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ESTABLISHING PERFORMANCE STANDARDS FOR BUILDING OF ALMOST ZERO CONSUMPTION

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Abstract- The Buildings are not only places for living but also part of the energy system and the economical process. Energy consumption of buildings is one of the keys for saving energy in a society. Buildings have great potential for energy savings, and in this sense, the European Union (EU) is trying to regulate the rules of its member states. In 2010, a new directive was published, which will help reduce EU buildings energy consumption in the long run. A requirement that all new buildings must be net zero energy consumers by 2020 has received the most attention. The directive further sets a framework for creating an integrated methodology for measuring energy performance, establishing minimum performance standards for new and certain existing buildings, and conducting regular inspections of critical buildings system. In this paper, we try to sign some fundamental aspects to achieve the proposed objectives.

Keywords: Energy Efficiency, Buildings, Nearly Zero-Energy Building.

I. INTRODUCTION

Energetic engineers, civil engineers, and architectural projects have acquired a new value after the adoption of the European Directive 2010/31/EU, which required that buildings be 'Consumption almost null' for 2020. This Directive defines a Nearly Zero-Energy Building as a building that has a very high energy performance, the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby [1]. This European Standard about energy efficiency should be, really it will be, a model change in construction.

The Directive also defines in its article 2 the major renovation as, "the renovation of a building where:

(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated; or,

(b) more than 25% of the surface of the building envelope undergoes renovation."

It says that member states of EU may choose to apply option (a) or (b), and in its article 7, it states that, "member states shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements set in accordance with article 4 [on setting minimum energy performance requirements] insofar as this is technically, functionally and economically feasible".

Buildings should respond with energy optimum in real time to the user requirements, considering external weather conditions and using technology to optimize traditional systems and solutions.

In Europe, energetic engineering and studies of architecture are working in so-called Net Zero Energy Building (NEZB) or Nearly Zero Energy Buildings, which can be both new and rehabilitated buildings. A NZEB conceives globally sustainability energy efficiency, ecology, certification energy, ISO 14001, etc. of a building, unifying all concepts in a single energy project, where architecture integrates energy from its initial phase.

The NEZB, as defined by Directive 2010/31/EU, has a clear objective: "the building must generate all the energy required for its operation". This implies that the reduction of the energy demand and the use of renewable energies will become a priority in the projects of building and rehabilitation. Simultaneously, the energy management in buildings will become a new challenge for engineers and architects.

The Directive includes a harmonized calculation methodology to push up the minimum energy performance requirements in member states of EU towards a cost-optimal level. This method is noted in a definition and an annex. It will be refined via a comitology process. Member states of EU will have to justify to the Commission any gap exceeding 15% between current and cost optimal requirements.

II. A CHANCE FOR SOCIETY

Spain has a large number of buildings very poor from the point of view of energy, in part because 60% of its

real estate has more than 30 years, as it is said in an own report of the Spanish government [2]. This inefficiency is accompanied by a worrying delay with respect European legislation. Besides a logic loss of competitiveness, the delay has caused that in 2011 the European Community sued Spain to the Court of Justice of the EU for not have an energy certification for existing buildings, which violates the Directive 2002/91/EC on energy efficiency.

To comply with the new European standards, the current Spanish legislation (Building Technical Code 2006, RD 21/2006, RD 47/2007, RD 1826/2009, etc.) will have to make many deep changes. This policy development will involve to implement energy efficiency standards that already are eligible to new buildings, as provided the aforementioned Building Technical Code (BTC) and Royal Decree 47/2007, to existing buildings. In addition, Spain has to establish an energy technical inspection system and mandatory objectives for rehabilitation.

To ensure the achievement of these goals, the new regulations should be accompanied by a stimulus to energy rehabilitation including aid programs to renewable installations using biomass, solar thermal and geothermal. In this process of reform, rehabilitation and energy certification of buildings will play a fundamental role. In next sections, the different elements that make energy refurbishment of a building will be discussed.

III. ENERGY IN BUILDING OPERATING COST

According to the Directive 2010/31/EU, in 2020 all new buildings must have an almost zero consumption of energy. This means that from that date all new buildings must have a very high level of energy efficiency and its energy must come from renewable sources. With the data provided by enterprises of Facilities Management, we can weigh the importance of the energy in the overall spending of a building. Facility management (or facilities management or FM) is the practice of coordinating the physical workplace with the people and work of the organization, integrates the principles of business administration, architecture, and the behavioral and engineering sciences [3]. In other words, it is an interdisciplinary field devoted to the coordination of space, infrastructure, people, and organization, often associated with the administration of office blocks, arenas, schools, convention centers, shopping complexes, hospitals, hotels, etc. [4].

However, FM facilitates on a much wider range of activities than just business services and these are referred to as non-core functions. Many of these are outlined below but they do vary from one business sector to another. In 2011, the energy in the overall spending of a building assumed 30% of the total operating cost [5]. If we consider that the growth rate of energy prices doubles the increase of the Consumer Price Index (CPI), it is conceivable that the relative importance of the energy consumption will also continue growing. It is expected in some scenarios that in 20 years this energy consumption will be 50% of the operating costs of a building.

As the price of energy grows, energy certification will turn into a mark of quality. It is already used in many European countries, where the certificate is placