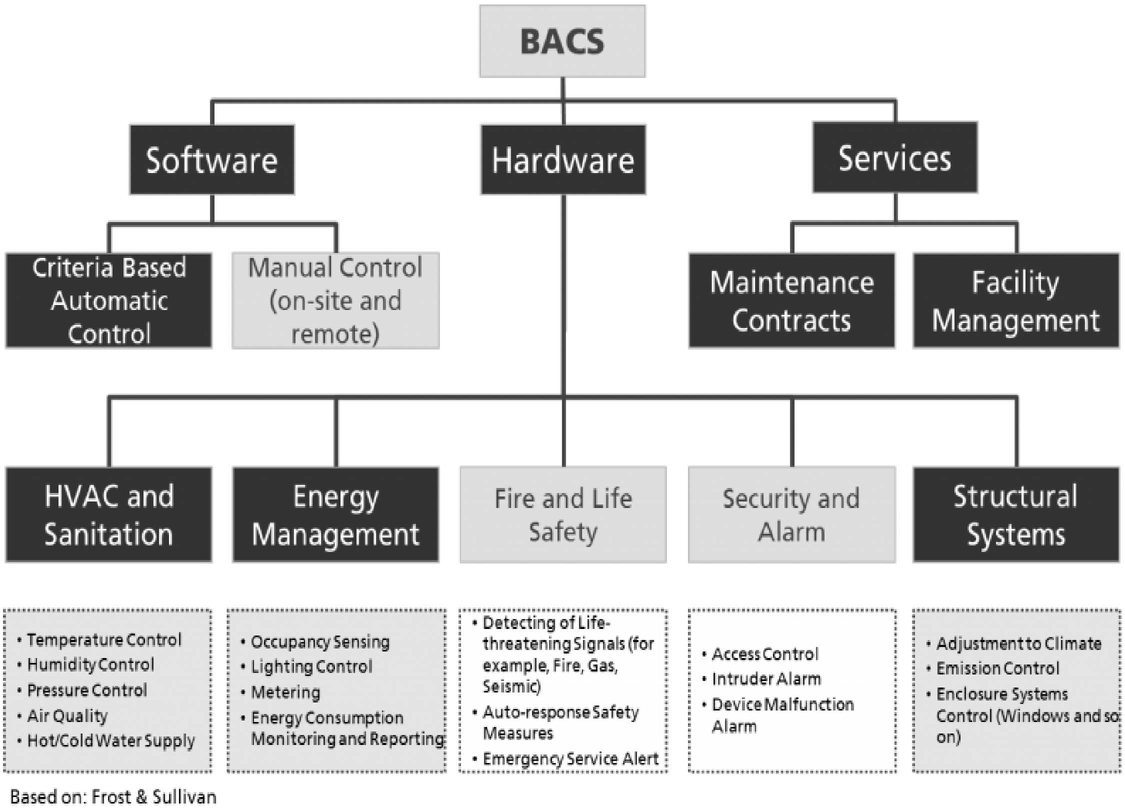


Fig. 11. BACS scope. Source: Frost & Sullivan.

2.3.4. TBM

The objective of TBM is to contribute intelligently to a global supervision of technical installations such as heating, ventilation, air conditioning, electricity or lighting as well as security and safety systems (alarms, access, ...) centralizing all information about a Base common management tool.

TBM allows the "connection" of the technical equipment of heating, comfort and security of the building. For the general purpose of Insurance, Mastering, Saving and Managing. Know in real time all the technical information of the building and to solve the problems quickly before the user is aware of the anomaly of monitoring of the installations and the realization of diagnoses which often avoid unnecessary trips.

The main objectives are: consuming less, polluting less, spending less for the same level of comfort, the same results and the same service. Three steps to do so (ALTEREA, 2014):

1. ***Transparency:*** measure, see and control the energy performance of your technical installations for more transparency = establishment of an energy metering plan. After analyzing your site, we will define the most "energy consuming" aspects and we will advocate the installation of meters adapted to your needs in order to have a precise measurement of your energy consumption.
2. ***Intelligence:*** optimization solutions and improvement of functionalities of your TBM offer more intelligence to your system. All that is needed is to understand the needs, identify opportunities, establish an action plan and implement it.
3. ***Performance:*** technical installation modernization solutions and reducing your energy consumption adds value to your building. It is necessary to amend the technical facilities to increase the energy efficiency of heating, ventilation, and air conditioning by including a performance guarantee. The project must ensure sufficient gains to finance the work and services for energy optimization with a present investment return time (Energy Performance Contracting).

2.3.5. Different Types of Automation in Buildings

Implementation of the home automation depends on the type of controls like wired or wireless. There are mainly three types of home automation systems (Kyas, 2013):

- Power Line: A power line system is the most affordable of all home automation, as it relies on your home's existing power lines to transfer your tools to a control interface. On the upside, this system can easily cover your entire home. However, on the downside, this technology may need noise filters and isn't as advanced as other types. Typically, power line systems are X10 technology based, which is the most popular, albeit oldest, protocol for home automation.
- Wired: In this type of automation, all the home equipment is connected to a main controller (programmable logic controller) through a communication cable. The equipment is attached with actuators to communicate with the main controller. The entire operations are centralized by the computer that continuously communicates with the main controller.
- Wireless: This is the expansion and advancement of wired automation which uses wireless technologies like IR, Zigbee, Wi-Fi, GSM, Bluetooth, etc., for achieving remote operation. As an example, the GSM based home automation provides the controlling of home equipment by an SMS to the GSM modem. As a practical example, the following home automation system project, in which loads are controlled by a touch panel, is very informative.

2.3.6. Main Components of Domotic System

- ***Sensors:*** The mission of a sensor is the conversion of magnitudes from one nature to another, usually electrical. These magnitudes may be physical, chemical, biological, etc. In a building, they will be in charge of providing all the necessary information for its later management. Common sensors are temperature, humidity, presence, lighting, etc. In most cases, the sensors have an encapsulation through which it achieves a correct operation by preventing it from being affected by external conditions other than the magnitude to be measured.

The following are the most important characteristics that define the operation of a sensor (Schneider Electric, 2012):

- Amplitude: Difference between measurement limits.
- Calibration: Known pattern of the measured variable that is applied while observing the output signal.
- Error: Difference between measured value and actual value.
- Accuracy: Concordance between measured value and actual value.
- Scale factor: Relation between the output and the measured variable.
- Reliability: Probability of non-error
- Hysteresis: Difference travel of the measure to increase or decrease this.
- Accuracy: Dispersion of the output values.
- Noise: Unwanted disturbance that modifies the value.
- Sensitivity: Relation between the output and the change in the measured variable.
- Operating temperature: Sensor operating temperature.
- Zone of error: Band of allowable deviations of the output.
- Several classifications of sensors can be made according to their characteristics, for example by feeding them:
- Active: They must be fed electrically to the appropriate levels (voltage, current, etc.). They are the most common.
- Liabilities: Do not need power.

Fig. 12. Sensors. Source: Google images

- ***Actuators:*** They are the electromechanical devices that act on the outside environment and physically affect the building. They convert one electrical quantity into another of another type (mechanical, thermal ...), somehow performing a reverse process to that of the sensors. Actuators can maintain continuous or discrete output levels.

  Examples of actuators can be the motor of a shutter, the contactors of a lighting circuit, lamps, radiators, sirens, etc.

- Relays: switches that allow switching higher power circuits through a low power signal.
- Contactors: they are relays of greater power.
- Dimmers: are devices based on semiconductors that allow to regulate the power that arrives at a load.

▪ ***Solenoid valve:*** Valves whose opening is controlled by an external electrical signal. They are mainly used to control flows of liquids or gases.
    - Electric motors: They convert electrical energy into mechanics to generate, in this way, a movement.
    - Electrical resistances: They are used to raise the temperature of the medium where they are

▪ ***Controllers:*** It is the system unit capable of receiving, processing or processing the information, according to a pre-established program or algorithm, and communicating it, when applicable, to the corresponding actuators. Thanks to the evolution of embedded electronics, some sensors and actuators have become autonomous by incorporating the function of the processor. In short, it is what characterizes the architecture of the system.
    - Physical regulators.
    - Microcontrollers.
    - Microprocessors.

▪ ***Gateways:*** A gateway is a connecting element between different networks of a house or building (domotic control, telephony, television and information technology) to a public data network, such as the Internet, Adaptation and translation between different protocols.

  The domotic control network may or may not be connected to the residential gateway; In case it is connected, the node can also perform the functions of residential gateway.

▪ ***Network:*** You can define a network as:
    - An interconnection of nodes (agents, devices ...) that exchange information or resources.
    - A set of independent interconnected elements.
    - A multiplicity of agents (nodes) acting autonomously (independent) coordinating spontaneously in the network and forming a reticular universe.

2.4. Energy Management Maintenance

One issue that we can't forget is maintenance. Proper maintenance achieves quality standards and reduces energy costs. Good preventive maintenance will reduce the need for corrective maintenance and as a result you will get better installation performance, reduced costs and a better quality of service.

As a result of a malfunction of the installations can cause excessive consumption of energy. Therefore, a regular maintenance program should be established that includes the following points:

- Replace the filters according to the manufacturer's recommendations, keep the surfaces of the exchangers clean, as well as grilles and vents in the air ducts.
- Check operating controls on a regular basis.
- Check that all solenoid valves and gates open and close completely without jams.
- Check that thermostats and humidifiers work properly.
- Check the calibration of the controls.
- Check the boiler plant and combustion equipment regularly.
- Detect water leaks in pipes, faucets and showers and repair them immediately.
- Clean windows for maximum natural light.
- Clean lamps and luminaires regularly, and replace at intervals recommended by the manufacturer.

Normally, the energy management system is based on a computer and a management software. However, the essential element of the program must always be the operator or person in charge of energy management.

The system receives energy consumption information, equipment on / off times and status variables that affect consumption. From there, the management of energy demand can have a highly variable level of complexity.

The simplest level is the accounting of energy consumption, not only in terms of costs, but also an analysis of energy consumption and price, and maintenance control.

The next step is to have sensors that send information to the computer that makes the reports, leaving the decisions in the hands of the person in charge of energy management.

Finally, the computer can perform actions on the equipment based on the information received, according to a specific program. This is the case of greater complexity and sophistication that ensures proper operation under changing conditions.

The availability of computer equipment and programs suitable for management, at very affordable prices, have allowed the widespread use of computerized management techniques for many of the tasks performed in a building or in any industrial process. Building and facilities management systems are increasingly being applied in all sectors of economic activity. It is the managers responsible who should decide which system is the most appropriate in their business.

From the current state of the art, the proposed expert system or intelligent energy management system (EMS) explicitly includes the supervision, diagnosis and prediction of future consumption between its functionalities, as well as the capacity to control consumption of energy. Plant to avoid the appearance of unnecessary consumption tips. This means that it performs not only a monitoring and analysis of data, but also active and innovative management, since it is able to intervene in production processes automatically and intelligently, as long as the user enables it for this.

The EMS will be based mainly on its ability to create load and consumption models based on information collected and entered by users, with which it can generate:

- Consumer Profiles.
- Prediction of consumption.
- Distribution of loads over time.
- Reduction of consumption peaks and contracted power.
- Diagnosis and detection of anomalies by detecting deviations from the models.

As a complement to improving electrical efficiency and taking advantage of the system infrastructure, you can also perform the following functions:

- Diagnosis of the installations and the quality of the electrical network delivered by the network operator.
- Determine by means of measurement of energy quality parameters, the impact of loads on the electric grid.

After analysing the energy management systems currently available and the available scientific literature, the general summary of the state of the art can be seen in Fig. below, which presents the tools currently used in EMS, and the areas of innovation Research and technological development.

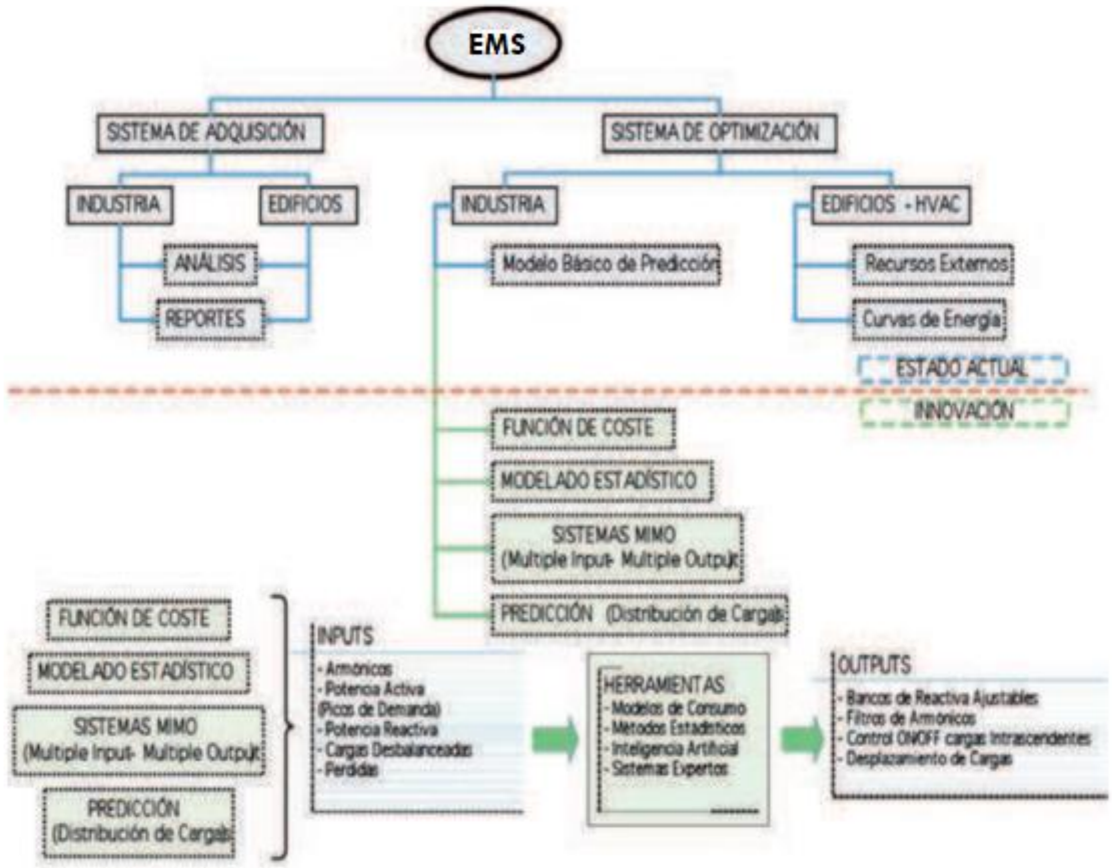


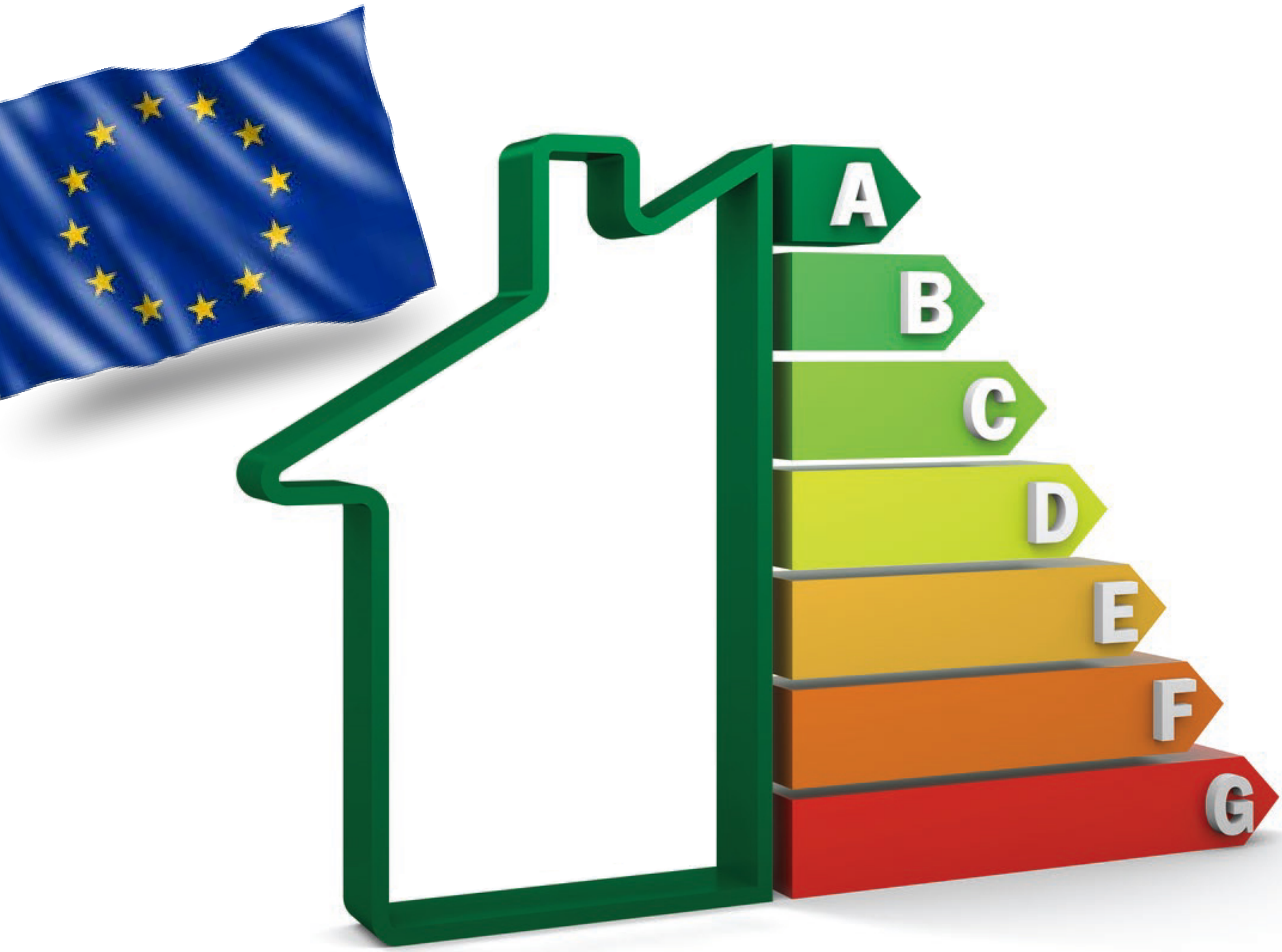
Fig. 13. Current tools and trends in EMS. Source: Enertika

The energy management model of the industry is much more complex than the building management model, which is summarized in the management of external resources and the prediction of energy curves.

In industry, by means of prediction models, cost functions and statistical models can be performed to manage them with MIMO systems, that means, that through the data entry and the correct use of tools can make some corrections to help us save energy.

In short, in this consists the implementation of the use of automation, in collecting data that through the right tools, could self-correcting possible and unnecessary energy costs without the need to intervene.

Standards and Regulations



III CHAPTER

3. STANDARDS AND REGULATIONS

3.1. Evolution of energy efficiency and management legislation

The Energy Efficiency Directive in buildings is the main European standard aimed at ensuring compliance with the EU's building objectives in relation to containment of greenhouse gas emissions, energy consumption and energy efficiency and generation of energy from renewable sources.

Directive 93/76 / EEC on the limitation of carbon dioxide emissions through the improvement of Energy Efficiency begins with Europe's concern to improve the energy efficiency of its buildings and thereby the objective of reducing its emissions of greenhouse gases. For the first time, some of the programs that will be developed later in the Building Energy Efficiency Directive (EPBD), such as the energy certification of buildings, the thermal insulation of new buildings and the periodic inspection of boilers are discussed.

The European Directive 2002/91 / EC on Energy Efficiency in Buildings was born in 2002, and as a maximum term it should be adapted in the member countries four years later, in January 2006.

In 2010 the previous EPBD was merged into the Energy Efficiency Directive 2010/31 / EU in Buildings, introducing concepts such as the comparative methodological framework to calculate the optimal levels of profitability of the minimum energy efficiency requirements of buildings and their Elements, introduces the concept of Almost Nil Energy Consumption Buildings. The almost zero or very low amount of energy required should be covered, to a very large extent, by energy from renewable sources, produced in situ or in the environment "and establishes the dates, on 31 December 2018 and 2020, For its application to all new buildings owned and occupied by public authorities, and for all new buildings, respectively. On the other hand, develops the Certificate of Energy Efficiency and establishes inspections for boilers and air conditioning.

In November 2012 Europe publishes the latest and current Directive 2012/27 / EU on Energy Efficiency of Buildings. This Directive complements the 2010 Directive as regards the exemplary function of buildings of public bodies and seeks to achieve the 20% target of energy savings under the 20/20/20 Plan to combat climate change.

In view of the risks involved in the execution and management of energy saving and energy efficiency projects, in particular in the industrial sector and in the building sector, it is considered necessary to take out civil liability insurance covering the risks arising Of these actions by energy service providers and other subjects that may operate in the future within the framework of the system of obligations.

3.2. European Directives

3.2.1. Directive 2010/31 / EU

It is the result of the recasting of the original Directive 2002/91 / EC. This first directive comes into force in 2003 in response to the need to:

- Integrate environmental protection requirements into the policies of the European Community (EU).

The aim of the directive is to promote the energy efficiency of buildings, taking into account external climatic conditions, local particularities, indoor environmental requirements and cost-effectiveness.

To this end, this document proposes to establish (among other things):

- A methodology for calculating energy efficiency
- Minimum efficiency requirements in new and existing buildings
- Energy certification of buildings

The calculation methodology must take into account at least:

- Thermal characteristics of the building.
- Heating, ACS and air conditioning installations
- Artificial and natural ventilation
- Installation of artificial lighting
- Layout and orientation of the building
- Passive solar systems and sun protection
- Indoor environmental conditions

In terms of minimum energy performance requirements, member states will have to ensure compliance according to previous methodology in new and existing buildings undergoing major renovations. Directive 2010/31 / EU updates the previous one and modifies some of its parts.

Three new contributions stand out in this directive:

- New methodological framework of energy efficiency requirements
- Buildings with almost zero energy consumption
- Financial Incentives and Market Barriers

The new methodological framework was born in order to set a guideline for defining the minimum requirements set by each member, so that they meet optimum levels of profitability.

- After 31 December 2020, all new buildings must be buildings of almost zero energy consumption.
- After 31 December 2018, all new buildings owned by public authorities must be so.

This directive also establishes the elaboration of national plans by the states to increase the number of buildings of almost null consumption.

3.2.2. Directive 2012/27 / EU

This directive came into force on 4 December 2012 in response to the unprecedented challenges of:

- Growing dependence on energy imports
- The scarcity of energy resources

- The need to limit climate change and overcome the economic crisis

The objectives defined in the document were as follows:

- Establish a common framework of measures to achieve the 2020 energy saving target
- Help remove barriers to energy efficiency in energy supply and consumption
- Setting national energy efficiency targets for 2020

Some of the most important measures in the directive are:

- Quantification of the energy efficiency target, which in 2020 will not exceed 1474 Mtoe of primary energy or 1078 Mtoe of final energy.
- Establishment of a system of obligations of energy efficiency that ensures that the energy distributors achieve a saving objective.
- Facilitating the access of individual consumers to individual meters at a competitive price to ensure a more precise consumption control.
- Securing large companies to energy audits by qualified experts at least every four years, and promoting energy audits for SMEs.
- Annual renovation of 3% of the total surface of buildings of the Admón.
- Central heating or cooling so that they meet at least the minimum energy performance requirements.
- Inclusion of energy efficiency considerations in the purchase by the administrations of products, services and buildings, also attending profitability, economic, sustainability and technical criteria.

By way of summary, the European framework on sustainability is composed of the following standards:

- Buildings energy efficiency directives
- Eco-design directive (energy-related products)
- Directive on energy labeling (energy related products)
- Regulation of Ecological Labeling
- Eco-label for buildings (office buildings first priority)
- Energy Efficiency Action Plan (2007-2012, 2013-2020)
- Green public procurement (GPP)
- Construction and Demolition Waste (Waste Framework Directive)
- Leading Markets Initiative (on Sustainable Construction)
- Resource Efficiency Roadmap
- Mandatory CE marking

3.3. SPANISH REGULATION

Since the present Case Study of the thesis is located in Spain we see the need to briefly mention the Spanish legislation. Although the vast majority are not obligatory, these nor serve as a guide to get maximum performance for our FD.

The Spanish legislation on energy efficiency and the environment has always been preceded by European regulations, since in many cases this has emerged as a necessity to comply with some standard imposed from Europe to the countries of the union.

Currently in Spain, standardization work related to this subject is still being developed, the most important legislation in the EU, which has amended the legislation in Spain on energy efficiency issues, is Directive 2012/27/EU, the Which can be considered "the root" of the legislation of this area in both Europe and Spain.

In fact, in Spain this Directive is transposed through a Royal Decree establishing a regulatory framework whose purpose is to develop and promote actions to improve an organization's energy efficiency, promote energy savings and avoid emissions of greenhouse gases.

In Spain, they have been transposed by the publication of the following Royal Decrees:

- Directive 2012/27/EU to RD 56/2016, of February 12, approving the energy efficiency, in relation to energy audits, accreditation of service providers and energy auditors and promotion of efficiency of the power supply
- Directive 2010/31/EU to 564/2017, of 2 June, approving the basic procedure for the certification of energy efficiency of buildings

Another regulation that is oriented towards our project is:

- Royal Decree 314/2006, approving the Technical Building Code. Especially mentioned the document DB-HE. of energy savings
- Royal Decree 1027/2007, which approves the Regulation of Thermal Installations in Buildings (RITE) It is worth mentioning (ITC-BT-51) where it establishes the specific requirements of the installation of automation systems, technical management of energy and security for homes and buildings, also known as domotic systems
- Royal Decree 47/2007, approving the Energy Certification of new buildings and major rehabilitations
- Royal Decree 56/2016, Energy Audits and Energy Management Systems

3.4. ISO STANDARDS

3.4.1. ISO 15232 - Energy Efficiency of Buildings Impact of Automation, Control and Management of Buildings

This European standard Entered into force in July 2007 was designed to establish conventions and methods for estimating the impact of building automation and control systems (BACS) and technical building management (TBM) on the consumption and energy efficiency of buildings.

This European standard also provides a guide to take BACS and TBM into account as much as possible in the corresponding standards to be prepared.

This European standard specifies a method for estimating the energy saving factors that can be used together with the energy assessment of buildings. This European standard complements a series of standards that have been developed to calculate the energy efficiency of the technical installations of buildings such as heating, cooling, ventilation and lighting systems. This European standard takes into account the fact that the energy consumption of a building can be reduced with BACS and TBM.

It establishes methods for estimating the impact of building automation and control systems (BACS) and technical building management (TBM) on the consumption and energy efficiency of buildings. Procedure for calculating energy efficiency based on user profiles for different types of building. The combination of these elements yields defined specifications for the achievement of a given efficiency class which defined efficiency classes are four: from A = highly efficient to D = inefficient.

This European standard specifies:

- A structured list of Building Automation and Control (BACS) and Technical Building Management (TBM) functions that have an impact on the energy performance of buildings.
- A method for defining the minimum requirements of the functions with respect to the BACS and the TBM to be implemented in buildings of different complexity.
- A method based on the factor to obtain a first estimate of the effect of these functions on typical buildings.
- Detailed methods for calculating the impact of these functions on a given building. These methods allow the introduction of the effect of these functions on the calculations of the energy efficiency classification and on the indicators calculated by the corresponding standards.

And it is addressed to:

- Owners of buildings, architects or engineers who have to specify the functions to be implemented in a particular new building or in the renovation of an existing building.
- Public authorities to define the minimum requirements for BACS and TBM functions for new buildings and for renovations as defined in the relevant standard.
- Public authorities, who are to define the inspection procedures for the technical installations, as well as for the inspectors who are to apply these procedures to verify if the level of BACS and TBM functions implemented is adequate.
- Public authorities to define calculation methods which take into account the effect of the BACS and TBM functions on the energy performance of buildings, as well as for program developers who have to implement these methods. Calculators and designers who have to use them.
- Designers, who must verify that the effect of all BACS and TBM functions is taken into account when assessing the energy efficiency of a building.

The following diagram shows the differences in energy consumption for three building types in the energy efficiency classes A, B and D relative to the basis values in rating C. For example, by using class A, 30% of the thermal energy can be saved in Offices.

Building Automation and Control (BAC) efficiency classes to EN 15232	Efficiency factor for thermal energy			Efficiency factor for electrical energy		
	Office	School	Hotel	Office	School	Hotel
A High energy performance building automation and control system (BACS) and technical building management (TBM)	0.70	0.80	0.68	0.87	0.86	0.90
B Advanced BACS and TBM	0.80	0.88	0.85	0.93	0.93	0.95
C Standard BACS	1	1	1	1	1	1
D Non energy efficient BACS	1.51	1.20	1.31	1.10	1.07	1.07

Fig. 14. BACS Classes. Source: Own work by EN ISO 15232

Below is a table with all the functions of automation and control that should be fulfilled to obtain the classification of the different classes of efficiency of the BACS according to which scope:

	Heating / Cooling control	Ventilation / Air conditioning control	Lighting	Sun protection
A	– Individual room control with communication between controllers – Indoor temperature control of distribution network water temperature – Total interlock between heating and cooling control	– Demand or presence dependent air flow control at room level – Variable set point with load dependant compensation of supply temperature control – Room or exhaust or supply air humidity control	– Automatic daylight control – Automatic occupancy detection manual on / auto off – Automatic occupancy detection manual on / dimmed – Automatic occupancy detection auto on / auto off – Automatic occupancy detection auto on / dimmed	– Combined light/blind/ HVAC control
B	– Individual room control with communication between controllers – Indoor temperature control of distribution network water temperature – Partial interlock between heating and cooling control (dependent on HVAC system)	– Time dependent air flow control at room level – Variable set point with outdoor temperature compensation of supply temperature control – Room or exhaust or supply air humidity control	– Manual daylight control – Automatic occupancy detection manual on / auto off – Automatic occupancy detection manual on / dimmed – Automatic occupancy detection auto on / auto off – Automatic occupancy detection auto on / dimmed	– Motorized operation with automatic blind control
C	– Individual room automatic control by thermostatic valves or electronic controller – Outside temperature compensated control of distribution network water temperature – Partial interlock between heating and cooling control (dependent on HVAC system)	– Time dependent air flow control at room level – Constant set point of supply temperature control – Supply air humidity limitation	– Manual daylight control – Manual on/off switch + additional sweeping extinction signal – Manual on/off switch	– Motorized operation with manual blind control
D	– No automatic control – No control of distribution network water temperature – No interlock between heating and cooling control	– No air flow control at room level – No supply temperature control – No air humidity control	– Manual daylight control – Manual on/off switch + additional sweeping extinction signal – Manual on/off switch	– Manual operation for blinds

Fig. 15. Function list assignment to energy performance classes. Source: Table 1 EN ISO 15232

3.4.2. ISO 16484 - Building automation and control systems (BACS)

EN ISO 16484 aims to achieve an acceptable interior environment and functional energy conservation and efficiency in the design of new buildings and the modernization of existing buildings.

It is applicable to building automation and control systems (BACS). This International Standard specifies the guiding principles for the design and implementation of projects and for the integration of other systems in the building automation and control system (BACS).

The purpose of this series of standards is to pretend to be used by those involved in the design, manufacture, technology, installation, commissioning and maintenance and preparation of BACS.

The quality of the execution of a BACS depends on the design of the building systems and the specification of the commissioning process. The scope of the start-up referred to in this part of the Standard

Phases of a bacs project

This section specifies the main actions and decisions required to carry out a project in its different phases (see Figure 1). It serves all parties involved in the different phases of a project. The phases of a project associated with the realization of a BACS are as follows.

1. ***Design phase:*** This section specifies the tasks that will be carried out in the design process of the different parts of a BACS. It is assumed that the information needed to develop the BACS is available at the beginning of the design process. The tasks to be performed are specific to the project and the system.

The design phase consists of:

- Determination of the requirements of the project
- Planning and organization of the project
- Technical specifications
- Establishment of a contract

2. ***Engineering Phase:*** This section specifies the tasks performed in the process of configuring the different parts of a BACS. These tasks are project and system specific.

The engineering phase consists of:

- Planning and coordination of the project
- Detailed functional design and hardware specifications
- Approval of engineering design
- Hardware configuration
- Configuration of the control strategy and the processing functions
- Configuration of the management and operation functions
- System testing

3. ***Installation Phase:*** This section specifies the tasks to be performed to install the different parts of a BACS. These tasks are project and system specific.

The work done during the engineering, installation and completion phases is the basis for preparing documentation and training. At the end of the installation phase, the documents should be updated to reflect the changes.

4. ***Finishing Phase:*** This section specifies the tasks to be performed in the Finishing Phase.

This international standard also specifies the documentation requirements of how it was built and the training. This international standard is not applicable to the operation and maintenance, nor is it applicable to retro or continuous commissioning, including a start-up authority.

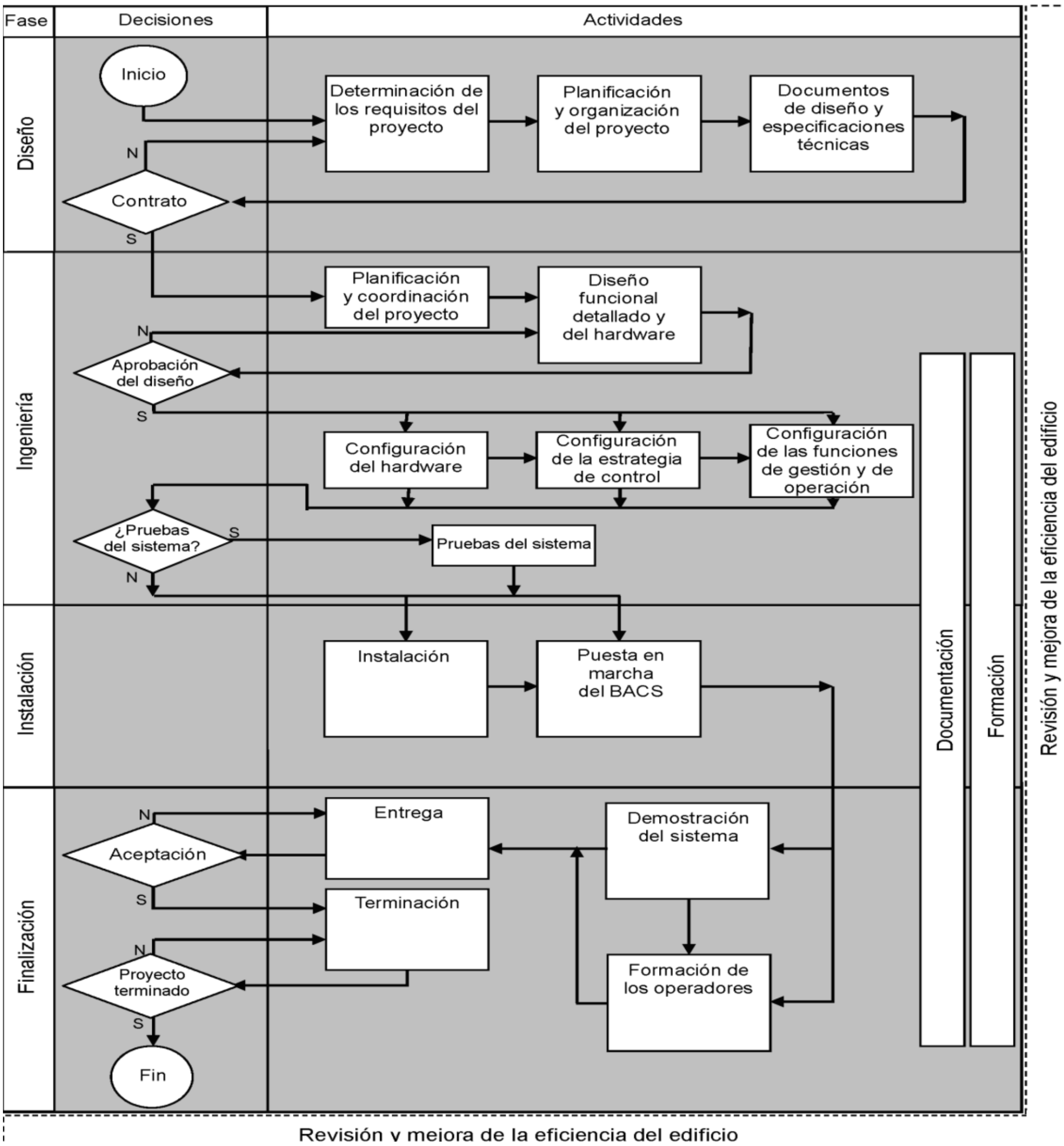


Fig. 16. Phases of the implementation process of a BACS. Source: EN ISO 16484

Case Study

Cañada del Hoyo City Council

IV CHAPTER

4. CASE STUDY - APPLICATION TO CAÑADA DEL HOYO

4.1. INTRODUCTION

Application of implantation of a EMS with automations in the municipality of Cañada del Hoyo, Cuenca.

4.1.1. Purpose of the analysis

The objective is to **demonstrate if once implemented "conventional" energy measures is economically profitable or not to implement automatisms in the energy management of a company** or on the contrary is a strategy of marketing of companies. In this case being a small town council could resemble that of the implantation in a SME.

The specific objectives of this study are:

- Respond to the question raised about the profitability of EMS
- "Monitor" the energy consumption of the city council
- Reduce the city's energy consumption

Focusing on the economic profitability of the SGE, since, if it is not, it can be attributed to a marketing strategy, which generates money, but indirectly.

4.1.2. Methodology of the analysis

The scope of the energy study comprises the totality of buildings of dominion and public management of the city council.

For its elaboration, the process that has been followed during the accomplishment of the practical case has been:

1. Contact with the municipality, its situation and characteristics
2. Collection of information on buildings and energy inventories
3. Compilation of actual consumption of each building
4. Interpretation of results
5. Analysis and summary of measures previously adopted
6. Analysis according to Annex 1 of UNE 15232
7. Development of possible improvement options
8. Selection of the most appropriate set of improvements for the town hall
9. Project feasibility analysis
10. Comparison with the new results of Annex 1 of UNE 15232
11. Economic Analysis
12. Conclusions

4.2. DESCRIPTIVE MEMORY

4.2.1. Location and characteristics

The first thing is to put in place where we are going to carry out the energy audit, so firstly the situation and its main characteristics will be exposed, followed by the energy inventory of the municipality.

Cañada del Hoyo is a Spanish municipality in the province of Cuenca, in the autonomous community of Castilla-La Mancha, located about 30 kilometres from Cuenca in the direction of Teruel.

Fig. 17. Location of Cañada del Hoyo in the province of Cuenca

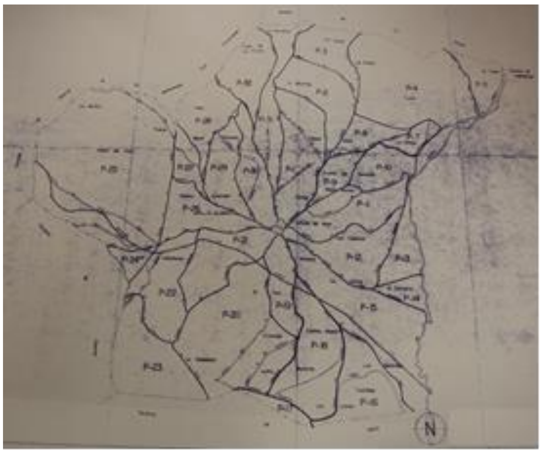


Fig. 18. Cadastral Map. Source: City Hall Cadastre

It has 280 inhabitants (INE 2015) and an area of 90.37 km^2.

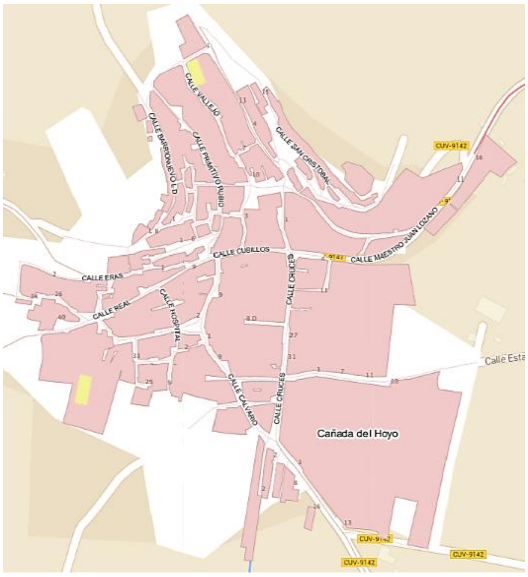


Fig. 19. Cartociudad Map. Source: Goolzoom

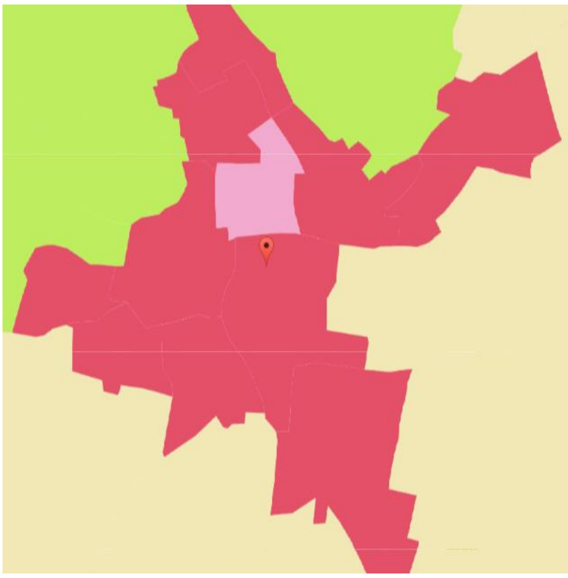


Fig. 20. Map Land Occupation. Source: Goolzoom

➔ **For a more detailed description of the CADASTRAL MAP see ANNEX I**

4.2.2. Climatological study of Cañada del Hoyo

It is quite important when we are talking about energy efficiency and to be able to carry out an energetic study, the location of the site of the buildings is crucial.

The climate is temperate and warm in Cañada del Hoyo located at an altitude of 1006m. There is precipitation throughout the year in Cañada del Hoyo. Even the driest month still has a lot of rain. The average annual temperature in Cañada del Hoyo is at 11.5 ° C. Precipitation is 508 mm per year.

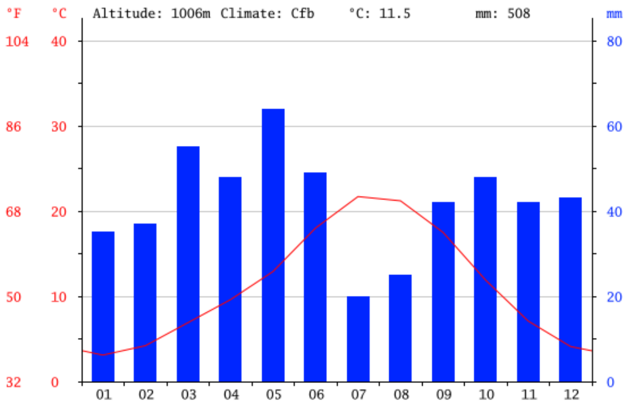


Fig. 21. Climograph of Cañada del Hoyo. Source: Climate-data.org

The driest month is July, with 20 mm. 64 mm, while the average fall in May. The month in which it has the highest rainfall of the year.

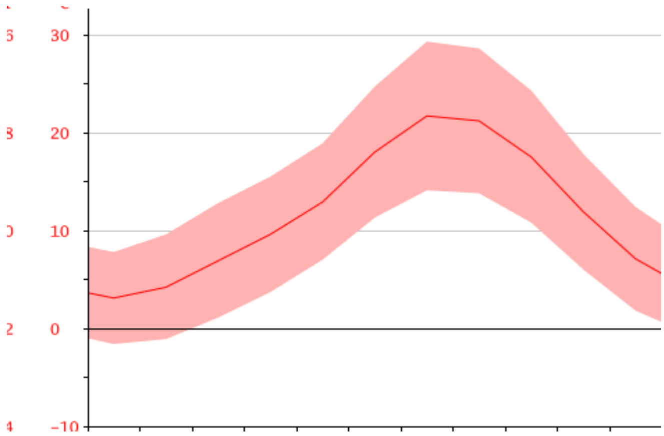


Fig. 22. Temperature Diagram of Cañada del Hoyo. Source: Climate-data.org

The hottest month of the year averaging 21.7 ° C in July. The coldest month of the year is 3.1 ° C in the middle of January.

mm	35	37	55	48	64	49	20	25	42	48	42	43
°C	3.1	4.2	6.9	9.6	12.9	18.0	21.7	21.2	17.5	11.9	7.1	4.1
°C (min)	-1.6	-1.1	1.1	3.7	7.0	11.3	14.1	13.8	10.8	6.0	1.8	-0.5
°C (max)	7.8	9.6	12.8	15.5	18.9	24.7	29.3	28.6	24.3	17.8	12.4	8.8
°F	37.6	39.6	44.4	49.3	55.2	64.4	71.1	70.2	63.5	53.4	44.8	39.4
°F (min)	29.1	30.0	34.0	38.7	44.6	52.3	57.4	56.8	51.4	42.8	35.2	31.1

Fig. 23. Climate table. Source: Climate-data.org

The difference in precipitation between the driest month and the wettest month is 44 mm. Average temperatures vary during the year at 18.6 ° C.

4.2.3. Inventory of buildings and municipal properties

The inventory of the set of buildings and properties that are likely to generate a consumption and therefore energy saving is the first step to perform to manage energy, "know what we have to know what to do."

It has been catalogued in different groups according to its use for its better analysis.

GROUP	EQUIPMENT
Office	Town Hall and Library
	Museum of Dinosaurs
Sanitary	Doctor´s Office
Education	School
Sports	Sports Center
	Local Pool
Social	Social Center
	Social Housing
Facilities and services	Street Lighting
	Water Treatment Plant
	Water Tank

Fig. 24. Inventory of buildings of the Cañada del Hoyo Town Hall. Source: Own Work

It briefly specifies the characteristics of each endowment and the main energy consumptions they produced.

Office Group

Town Hall and Library

Fig. 25. Photograph of the City Hall of Cañada del Hoyo, Cuenca. Source: Own Work

It is located in the main square of the village, called "Plaza Mayor" and has a constructed area of approximately 380 m^2.

It is the largest building managed by the town hall, since, although there are larger buildings, its management is outsourced.

Hours of Use: Both the city hall and the library is from 9:00 a.m. to 2:00 p.m. From Monday to Friday, thus adjusting to the use of the needs of the people, generating only 5 hours of energy consumption.

The endowments with which it counts are the following:

No. Luminaires	147
Average consumption Luminaires (Wh)	Halogens of 50
No. Photocopiers / Printers	2 Printers - 400Wh and 1 Photocopier - 900Wh
No. Computers	4 desktop PC with consumption of 300 Wh
No. Home appliances	1 Refrigerator with consumption of 800Wh
No. Radiator Elements	148
No. Boilers	1 Gasoil Boiler Roca Lidia GT (Condensation)
No. Air conditioners	1 VRV with consumption of 5KWh
No. Solar panels	8 with input of 260Wh

Fig. 26. Endowment of the City Hall of Cañada del Hoyo, Cuenca. Source: Own Work

Museum of dinosaurs

Fig. 27. Photograph of the Museum of dinosaurs of Cañada del Hoyo, Cuenca. Source: Own Work

It is located on the outskirts of the village, approximately 1km from the village center and next to the pool. It has an area of approximately 300 m^2.

The management of the museum is coordinated between the city council and the deputation through an agreement to promote culture in small towns, reason why the expenses are partially subsidized.

Hours of Use: It is a museum of main tourist use; the schedule is only weekends and holidays. Being Saturdays and Sundays in the morning from 10:00 a.m. to 13:00 p.m. and in the afternoon from 16:00 p.m. to 8:00 p.m. A use of 7 hours a day, 2 days a week.

The endowments with which it counts are the following:

No. Luminaires	44
Average consumption Luminaires (Wh)	Halogens of 50
No. Photocopiers / Printers	1 Printer - 400Wh
No. Computers	1 Laptop - 60Wh
No. Air conditioners	3 Condensers with consumption of 3 KWh
No. Solar panels	4 with input of 260Wh

Fig. 28. Endowment of the Museum of dinosaurs of Cañada del Hoyo, Cuenca. Source: Own Work

Next, we can see a consumption profile for this type of buildings, which, as we can see, is in line with the provisions we have, the highest consumption being air conditioning, equipment and lighting.

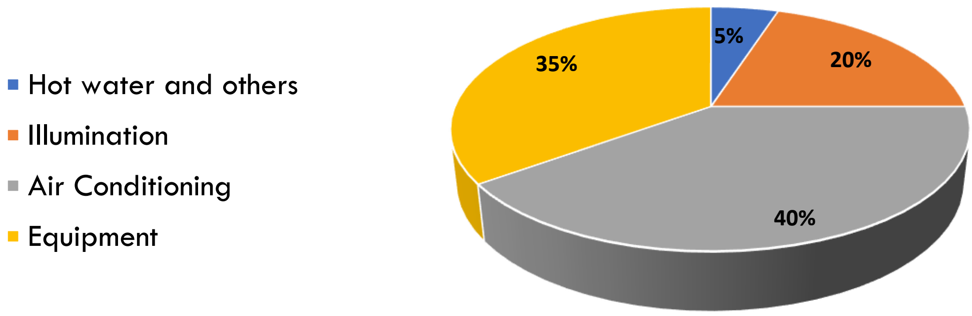


Fig. 29. Energy consumption profile of office buildings. Source: Own Work with data from Guide for Energy Audits in office buildings in the Community of Madrid. General Directorate of Industry, Energy and Mines of the Community of Madrid.

Sanitary Group

Doctor´s Office

Fig. 30. Photograph of the Doctor´s Office of Cañada del Hoyo, Cuenca. Source: Own Work

The Doctor´s Office is located in the south-east part of the town, where most of the town hall's facilities are located. It has an area of approximately 150 m2.

Being a service that is given to the people, to continue having a medical consultation for its citizens, the building is ceded and managed by the city council, although the health staff corresponds to SESCAM.

Hours of Use: The hours are from Monday to Friday, from 9:00 a.m. to 13:00 a.m., for the issuing of prescriptions and some minor medical consultation. 4 hours of daily use during the week.

The endowments with which it counts are the following:

No. Luminaires	17
Average consumption Luminaires (Wh)	Incandescent 80
No. Photocopiers / Printers	2 Printers - 400Wh
No. Computers	2 Laptops - 60Wh
No. Home appliances	1 Refrigerator with consumption of 800Wh
No. Radiator Elements	73
No. Boilers	1 Gasoil boiler shared with schools
No. Air conditioners	1 Condenser of 3 KWh

Fig. 31. Endowment of Doctor´s Office of Cañada del Hoyo, Cuenca. Source: Own Work

Next, we can see a consumption profile for this type of buildings.

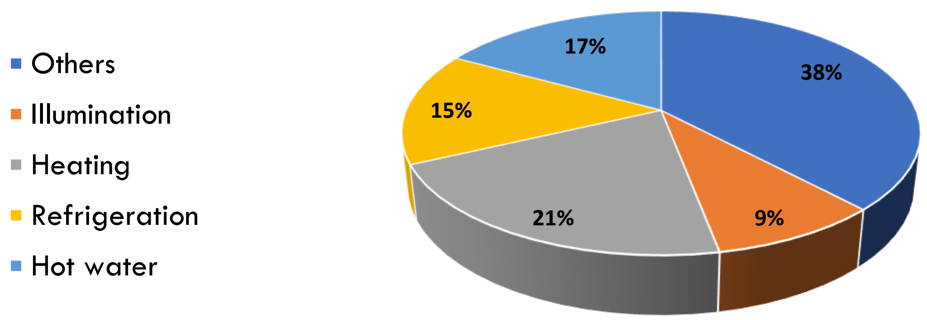


Fig. 32. Energy consumption profile of a hospital. Source: Own Work with data from Energy Saving and Efficiency Strategy in Spain 2004-2012 E4, building chapter.

Education Group

School

Fig. 33. Photograph of the School of Cañada del Hoyo, Cuenca. Source: Own Work

The schools are located in the south-east part of the village, next to the fronton and the clinic. It has an area of approximately 100 m^2.

As with the practice, although the contribution of the teaching staff is the responsibility of the education system of Castilla la Mancha, the city council provides the means to provide the service to its citizens.

Hours of Use: Only use in the school calendar and the schedule is from Monday to Friday, from 8:30 a.m. to 2:30 p.m. 6 hours a week on weekdays.

The endowments with which it counts are the following:

No. Luminaires	12
Average consumption Luminaires (Wh)	Incandescent 60
No. Photocopiers / Printers	1 Printer - 350Wh
No. Computers	1 Laptop - 60Wh
No. Home appliances	1 Refrigerator with consumption of 800Wh
No. Radiator Elements	45
No. Boilers	1 Gasoil boiler shared with schools

Fig. 34. Endowment of High School of Cañada del Hoyo, Cuenca. Source: Own Work

Next, we can see the consumption profile of educational centers, highlighting consumption in heating and lighting.

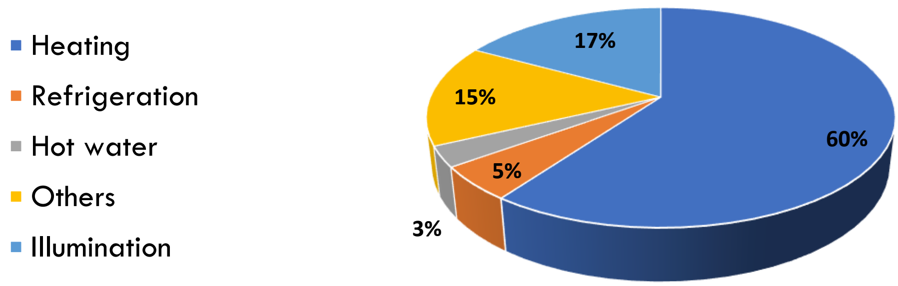


Fig. 35. Energy consumption profile of an educational center: university / college. Source: Own Work with data from Energy Saving and Efficiency Strategy in Spain 2004-2012 E4, building chapter.

Sports Group

Sports Center

Fig. 36. Photograph of the Sports Center of Cañada del Hoyo, Cuenca. Source: Own Work

Located behind the schools and the clinic, the fronton is used for sports activities, as well as for celebrating the town festivals. It has an approximate surface of 800 m^2.

The pediment only has a halogen spotlight of 500W.

Local Pool

Fig. 37. Photograph of the Local Pool of Cañada del Hoyo, Cuenca. Source: Own Work

It is located next to the Museum of Dinosaurs, 1km from the center of the village and has an approximate surface area of 150m^2.

Hours of Use: The swimming pool is only open in the summer months, from June to mid-September and is open every day from Monday to Sunday, with a timetable from 10:00 to 20:00 uninterrupted. It only opens 3 months and a half but the use is quite intensive, since it is open 10 hours every day of the week.

The endowments with which it counts are the following:

No. Luminaires	28
Average consumption Luminaires (Wh)	Halogens of 50
No. Home appliances	2 Refrigerators with consumption of 800Wh
Pool purifier engines	2 with consumption of 5KWh

Fig. 38. Endowment of Local Pool of Cañada del Hoyo, Cuenca. Source: Own Work

Next, we can see the consumption profile of the sports centers, highlighting the consumption in air conditioning, use that in this case is not given in any of the sports facilities.

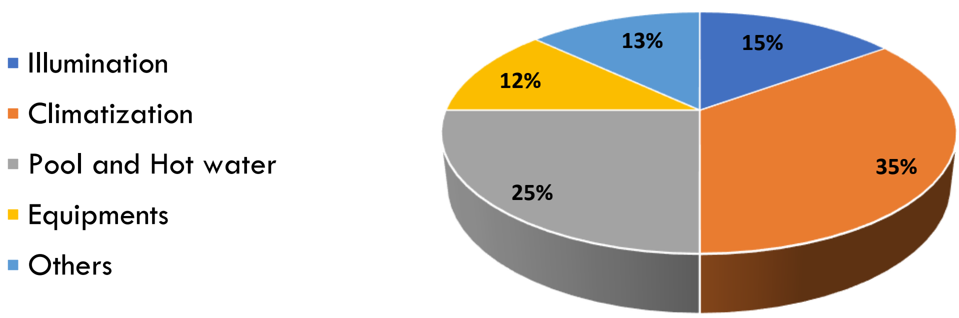


Fig. 39. Energy consumption profile of s.c. Source: Own Work with data from Guide to Energy Efficiency in sports facilities. General Directorate of Industry, Energy and Mines of the Community of Madrid

Social Group

Social Center

Fig. 40. Photograph of the Social Center of Cañada del Hoyo, Cuenca. Source: Own Work

It is located in the main square of the village, next to the Town Hall and has a constructed area of approximately 300 m^2.

Hours of Use: It has no fixed timetable, since it is only used when requested by someone or to celebrate some act or party.

The endowments with which it counts are the following:

No. Luminaires	28
Average consumption Luminaires (Wh)	Halogens of 50
No. Home appliances	1 Refrigerator with consumption of 800Wh
No. Radiator Elements	72
No. Boilers	1 Old Gasoil Boiler
No. Air conditioners	1 Condensers with consumption of 2KWh

Fig. 41. Endowment of Local Pool of Cañada del Hoyo, Cuenca. Source: Own Work

Social Housing

Fig. 42. Photograph of Social Housing of Cañada del Hoyo, Cuenca. Source: Own Work

The social housing is located in the south-east part of the village, next to the fronton and schools. There are 3 homes available, and each one has an area of approximately 60 m^2.

It should be noted that the heating of these homes is done through wood stoves, since it is a town with many wood resources.

The endowments with which it counts are the following:

No. Luminaires	20
Average consumption Luminaires (Wh)	Incandescent 60
No. Home appliances	Refrigerator-800Wh/Washing Machine-900Wh

Fig. 43. Endowment of Social Housing of Cañada del Hoyo, Cuenca. Source: Own Work

Group Facilities and Services

Street Lighting

Fig. 44. Photograph of the type of luminaire used in the Public Lighting. Source: Own Work

There are two types of luminaires of Public Lighting, one of Lantern located in the squares and the majority in the town that is the Street lamps.

The endowments with which it counts are the following:

Lantern	10
Street lamp	148

Fig. 45. Endowment of Street Lighting of Cañada del Hoyo, Cuenca. Source: Own Work

Water Treatment Plant

Fig. 46. Photograph of Water Treatment Plant of Cañada del Hoyo, Cuenca. Source: Own Work

The purifier is located approximately 2-3 km from the village, due to odors and the proximity of the river. The house has 50m^2.

The endowments with which it counts are the following:

No. Luminaires	2
Average consumption Luminaires (Wh)	Incandescent 100
Sewage Treatment Plant	2 with consumption of 3 KWh

Fig. 47. Endowment of Purifying Plant of Cañada del Hoyo, Cuenca. Source: Own Work

Water Tank

Fig. 48. Photograph of Water Tank of Cañada del Hoyo, Cuenca. Source: Own Work

It is located in the upper part of the town, next to the castle, so as to operate by inertia in the supply and not consume energy. The house has 30m^2.

The endowments with which it counts are the following:

No. Luminaires	1
Average consumption Luminaires (Wh)	Incandescent 100
Drive pump	2 with consumption of 2 KWh

Fig. 49. Endowment of Water Tank of Cañada del Hoyo, Cuenca. Source: Own Work

- ➔ **For a more detailed description of EQUIPMENT MAP see ANNEX II**
- ➔ **For a more detailed description of FULL ENERGY INVENTORY see ANNEX III**

4.3. SUMMARY OF MEASURES ALREADY TAKEN

As previously mentioned, reference was made to the master's final dissertation at the Universidad Politécnica de Madrid, in which a series of "conventional" measures, both active and passive, were taken for the improvement and energy management of the Cañada del Hoyo council.

The measures were taken taking into account the annual budget that has the city council in electricity and maintenance.

Ayuntamiento de Cañada del Hoyo

PRESUPUESTO ECONOMICO DE GASTOS

RELACION DE APLICACIONES PRESUPUESTARIAS

AREA DE GASTO: 1 POLITICA DE GASTO: 1.6 GRUPO DE PROGRAMAS: 1.6.5

APLICACIÓN PRESUPUESTARIA						
CLASIFI. POR PRG.	CLASIFICACION ECONOMICA	DENOMINACION DE LA APLICACIÓN	POR SUBCONCEPTO	POR CONCEPTO	POR ARTICULO	POR CAPITULO
		CAPITULO 2. GASTOS CORRIENTES EN BIENES Y				
		Art. 21. Reparaciones, mantenimiento y conservación				
165	21002	Reparacion mantenimiento y conservacion alumbrado municipal	4.000,00	4.000,00	4.000,00	
		Art. 22. Material, suministros y otros				
165	22101	Alumbrado público. Gasto alumbrado publico Cañada del Hoyo	30.000,00	30.000,00	30.000,00	
			TOTAL CAPITULO 2. GRUPO DE PROGRAMAS 1.6.5			34.000,00

Fig. 50. Public expenditure on public lighting in Cañada del Hoyo. Source: Cañada del Hoyo T.H.

The town hall spends 30.000€ per year on the cost of public lighting and 4.000€ on maintenance of the same, which is 34.000€ per year.

Ayuntamiento de Cañada del Hoyo

PRESUPUESTO ECONOMICO DE GASTOS

RELACION DE APLICACIONES PRESUPUESTARIAS

AREA DE GASTO: 3 POLITICA DE GASTO: 3.2 GRUPO DE PROGRAMAS: 3.2.0

APLICACIÓN PRESUPUESTARIA						
CLASIFI. POR PRG.	CLASIFICACION ECONOMICA	DENOMINACION DE LA APLICACIÓN	POR SUBCONCEPTO	POR CONCEPTO	POR ARTICULO	POR CAPITULO
		CAPITULO 2. GASTOS CORRIENTES EN BIENES Y				
		Art. 21. Reparaciones, mantenimiento y conservación				
320	21201	Reparacion mantenimiento y conservacion colegio publico.	2.000,00	2.000,00	2.000,00	
		Art. 22. Material, suministros y otros				
320	22103	Combustible calefaccion escuelas y centro social	4.000,00	4.000,00	4.000,00	
			TOTAL CAPITULO 2. GRUPO DE PROGRAMAS 3.2.0			6.000,00

Fig. 51. Public expenditure on heating of schools and sanitary office. Source: Cañada del Hoyo T.H.

To heat the schools, the sanitary office, the city council has an annual budget of 4.000€ in fuel costs for the boiler.

Ayuntamiento de Cañada del Hoyo

PRESUPUESTO ECONOMICO DE GASTOS

RELACION DE APLICACIONES PRESUPUESTARIAS

AREA DE GASTO: 3 POLITICA DE GASTO: 3.4 GRUPO DE PROGRAMAS: 3.4.2

APLICACIÓN PRESUPUESTARIA						
CLASIFI. POR PRG.	CLASIFICACION ECONOMICA	DENOMINACION DE LA APLICACIÓN	POR SUBCONCEPTO	POR CONCEPTO	POR ARTICULO	POR CAPITULO
		CAPITULO 2. GASTOS CORRIENTES EN BIENES Y				
		Art. 21. Reparaciones, mantenimiento y conservación				
342	21005	Instalaciones deportivas. Reparacion mantenimiento y conservacion piscina municipal	7.000,00	7.000,00	7.000,00	
			TOTAL CAPITULO 2. GRUPO DE PROGRAMAS 3.4.2			7.000,00

Fig. 52. Public expenses in maintenance and conservation of the Pool. Source: Cañada del Hoyo T.H.

Although this budget is not attributable to an energy consumption or derived from it, a part of this expenditure contains the energy budget of the same, which for the information they have provided is estimated at 1.000€.

As we can see, the locality does not have great expenses, since it is a very small town and its **expenditure budget in 2016 amounts to 100.000€.**

4.3.1. Active Measures

This series of problems was detected and the following measures were proposed:

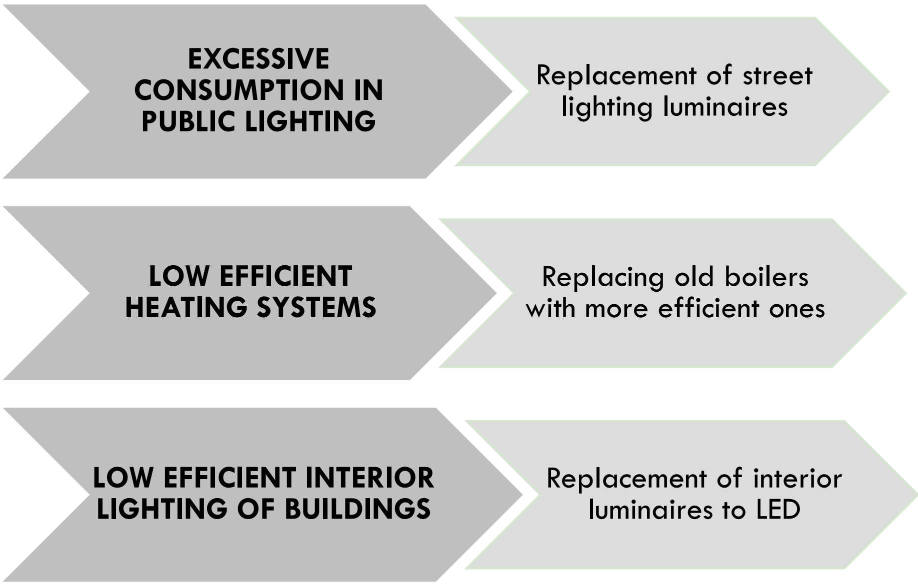


Fig. 53. Problems and Active Measures implemented to solve them. Source: Own Work

Replacement of street lighting luminaires

With the replacement of luminaires to an LED system, very significant savings were achieved.

Fig. 54. Tot. savings achieved replacing Public Lighting to LED System. Source: Own Work

With this measure, the annual savings would be 9.575,16€, energy costs and maintenance.

Replacing old boilers with more efficient ones

It was proposed to change old boilers to more efficient condensation.

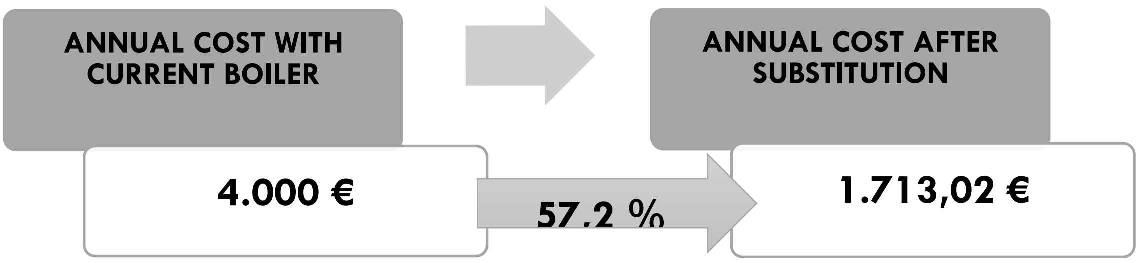


Fig. 55. Savings achieved with the substitution to Condensation Boiler. Source: Own Work

With the boiler that proposed condensation and diesel as fuel, the saving is significant, with an annual consumption of 1.613,02€. This is 2.386,98€ less than the annual heating and maintenance budget estimated at 100€ per year. This represent an annual cost of 1.713,02€, compared to 4.000€ today, **the annual savings would be 2.286,98€**, energy costs and maintenance.

Replacement of interior luminaires to LED

With the replacement of light bulbs from buildings to LEDs, significant savings were achieved, though not as important as with street lighting.

Fig. 56. Tot. savings achieved by replacing interior luminaires with LED syst. Source: Own Work

With this measure, **the annual savings would be 1.123,4€,** energy costs and maintenance.

4.3.2. Passive Measures

Passive Measures are those that act on the demand of the building, reducing it or avoiding unnecessary losses of the energy supplied.

For this case, since the use of most of the buildings is very small and limited, two types of measures were proposed:

- Regulation of energy habits
- Energy tariff optimization

Regulation of energy habits

With the implementation of these measures of change of energy habits is estimated that can **save up to an additional 15%.**

Energy tariff optimization

After the study of energy bills provided by the city council, it was observed that they do not have tariffs optimized for the given use, reason why it is paying a higher price for the KWh. **The city council pays around 12% more for the KWh price than necessary.**

Below, we can see a summary of all the savings achieved with the measures proposed in the FD "Energy Management, Marketing or Need?" Of the UPM.

TYPE OF MEASURE	MEASURE	SAVING ON CONSUMPTION %	SAVING (€)	AMORTIZATION OF INVESTMENT TO 10 YEARS (€)	TOTAL SAVING (€)
ACTIVE MEASURES	Replacement of street lighting luminaires	70,05 %	9.575,16 €	- 3.980 €	5.595,16 €
	Replacing old boilers with more efficient ones	57,2 %	2.286,98 €	- 207 €	2.079,98 €
	Replacement of interior luminaires to LED	81,31 %	1.123,4 €	- 358,85 €	764,55 €
PASSIVE MEASURES	Regulation of energy habits	15 %	5.250 €	-	5.250 €
	Energy tariff optimization	12 %	3.600 €	-	3.600 €

Fig. 57. Summary table of savings achieved with measures in FD "Gestión energética, ¿Marketing o necesidad?. Source: Own work

According to the calculations made, **they were to save annually 17.289,69 €.** This amount represents a very important saving in a locality whose annual budget is 100.000 €.

With the results obtained, **it was demonstrated that the savings achieved are very significant, so that no company, much less a municipality can afford not to implement an Energy Management System.** With not very important investments, and taking logical measures of use and saving, can achieve significant reductions in energy consumption.

➔ **All calculations of these measures are performed in the previous TFM.**

4.4. PROPOSALS FOR IMPROVEMENT

Once reviewed the measures already taken, the proposals that are raised will be focused on the improvement with automatisms. Some of these measures do not have a direct impact with energy, but ultimately with the management of buildings and savings for the city council through the use of automatisms, since with automatisms can be obtained many more benefits.

The main benefits of building automation include:

- Lower energy usage
- Optimization of energy usage
- Security and privacy
- Control over energy resources
- Control of operating conditions:
  - Humidity

- Air Volume
- Temperature

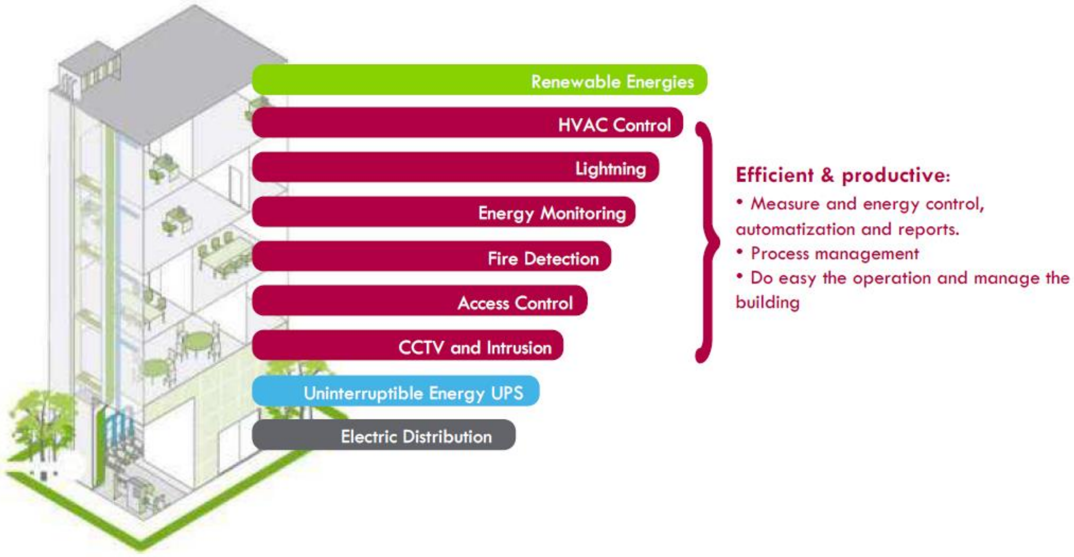


Fig. 58. Summary automatisms integration. Source: Own Work

The UNE-EN 15232 standard defines a method to estimate the energy saving factors that can be used together with the energy evaluation of buildings. This takes into account the fact that it can reduce the energy consumption of a building with the systems of automation and control of buildings.

It specifies a method for determining the so-called efficiency classes of automation and control equipment and systems (onwards "control efficiency classes").

These classes define the functions that have an effect on the energy efficiency of buildings and go from class A, which is the kind of control efficiency that provides greater savings to the building, to class D, which is assigned to the Automation and control system that provides no energy savings.

To know in the current state that there is a level of automation of the infrastructure of the city council, has been analyzed according to table 1 of ISO EN 15232. According to the table, **the infrastructures have a class D efficiency in BACS.**

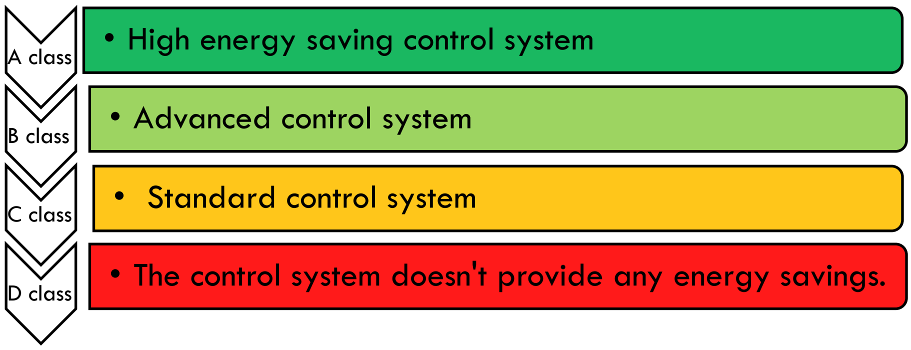


Fig. 59. BACS Energy Performance Classes. Source: Own Work by EN 15232 Building Automation

According with this classification, the municipality does not have energy efficient BACS, because currently the municipality has no automatisms.

➔ **For a more detailed description of the Classification of the Current State according with TABLE 1. ISO EN 15232 see ANNEX IV**

In order to be able to analyze the improvement with energy-efficient automatisms, it is necessary to estimate the current energy rating, which has been estimated approximately by means of envelopes, type of carpentry and installations.

CURRENT ENERGY EFFICIENCY RATING						
Town Hall and Library	Museum of Dinosaurs	Doctor´s Office	School	Local Pool	Social Center	Social Housing
C	D	F	F	E	F	G

Fig. 60. Current Energy Efficiency Rating. Source: Own Work

Once the state of the automation facilities is known, it is proposed to propose measures to implement for the correct management of energy in the municipality of Cañada del Hoyo:

Monitoring and control software

A decentralized system is proposed, managed by an external company, since it is a very small town, there are no specialized personnel that can be dedicated to the correct maintenance or to make the necessary corrections according to the extracted data.

It is proposed the implementation of software ***Smarkia Monitor***, to perform a monitoring and analysis of consumption and energy costs (electricity, water, diesel ...), allowing the detailed analysis and unified management of the entire complex of buildings.

With this software will be managed the rest of automatisms, detectors and sensors installed in all the buildings of the town hall.

Reducing Energy Use for Lighting

Lighting can be turned on and off with a building automation system based on time of day, or the occupancy sensors and timers. One typical example in the street lighting is to turn the lights in a space on for a half hour since the last motion was sensed. A photocell placed outside a building can sense darkness, and the time of day, and modulate lights.

- Motion Sensors
- Automatic control of the ON and OFF of all the lights: It allows to avoid leaving lights on when leaving the house.
- Automatic control of the ON and OFF of the exterior lights according to the sunlight.

Reducing Energy Use for Hot Water

- Installing time controls and setting them to reflect the hours of hot water requirement
- Setting sanitary hot water thermostats to the appropriate temperature
- Switching off electric heating elements (immersion) when hot water from the boiler is available
- Switching off any associated pumps when hot water is not required

Reducing Consumption of Office Equipment and Appliances

Office equipment currently consumes 15% of the total electricity used in offices, this is expected to rise to 30% by 2020, here are also associated costs of increasing cooling and ventilation requirements to overcome the additional heat that office equipment produces.[1]

- Switching off or enabling power down mode reduces the energy consumption and heat produced by equipment.
- Upgrading existing equipment. Some energy efficient appliances may cost more but they will recoup savings over their lifetime.
- Matching the equipment to the task. Bear in mind current and predicted requirements and purchase equipment that meet these.

Automation in HVAC

- Zoning and temperature control efficiently
  - Individual temperature control.
- Install Thermostats with Individual temperature control
- Control ON/OFF according to the time of the boiler by programmer
- Lower the average temperature of the flow

Ventilation and Air Quality

There are many ways to reduce the energy lost in ventilation systems, we propose the following:

- Advanced sensor and control systems provide ventilation only where and when it's needed: Most installed systems implement fixed air-exchange rates as specified by code, but ventilation needs depend upon occupancy, building purpose and internal activities, and other factors (e.g., a hospital). Significant efficiencies could be gained if ventilation systems provided only the fresh air needed to maintain required levels of carbon dioxide (CO_2) and other compounds. Such systems are known as demand-controlled ventilation. Modern systems can use sensors to detect concentrations of CO_2 and other contaminants, and this information can be used to make appropriate adjustments to ventilation rates. However, keeping them in calibration has proven difficult. Good control systems may be able to reduce ventilation-related energy use in residences by as much as 40%.

It has been particularly difficult to get advanced systems into smaller buildings. More than half of buildings larger than 10.000 square feet use economizers and variable air volume systems, but less than 10% of buildings smaller than 10.000 square feet use them. Technologies that are inexpensive and easy to use in smaller would be particularly useful.

[1] Sustainable energy regulation and policymaking for Africa. Module 18: Energy efficiency in buildings

For our practical case, it is proposed to install an aerator opening in the windows controlled by software for air renovation according to the air quality measurement of the installed detectors, until obtaining an optimum quality also to lower awnings according to solar hour.

Blind Control

- Install motorizations in the blinds to control sun protection (cooling) and natural illumination

Access Control

- Analogue and IP Closed Circuits
- Alarm Activation and Event Recording

Fire protection

- Remote monitoring of alarms and states
- Supervision of Extinction Equipment
- Communication with fire stations

All this type of measures is those that are going to be installed in the different infrastructures of buildings in the town hall of Cañada del Hoyo, but these are the general measures, according to the type of building and use it will be necessary to implement different measures.

For this purpose, a table has been made with the automatisms to be implemented for each equipment, as well as the energy rating, according to ISO 15232, which It will have with each measure, and the final classification of the equipment.

➔ **For a more detailed description of the different automatisms proposed for each equipment and his classification according with ISO EN 15232 see ANNEX V**

The class of each chapter of automatic control used for the ANNEX V has been performed according to the Table 2- Function list and assignment to BAC efficiency classes of ISO 15232.

➔ **For a more detailed description of the calculation of the classification of each automatic control chapter according with TABLE 2. ISO 15232 see ANNEX VI**

ENERGY RATING (BACS) WITH MEASURES – UNE 15232						
Town Hall and Library	Museum of Dinosaurs	Doctor´s Office	School	Local Pool	Social Center	Social Housing
D	**D**	**D**	**D**	**D**	**D**	**D**

Fig. 61. Energy Rating (BACS) with Measures. Source: Own Work using ISO 15232

We conclude from this, that despite the domotic improvements made to the Cañada del Hoyo City Hall, the system is not providing any important improvement to energy efficiency. Since once all the sections that are of application are punctuated, the qualification of the control will be the minor of all the classes obtained. The table in the annex indicates that we do not have any energy efficiency improvements, so the new certification would be the same as the one obtained so far.

4.5. ECONOMIC ANALYSIS

Finally, we are going to analyze what are the savings and profitability that we take after implanting the automatisms described previously.

4.5.1. Cost Study

The cost of the automation will be decisive to see the profitability of the measures. In order to obtain prices, different price bases have been used, as well as sources of home automation companies as: *Domonova, Ioxonne, Somfy, Hedo & Montero S.L.*

The number of units has been previously calculated, taking into account the areas where the measures and the different infrastructures will be implemented and all prices have been calculated including workforce.

Next, we will see the cost of implementing each measure.

COST STUDY				
TYPE OF MEASURE	**MEASURE**	**Nº UNITS**	**UNITARY COST (€/UD)**	**PARTIAL COST (€)**
Heating Control	Install Thermostats with Individual temperature control	2	475	950
	Install Thermostat	3	145	435
	Zoning the Heating by rooms	2	430	860
	Lower the average temperature of the flow	2	50	100
	Control ON/OFF according to the time of the boiler by programmer	5	193	965
Hot Sanitary Water Supply	Install Thermostats to reduce temperature unnecesary	6	145	870
	Install a programmer to time control of the hours of hot water requirement	6	193	1158
Cooling Control	Install Thermostats with Individual temperature control	2	Is used the same as heating	/

	Install Thermostat	3	Is used the same as heating	/
	Zoning the Cooling by rooms	2	430	860
	Control ON/OFF according to the time of the AC by programmer	5	193	965
Ventilation and Air Conditioning Control	Install detectors to measure air quality	1	294	294
	Install aerator opening in the windows controlled by software	10	695	6950
Lighting Control	Install motion sensors to turn ON/OFF the lights	42	48	2016
	Installation of photoelectric sensors to switch ON or OFF the public lighting according to the sunlight	1	625	625
Blind Control	Install motorizations in the blinds to control sun protection (cooling) and natural illumination	10	315	3150
Technical Management	Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	1	12000	12000
	Contract a decentralized system managed by an external company	10 (years)	2500	25000
Equipment	Upgrading existing equipment	21	350	7350
	Switching off or enabling power down the energy of the equipments by software	4	280	1120
Access Control and Fire Protection	Analogue and IP Closed Circuits	1	2300	2300
	Alarm Activation and Event Recording	1	1600	1600

	Remote monitoring of alarms and states and supervision of extinction equipment	6	600	3600
	Communication with police and fire stations	6	320	1920
			TOTAL COST	**75.088,00 €**

Fig. 62. Cost Study for the automatism measures. Source: Own Work with Date Bases

For the calculation of the cost of the external management of the monitoring and the control of automatisms, it is taken into account 10 years, since it is the period of time that in next point we will use for the amortization.

The approximate total cost of these automatisms, for 10 years, without taking into account the maintenance of them, is **75.088€.** A high investment for such a small town hall.

4.5.2. Savings achieved with measures

In order to calculate the saving percentages of the measures, it is necessary to know in advance the areas and the orientation of the infrastructures where the measures will be implemented, in order to estimate the estimated percentage of expenditure by area and applying the percentage reduction of the measure.

GROUP	EQUIPMENT	AREA	ORIENTATION OF THE MAIN FAÇADE
Office	Town Hall and Library	380 m^2	South
	Museum of Dinosaurs	300 m^2	South
Sanitary	Doctor´s Office	150 m^2	South-East
Education	School	100 m^2	South-East
Sports	Sports Center	800 m^2	-
	Local Pool	150 m^2	South-East
Social	Social Center	300 m^2	West
	Social Housing	3 x 60 m^2	South-East
Facilities and services	Street Lighting	-	-
	Water Treatment Plant	50 m^2	-
	Water Tank	30 m^2	-

Fig. 63. Areas and Orientation of each Equipment. Source: Own Work

Savings percentages have been collected from the following sources:

- Domonova
- Ioxonne
- Somfy
- Hedo & Montero S.L.

- Consumos, Medidas y Potenciales Ahorros en Edificios. Grupo de Trabajo "Rehabilitación Energética de Edificios" de Asociación de Empresas de Eficiencia Energética.

Next, we can see the table in which the savings are detailed, depending on the measures taken at each site.

SAVINGS ACHIEVED WITH MEASURES							
TYPE OF MEASURE	**ANNUAL EXPENDITURE ESTIMATION (€)**	**TOTAL AREA (M2)**	**MEASURE**	**AFFECTED AREA (M2)**	**SAVING BY MEASURE (%)**	**SAVING ON CONSUMPTION (%)**	**PARTIAL ANNUAL SAVING (€)**
Heating Control	3200	1230	Install Thermostats with Individual temperature control	530	10,00%	4,31%	137,89
			Install Thermostat	700	7,00%	3,98%	127,48
			Zoning the Heating by rooms	530	15,00%	6,46%	206,83
			Lower the average temperature of the flow	530	6,00%	2,59%	82,73
			Control ON/OFF according to the time of the boiler by programmer	1230	12,00%	12,00%	384,00
Hot Sanitary Water Supply	800	1380	Install Thermostats to reduce temperature unnecesary	1380	5,00%	5,00%	40,00
			Install a programmer to time control of the hours of hot water requirement	1380	6,50%	6,50%	52,00
Cooling Control	1850	1130	Install Thermostats with Individual temperature control	530	12,00%	5,63%	104,12
			Install Thermostat	600	9,00%	4,78%	88,41
			Zoning the Cooling by rooms	530	15,00%	7,04%	130,15
			Control ON/OFF according to the time of the AC by programmer	1130	12,00%	12,00%	222,00
Ventilation and Air Conditioning Control	/	380	Install detectors to measure air quality	380	15% HVAC	15% (1610,74€)	241,61
			Install aerator opening in the windows controlled by software				
Lighting Control	35000	1380 m2 Lighting Building	Install motion sensors to turn ON/OFF the lights	1380	10,00%	10,00%	500,00
			Installation of photoelectric sensors to switch ON or OFF the public lighting according to the sunlight	/	9% S.L.	9% (30000€)	2700,00
Blind Control	/	380	Install motorizations in the blinds to control sun protection (cooling) and natural illumination	380	6 % HVAC+LIGHT	6% (2987,55€)	179,25
Technical Management	/	/	Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	/	5% TOTAL SAVINGS	5% (6154,95€)	307,75
			Contract a decentralized system managed by an external company				
Equipment	4500	1640	Upgrading existing equipment	1540	25,00%	23,48%	1056,40
			Switching off or enabling power down the energy of the equipments by software	930	4,00%	2,27%	102,07
Access Control and Fire Protection	200 (Maintenance)	1380	Analogue and IP Closed Circuits	/	/	/	/
			Alarm Activation and Event Recording	/	/	/	/
			Remote monitoring of alarms and states and supervision of extinction equipment	/	/	/	/
			Communication with police and fire stations	/	/	/	/
				TOTAL ANNUAL SAVINGS			**6.462,70 €**

Fig. 64. Savings achieved with measures. Source: Own Work with Percentages from Date Bases

As we can see, with the implementation of measures, the savings achieved are minimal, only **6.462,70€.** Further, the use of these automatisms, will have consumption and maintenance, which is not being taken into account, which further reduces the savings achieved.

4.5.3. Amortization analysis

To calculate the amortization of the investment, these premises will be taken into account:

- Amortization in 10 years
- For the financing of the works it is considered that the municipality has sufficient funds, reason why it does not carry an associated financial expense
- The annual interest rate is considered to be 3%

An investment of: **75.088€ - 22.500€ (Management Company) = 52.588€ (Investment)**

Annual costs management company: **2.500 € per annum (Investment)**

The annual savings / benefits would be: **6.462,70 € per annum (Revenue)**

Cash Flows

The cash flow produced between the investments and the 10-year savings is as follows:

	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
INVESTMENT	-52588,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00
SAVINGS	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70
FLOW	-46125,30	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70

Fig. 65. Cash flow from the investment to 10 years. Source: Own Work

Investment Update: Net Present Value

With the cash flow calculated for the 10 years, the next step is to apply the formula of the NPV to know what value has today the savings that will obtain in the coming years after the initial investment.

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+k)^t} - NCF_0$$

NCF_0 = initial cash outlay on project
NCF_t = net cash flow generated by project at time t
n = life of the project
k = required rate of return

	YEAR												
	0	1	2	3	4	5	6	7	8	9	10	INTEREST	NPV
INVESTMENT	-52588,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	0,03	-73913,51
SAVINGS	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	0,03	61590,84
FLOW	-46125,30	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	0,03	**-12322,67**

Fig. 66. Calculation of the NPV of the investment to 10 years. Source: Own Work

After the calculation, we have a negative NPV of -12.322,67€, so it would be quite economically negative to carry out this operation, as it can be said that it is a very bad investment.

Internal Rate of Return

The IRR of the project is obtained using the following formula:

$$IRR = r_a + \frac{NPV_a}{NPV_a - NPV_b}(r_b - r_a)$$

r_a = lower discount rate chosen
r_b = higher discount rate chosen
N_a = NPV at r_a
N_b = NPV at r_b

It consists of zero to the NPV. As this is a complex process, it is done with the help of the Excel tool that greatly simplifies the process.

	YEAR											
	0	1	2	3	4	5	6	7	8	9	10	
INVESTMENT	-52588,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	-2500,00	
SAVINGS	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	6462,70	IRR
FLOW	-46125,30	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	3962,70	-3%

Fig. 67. Calculation of the IRR of the investment to 10 years. Source: Own Work

The IRR on Investment is negative (-3%) then, without a doubt, **this investment is not economically profitable.**

Since the IRR on Investment is negative (-3%), this investment is not economically profitable. Thus, the benefits achieved are exclusively due to environmental and marketing factors.

Furthermore, these results are optimistic, since they do not incorporate the cost of maintenance and the consumption of automatisms. The implementation cost of automatic mechanisms is high and the savings achieved are hardly significant. Therefore, the use of automation is not profitable unless it is implemented in greater areas.

5. CONCLUSIONS

Over the next few years an enormous amount of money will be invested to develop technologies for the new energy network, requiring a thorough field study before extending integration. The current crisis is really an opportunity to invest in new technologies for energy savings and efficiency, making the development of the "Smart Grid" an exceptional opportunity. The result will be an affordable, secure and reliable supply of energy and information essential to the knowledge economy of the 21st century.

In the saving and energy management that society demands from companies and institutions in its plants and buildings, the EMS understood as management monitoring and automation systems play an essential role, as shown by the current references, if it is to be achieved the maximum use of energy.

The performance or control of non-critical loads and the use of local sources of renewable generation are the next step for the EMS, which will evolve from simple monitoring and reporting systems to true automatic control of loads and generation sources.

In order to manage and integrate all these characteristics mentioned in a single system and achieve an automation of the consumptions optimization, artificial intelligence tools, Expert Systems, Software Agents, have demonstrated their potential and feasibility of application, will be essential tools.

The future is to make the most of artificial intelligence tools, integrate monitoring, intelligent data analysis (report and graphs) and automated control over non-critical loads and local sources of renewable energy generation, in order to optimize and manage energy consumption automatically and manage demand to consume at least possible cost, without affecting production or comfort, taking advantage of the new conditions presented by a liberalized energy market.

There are a number of benefits derived from the implementation of an Energy Management System that have been demonstrated:

Energetic and environmental:

- Optimization of energy use (Energy Efficiency)
- Savings in the energy bill
- Reduction of risks arising from fluctuations in the prices of energy resources
- Reducing the impact on climate change
- Adequate use of natural resources

Marketing:

- Image of commitment to sustainable energy development
- Reinforcing the image of a company committed to climate change
- Compliance with legal requirements
- Promotion of energy efficiency in organizations

Once analyzed through the practical case, the measures that can be taken with automatisms and the practical use of them, **it can be appreciated that this series of**

measures can be quite profitable to install them in large areas, but not in the type of infrastructures analysed, since nowadays the investment is quite high to amortize it with a consumption not very high.

Therefore, we can say, as it was seen in the previous thesis, that **the implantation of an EMS is profitable, but not at any price**, since to implant automatisms has not been profitable, and in this case, **it has been one more measure of marketing than of real savings.**

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ANNEXES

ANNEX I

CADASTRAL MAP

GOBIERNO DE ESPAÑA

MINISTERIO DE HACIENDA Y ADMINISTRACIONES PÚBLICAS

SECRETARÍA DE ESTADO DE HACIENDA

DIRECCIÓN GENERAL DEL CATASTRO

Sede Electrónica del Catastro

Provincia de CUENCA

Municipio de CAÑADA DEL HOYO

Coordenadas U.T.M. Huso: 30 ETRS89

ESCALA 1:8,500

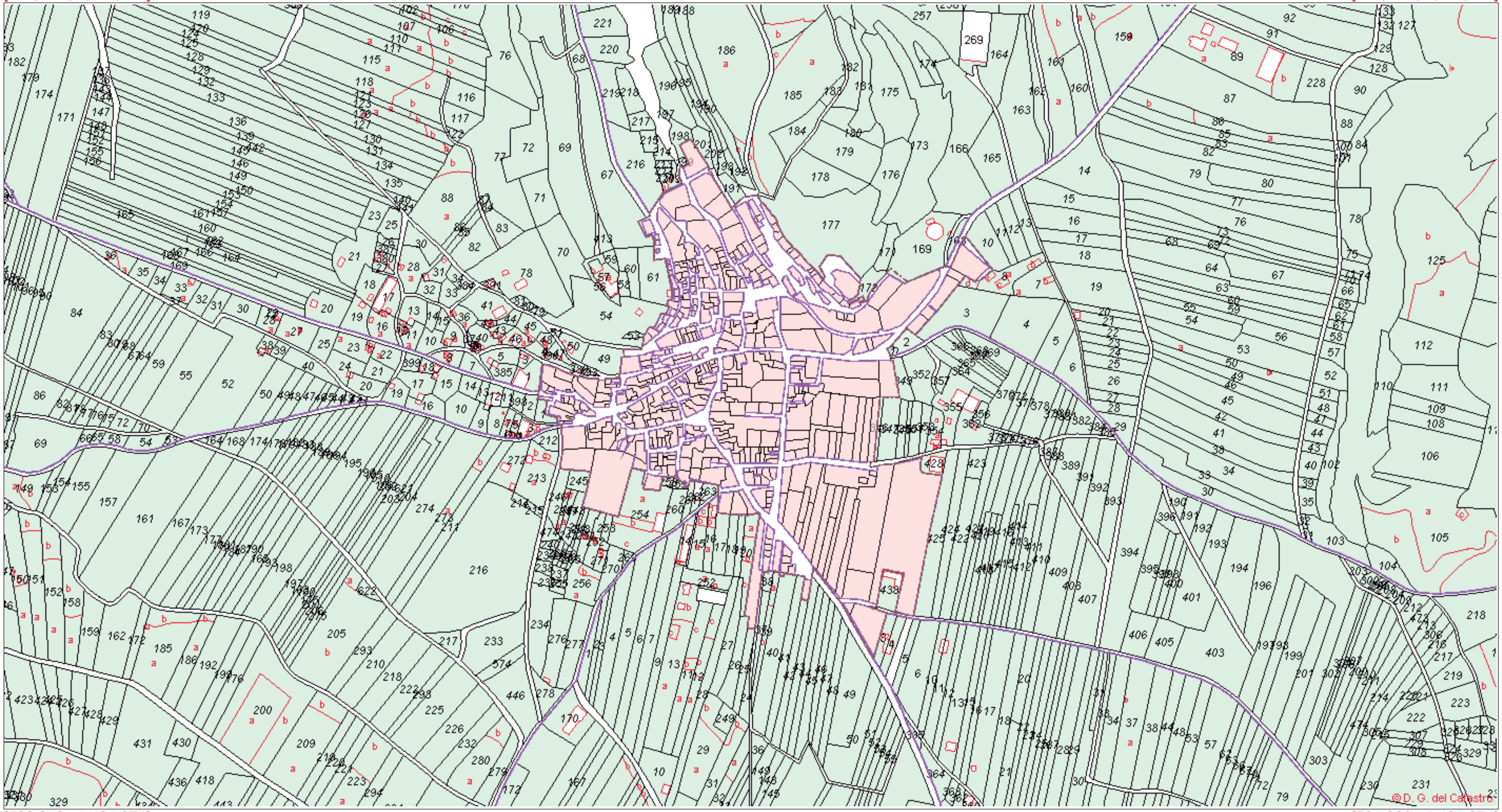
100m 0 100 200m

N

CARTOGRAFÍA CATASTRAL

[592,949 ; 4,425,478]

[594,989 ; 4,425,478]



[592,949 ; 4,424,374]

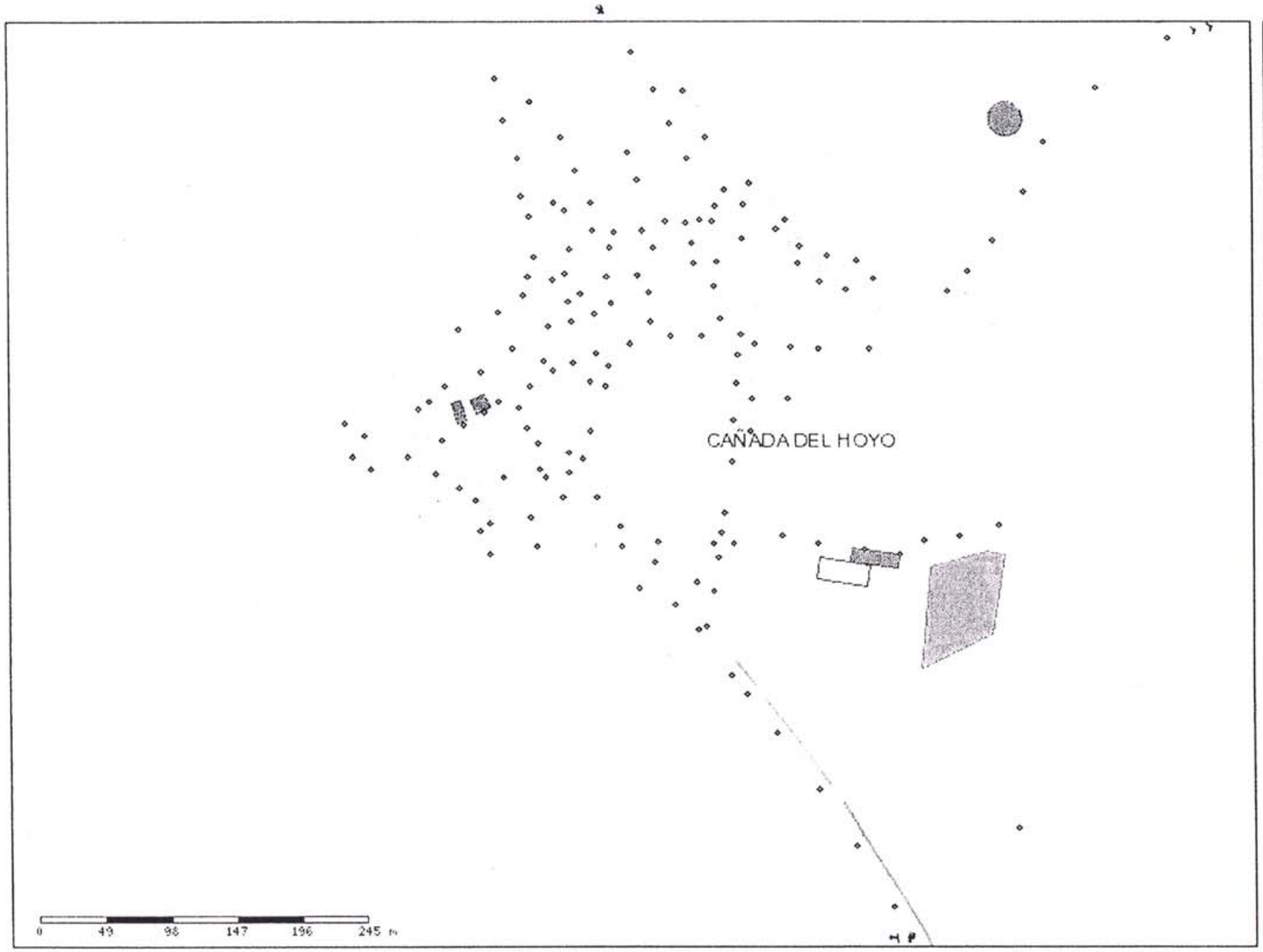
[594,989 ; 4,424,374]

Coordenadas del centro: X = 593,969 Y = 4,424,926

Este documento no es una certificación catastral

ANNEX II

EQUIPMENT MAP



LEYENDA

Infraestructura Viaria
Estados
Bueno
Ejecución
Malo
No pavimentado
Regular

Alumbrado
Puntos de Luz

Equipamientos
Clases
Casa Consistorial
Centro Asistencial
Centro Cultural
Cementerios
Centros de Enseñanza
Centros Sanitarios
Edificios públicos sin uso
Extinción de incendios
Instalaciones Deportivas
Lonjas, mercados y ferias
Mataderos
Parques y Jardines Naturales
Tanatorios

Carreteras
Autopistas y Autovias Estatales
Autopistas y Autovias Autonómicas
Carreteras Nacionales
Red Autonómica Básica
Red Autonómica Comarcal
Red Autonomica Local
Carreteras Diputación
Otras Carreteras

ENCUESTA DE INFRAESTRUCTURA Y EQUIPAMIENTOS LOCALES

DIPUTACIÓN PROVINCIAL DE CUENCA

Municipio: CAÑADA DEL HOYO

Código INE: 16046

Mapa de Equipamientos

Escala: 1:2000

30-9-2015

ANNEX III

FULL ENERGY INVENTORY

FULL ENERGY INVENTORY

GROUP	EQUIPMENT	No. Luminaires	Average consumption Luminaires (Wh)	No. Photocopiers / Printers	No. Computers	No. Home appliances	No. Radiator Elements	No. Boilers	No. Air conditioners	No. Solar panels	COMMENTS
OFFICE	Town Hall and Library	147	50	2 Printers-400Wh and 1 Photocopier-900Wh	4 PC - 300Wh	1 Refrigerator - 800Wh	148	1 Diesel	1 VRV 5KWh	8 - 260 Wh of Captation	
	Museum of Dinosaurs	44	50	1 Printer - 350Wh	1 Laptop - 60Wh	-	-	-	3 Condensers 3KWh	4- 260 Wh of Captation	
SANITARY	Doctor´s Office	17	80	2 Printers - 400Wh	2 Laptops - 60Wh	1 Refrigerator - 800Wh	73	1 Shared Diesel	1 Condenser 3KWh	-	
EDUCATION	School	12	60	1 Printer - 350Wh	1 Laptop - 60Wh	-	45	1 Shared Diesel	-	-	
SPORTS	Sports Center	1	500	-	-	-	-	-	-	-	
	Local Pool	28	50	-	-	2 Fridges - 800Wh	-	-	-	-	Additionally it has 2 waterworks engines that consume 5KWh
SOCIAL	Social Center	28	50	-	-	1 Freezer Chest - 150Wh	72	1 Diesel	2 Condensers 2KWh	-	
	Social Housing	20	60	-	-	1 Refrigerator - 800Wh and 1 Washing Machine - 900 Wh	-	-	-	-	
FACILITIES AND SERVICES	Street Lighting	158	100	-	-	-	-	-	-	-	
	Water Treatment Plant	2	100	-	-	-	-	-	-	-	It has 2 motors that consume 3 KWh
	Water Tank	1	100	-	-	-	-	-	-	-	It has 2 motors that consume 2KWh of drive

ANNEX IV

TABLE 1. ISO 15232 - CURRENT STATE

Table 1 — Function list and assignment to BAC efficiency classes

		Definition of classes							
		Residential				Non residential			
		D	C	B	A	D	C	B	A
AUTOMATIC CONTROL									
HEATING CONTROL									
Emission control									
	The control system is installed at the emitter or room level, for case 1 one system can control several rooms								
0	No automatic control								
1	Central automatic control					X			
2	Individual room automatic control by thermostatic valves or electronic controller								
3	Individual room control with communication between controllers and to BACS								
4	Integrated individual room control including demand control (by occupancy, air quality, etc.)								
Control of distribution network hot water temperature (supply or return)									
	Similar function can be applied to the control of direct electric heating networks								
0	No automatic control					X			
1	Outside temperature compensated control								
2	Indoor temperature control								
Control of distribution pumps									
	The controlled pumps can be installed at different levels in the network								
0	No control								
1	On off control					X			
2	Variable speed pump control with constant Δp								
3	Variable speed pump control with proportional Δp								
Intermittent control of emission and/or distribution									
	One controller can control different rooms/zone having same occupancy patterns								
0	No automatic control								
1	Automatic control with fixed time program					X			
2	Automatic control with optimum start/stop								
Generator control									
0	Constant temperature					X			
1	Variable temperature depending on outdoor temperature								
2	Variable temperature depending on the load								
Sequencing of different generators									
0	Priorities only based on loads						X		
1	Priorities based on loads and generator capacities								
2	Priorities based on generator efficiency (check other standard)								

Table 1 — (*continued*)

		Definition of classes							
		Residential				**Non residential**			
		D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
COOLING CONTROL									
Emission control									
	The control system is installed at the emitter or room level, for case 1 one system can control several rooms								
0	No automatic control					X			
1	Central automatic control								
2	Individual room automatic control by thermostatic valves or electronic controller								
3	Individual room control with communication between controllers and to BACS								
4	Integrated individual room control including demand control (by occupancy, air quality, etc.)								
Control of distribution network cold water temperature (supply or return)									
	Similar function can be applied to the control of direct electric heating networks								
0	No automatic control					X			
1	Outside temperature compensated control								
2	Indoor temperature control								
Control of distribution pumps									
	The controlled pumps can be installed at different levels in the network								
0	No control								
1	On off control					X			
2	Variable speed pump control with constant Δp								
3	Variable speed pump control with proportional Δp								
Intermittent control of emission and/or distribution									
	One controller can control different rooms/zone having same occupancy patterns								
0	No automatic control								
1	Automatic control with fixed time program					X			
2	Automatic control with optimum start/stop								
Interlock between heating and cooling control of emission and/or distribution									
0	No interlock					X			
1	Partial interlock (dependant of the HVAC system)								
2	Total interlock								
Generator control									
0	Constant temperature					X			
1	Variable temperature depending on outdoor temperature								
2	Variable temperature depending on the load								
Sequencing of different generators									
0	Priorities only based on loads						X		
1	Priorities based on loads and generator capacities								
2	Priorities based on generator efficiency (check other standard)								

Table 1 — (*continued*)

		Definition of classes							
		Residential				Non residential			
		D	C	B	A	D	C	B	A
VENTILATION AND AIR CONDITIONING CONTROL									
Air flow control at the room level									
0	No control								
1	Manual control								
2	Time control						X		
3	Presence control								
4	Demand control								
Air flow control at the air handler level									
0	No control								
1	On off time control						X		
2	Automatic flow or pressure control with or without pressure reset								
Heat exchanger defrost control									
0	Without defrost control								
1	With defrost control						X		
Heat exchanger overheating control									
0	Without overheating control								
1	With overheating control						X		
Free mechanical cooling									
0	No control					X			
1	Night cooling								
2	Free cooling								
3	H,x- directed control								
Supply Temperature control									
0	No control								
1	Constant set point						X		
2	Variable set point with outdoor temperature compensation								
3	Variable set point with load dependant compensation								
Humidity control									
0	No control								
1	Supply air humidity limitation						X		
2	Supply air humidity control								
3	Room or exhaust air humidity control								

Table 1 — (*concluded*)

		Definition of classes							
		Residential				Non residential			
		D	C	B	A	D	C	B	A
LIGHTING CONTROL									
Occupancy control									
0	Manual on/off switch					X			
1	Manual on/off switch + additional sweeping extinction signal								
2	Automatic detection Auto On / Dimmed								
3	Automatic detection Auto On / Auto Off								
4	Automatic detection Manual On / Dimmed								
5	Automatic detection Manual On / Auto Off								
Daylight control									
0	Manual						X		
1	Automatic								
BLIND CONTROL									
0	Manual operation					X			
1	Motorized operation with manual control								
2	Motorized operation with automatic control								
3	Combined light/blind/HVAC control (also mentioned above)								
HOME AUTOMATION SYSTEM **BUILDING AUTOMATION AND CONTROL SYSTEM**									
0	No home automation No building automation and control system					X			
1	Centralized adapting of the home & building automation and control system to users needs: e.g. time schedule, set points…								
2	Centralized optimizing of the home and building automation and control system: e.g. tuning controllers, set points…								
TECHNICAL HOME AND BUILDING MANAGEMENT									
Detecting faults of home and building systems and providing support to the diagnosis of these faults									
0	No					X			
1	Yes								
Reporting information regarding energy consumption, indoor conditions and possibilities for improvement									
0	No					X			
1	Yes								

ANNEX V

PROPOSED MEASURES WITH ENERGY RATING

PROPOSED MEASURES

GROUP	EQUIPMENT	CURRENT ENERGY EFFICIENCY RATING	PROPOSED MEASURES									ENERGY RATING WITH MEASURES - UNE 15232
			Heating Control	Hot Sanitary Water Supply	Cooling Control	Ventilation and Air Conditioning Control	Lighting Control	Blind Control	Technical Management	Equipment	Access Control and Fire Protection	
OFFICE	Town Hall and Library	C	Install Thermostats with Individual temperature control	Install Thermostats to reduce temperature unnecesary	Install Thermostats with Individual temperature control	Install detectors to measure air quality	Install motion sensors to turn ON/OFF the lights	Install motorizations in the blinds to control sun protection (cooling) and natural illumination	Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Upgrading existing equipment	Analogue and IP Closed Circuits	D
			Zoning the Heating by rooms	Install a programmer to time control of the hours of hot water requirement	Zoning the Cooling by rooms	Install aerator opening in the windows controlled by software			Contract a decentralized system managed by an external company	Switching off or enabling power down the energy of the equipments by software	Alarm Activation and Event Recording	
			Lower the average temperature of the flow		Control ON/OFF according to the time of the AC by programmer						Remote monitoring of alarms and states and supervision of extinction equipment	
			Control ON/OFF according to the time of the boiler by programmer								Communication with police and fire stations	
	Museum of Dinosaurs	D	Install Thermostat	Install Thermostats to reduce temperature unnecesary	Install Thermostat		Install motion sensors to turn ON/OFF the lights		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Upgrading existing equipment	Remote monitoring of alarms and states and supervision of extinction equipment	D
			Control ON/OFF according to the time of the boiler by programmer	Install a programmer to time control of the hours of hot water requirement	Control ON/OFF according to the time of the AC by programmer				Contract a decentralized system managed by an external company	Switching off or enabling power down the energy of the equipments by software	Communication with police and fire stations	
SANITARY	Doctor´s Office	F	Install Thermostats with Individual temperature control	Install Thermostats to reduce temperature unnecesary	Install Thermostats with Individual temperature control		Install motion sensors to turn ON/OFF the lights		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Upgrading existing equipment	Remote monitoring of alarms and states and supervision of extinction equipment	D
			Zoning the Heating by rooms	Install a programmer to time control of the hours of hot water requirement	Zoning the Cooling by rooms				Contract a decentralized system managed by an external company	Switching off or enabling power down the energy of the equipments by software	Communication with police and fire stations	
			Lower the average temperature of the flow		Control ON/OFF according to the time of the AC by programmer							
			Control ON/OFF according to the time of the boiler by programmer									
EDUCATION	School	F	Install Thermostat	Install Thermostats to reduce temperature unnecesary			Install motion sensors to turn ON/OFF the lights		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Switching off or enabling power down the energy of the equipments by software	Remote monitoring of alarms and states and supervision of extinction equipment	D
			Control ON/OFF according to the time of the boiler by programmer	Install a programmer to time control of the hours of hot water requirement					Contract a decentralized system managed by an external company		Communication with police and fire stations	

Class A **Class C**

Class B **Class D**

PROPOSED MEASURES

GROUP	EQUIPMENT	CURRENT ENERGY EFFICIENCY RATING	PROPOSED MEASURES									ENERGY RATING WITH MEASURES - UNE 15232
			Heating Control	Hot Sanitary Water Supply	Cooling Control	Ventilation and Air Conditioning Control	Lighting Control	Blind Control	Technical Management	Equipment	Access Control and Fire Protection	
	Sports Center	-										
SPORTS	Local Pool	E		Install Thermostats to reduce temperature unnecesary			Install motion sensors to turn ON/OFF the lights		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Upgrading existing equipment	Remote monitoring of alarms and states and supervision of extinction equipment	D
				Install a programmer to time control of the hours of hot water requirement					Contract a decentralized system managed by an external company		Communication with police and fire stations	
SOCIAL	Social Center	F	Install Thermostat	Install Thermostats to reduce temperature unnecesary	Install Thermostats		Install motion sensors to turn ON/OFF the lights		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems	Upgrading existing equipment	Remote monitoring of alarms and states and supervision of extinction equipment	D
			Control ON/OFF according to the time of the boiler by programmer	Install a programmer to time control of the hours of hot water requirement	Control ON/OFF according to the time of the AC by programmer				Contract a decentralized system managed by an external company		Communication with police and fire stations	
	Social Housing	G								Upgrading existing equipment		D
FACILITIES AND SERVICES	Street Lighting						Installation of photoelectric sensors to switch ON or OFF the public lighting according to the sunlight		Implementation of software ***Smarkia Monitor*** to monitoring and control of all Automation Systems			
		-							Contract a decentralized system managed by an external company			
	Water Treatment Plant	-								Upgrading existing equipment		
	Water Tank	-								Upgrading existing equipment		

Class A	**Class C**
Class B	**Class D**

ANNEX VI

TABLE 2. ISO 15232 - FUNCTION LIST

TABLE 2- Function list and assignment to BAC efficiency classes EN 15232

		Non residential Town Hall and Library				Non residential Museum of Dinosaurs				Non residential Doctor´s Office				Non residential School				Non residential Local Pool				Non residential Social Center				Non residential Social Housing			
		D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A
	AUTOMATIC CONTROL																												
1	**HEATING CONTROL**																												
1.1	Emission control: The control system is installed at the emitter or room level, for case 1 one system can control several rooms.																	DOESN'T APPLY								DOESN'T APPLY			
0	No automatic control.																												
1	Central automatic control.																												
2	Regulation of individual environments.		x				X				X				X								X						
3	Regulation of individual environments with communication.																												
4	Individual regulation of environments with communication and presence control.																												
1.2	Regulation of the emission for the TABS.																	DOESN'T APPLY								DOESN'T APPLY			
0	No automatic regulation is performed.																												
1	Centralized automatic control.																												
2	Advanced centralized automatic control.			x				X				X				X								X					
3	Advanced centralized automatic control with intermittent operation and / or regulation of the room temperature feedback.																												
1.3	Regulation of the temperature (hot water or return) of the hot water in the distribution network.																	DOESN'T APPLY								DOESN'T APPLY			
0	No automatic regulation is performed.					X								X								X							
1	Regulation with external temperature compensation.		x								X																		
2	Regulation based on demand.																												
1.4	Control of distribution pumps in networks.																	DOESN'T APPLY								DOESN'T APPLY			
0	No automatic regulation is performed.																												
1	Start / stop control.		x				X				X				X								X						
2	Multi-step adjustment.																												
3	Control of variable speed pumps.																												
1.5	Intermittent emission control and / or distribution.																	DOESN'T APPLY								DOESN'T APPLY			
0	No automatic regulation is performed.																												
1	Automatic adjustment with a preset schedule.																												
2	Automatic adjustment with start / stop optimization.			x				X				X				X								X					
3	Automatic regulation with demand assessment.																												
1.6	Regulation of the generator for combustion and district heating.																	DOESN'T APPLY								DOESN'T APPLY			
0	Constant temperature regulation.					X																X							
1	Variable temperature control depending on outdoor temperature.				x								X				X												
2	Variable temperature control depending on the load.																												
1.7	Generator setting for heat pumps.																	DOESN'T APPLY								DOESN'T APPLY			
0	Constant temperature regulation.					X																X							
1	Variable temperature control depending on outdoor temperature.			x								X				X													
2	Variable temperature regulation depending on load or demand.																												
1.8	Sequence of different generators.	DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY			
0	Priorities based on running time only.																												
1	Priorities based on loads only.																												
2	Priorities based on loads and demand only.																												
3	Priorities based on generator efficiency.																												
2	**REGULATION OF HOT SANITARY WATER SUPPLY**																												

TABLE 2- Function list and assignment to BAC efficiency classes EN 15232

	Non residential Town Hall and Library				Non residential Museum of Dinosaurs				Non residential Doctor´s Office				Non residential School				Non residential Local Pool				Non residential Social Center				Non residential Social Housing			
	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A
2.1 Regulation of the storage temperature of domestic hot water with integrated electric heater or electric heat pump.	DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY			
0 Automatic start / stop regulation.																												
1 Automatic start / stop and time-off setting of the load.																												
2 Automatic start / stop and time-off control of the load with storage management with multiple detectors.																												
2.2 Regulation of hot water storage temperature using heat generation.																									DOESN'T APPLY			
0 Automatic start / stop regulation.																												
1 Automatic start / stop and time-off setting of the load.																												
2 Automatic start / stop control, time-off of load and demand-oriented supply or storage management with multiple detectors.			X				X				X				X				X				X					
3 Automatic start / stop adjustment, time-off of load, demand-oriented supply or return temperature and storage management with multiple detectors.																												
2.3 Regulation of the hot water storage temperature, with seasonal variation: with heat generation or integrated electric heating.	DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY			
0 Regulation with manual selection with start / stop load pump, or heating electric.																												
1 Regulation with automatic selection with load pump start / stop, or electric heating and time disconnection of the load.																												
2 Regulation with automatic selection with start / stop load pump, or electric heating, time-off of load and demand-oriented supply or storage management with multiple detectors.																												
3 Regulation with automatic selection with heat generation, supply oriented to the demand and regulation of the temperature of return or electric heating, disconnection by time of the load and management of storage with multiple detectors.																												
2.4 Regulation of the storage temperature of hot water with solar collector and thermogeneration.	DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY				DOESN'T APPLY			
0 Regulation with manual selection of solar energy or thermogeneration.																												
1 Automatic regulation of the solar storage load (Prio.1) and additional storage load.																												
2 Automatic regulation of the solar storage load (Prio.1) and additional storage load and demand-oriented supply or storage management with multiple detectors.																												
3 Automatic regulation of the solar storage load (Prio.1) and additional storage load, demand-oriented supply, return temperature regulation and storage management with multiple detectors.																												
2.5 Regulation of the hot water circulating pump.																									DOESN'T APPLY			
0 No time interruption program.																												
1 With time interruption program.			X				X				X				X				X				X					
2 Demand-oriented regulation.																												
3 COOLING CONTROL																												
3.1 Emission control: The control system is installed at the emitter or room level, for case 1 one system can control several rooms.																	DOESN'T APPLY								DOESN'T APPLY			
0 No automatic control.																												
1 Central automatic control.					X								X															
2 Regulation of individual environments.		X								X												X						

TABLE 2- Function list and assignment to BAC efficiency classes EN 15232

	Non residential Town Hall and Library	Non residential Museum of Dinosaurs	Non residential Doctor´s Office	Non residential School	Non residential Local Pool	Non residential Social Center	Non residential Social Housing
	D C B A	D C B A	D C B A	D C B A	D C B A	D C B A	D C B A
3 Regulation of individual environments with communication.							
4 Individual regulation of environments with communication and presence control.							
3.2 Regulation of the emission for the TABS for refrigeration.					DOESN'T APPLY		DOESN'T APPLY
0 No automatic regulation is performed.							
1 Centralized automatic control.							
2 Advanced centralized automatic control.	X	X	X	X		X	
3 Advanced centralized automatic control with intermittent operation and / or regulation of room temperature feedback.							
3.3 Temperature regulation of the cold water in the distribution network (flow or return)					DOESN'T APPLY		DOESN'T APPLY
0 Constant temperature regulation.		X		X			
1 Offset outside temperature regulation.	X		X			X	
2 Regulation based on demand.							
3.4 Control of distribution pumps in networks.					DOESN'T APPLY		DOESN'T APPLY
0 No automatic regulation is performed.							
1 Start / stop control.	x	X	X	X		X	
2 Multi-step adjustment.							
3 Control of variable speed pumps.							
3.5 Intermittent emission control and / or distribution.					DOESN'T APPLY		DOESN'T APPLY
0 No automatic regulation is performed.							
1 Automatic adjustment with a preset schedule.							
2 Automatic adjustment with start / stop optimization.	x	X	X	X		X	
3 Automatic regulation with demand assessment.							
3.6 Interlocking between the regulation of heating and cooling in the emission and / or distribution.					DOESN'T APPLY		DOESN'T APPLY
0 Without interlocking.	x	X	X	X		X	
1 Partial interlocking (depending on heating, ventilation, HVAC air conditioning).							
2 2 Total interlocking.							
3.7 Differentiated Generator Regulation for Cooling.					DOESN'T APPLY		DOESN'T APPLY
0 Constant temperature regulation.	X	X	X	X		X	
1 Variable temperature control depending on outdoor temperature.							
2 Variable temperature control depending on the load.							
3.8 Sequencing of different generators.	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 Priorities only based on loads.							
1 Priorities based on loads and generator capacities.							
2 Priorities based only on loads and demand for generator capacity.							
3 Priorities based on generator efficiency.							
4 VENTILATION AND AIR CONDITIONING CONTROL							
4.1 Air flow control at the room level.		DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 No control.							
1 Time control.							
2 Presence control.							

TABLE 2- Function list and assignment to BAC efficiency classes EN 15232

	Non residential Town Hall and Library	Non residential Museum of Dinosaurs	Non residential Doctor´s Office	Non residential School	Non residential Local Pool	Non residential Social Center	Non residential Social Housing
	D C B A	D C B A	D C B A	D C B A	D C B A	D C B A	D C B A
3 Demand control.	x						
4.2 Regulation of the air flow or pressure at the level of the air conditioner.		DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 Out of control.							
1 Start / stop time control.							
2 Multi-step adjustment.							
3 Automatic adjustment of flow or pressure.	x						
4.3 Control of the protection against the formation of ice of the side of the air discharged of the energy recovery.	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 Without defrost control.							
1 With defrost control.							
4.4 Heat exchanger overheating control.	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 Without overheating control.							
1 With overheating control.							
4.5 Free mechanical cooling.		DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 No control.							
1 Night cooling.							
2 Free cooling.	x						
3 H,x- directed control.							
4.6 Regulation of the temperature of the air of impulsion.		DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 Without automatic control.							
1 Constant set point.							
2 Variable setpoint with outdoor temperature compensation.							
3 Variable setpoint with demand-dependent compensation.	x						
4.7 Humidity control.		DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY	DOESN'T APPLY
0 No control.	X						
1 Dew Point Regulation.							
2 Direct humidity control.							
5 LIGHTING CONTROL							
5.1 Occupancy control.							DOESN'T APPLY
0 Manual switch to switch on / off.							
1 Manual switch to switch on / off + additional generalized power off signal.							
2 Automatic detection.	x	X	X	X	X	X	
5.2 Daylight control.							DOESN'T APPLY
0 Manual							
1 Automatic	x	X	X	X	X	X	
6 BLIND CONTROL					DOESN'T APPLY		DOESN'T APPLY
0 Manual operation.		X	X	X		X	
1 Motorized operation with manual control.							
2 Motorized operation with automatic control.	x						
3 Combined light/blind/HVAC control (also mentioned above).							
7 TECHNICAL MANAGEMENT OF HOUSING AND BUILDINGS							
7.1 Detecting faults of home and building systems and providing support to the diagnosis of these faults.							DOESN'T APPLY
0 No							

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	Non residential Town Hall and Library				Non residential Museum of Dinosaurs				Non residential Doctor´s Office				Non residential School			
	D	C	B	A	D	C	B	A	D	C	B	A	D	C	B	A
1 Yes				x				X				X				X
7.2 Reporting information regarding energy consumption, indoor conditions and possibilities for improvement.																
0 No																
1 Yes				x				X				X				X
FINAL SCORE	**D**				**D**				**D**				**D**			

	Non residential Local Pool				Non residential Social Center				Non residential Social Housing			
	D	C	B	A	D	C	B	A	D	C	B	A
1 Yes				X				X				
7.2 Reporting information regarding energy consumption, indoor conditions and possibilities for improvement.									DOESN'T APPLY			
0 No												
1 Yes				X				X				
FINAL SCORE	**D**				**D**				**D**			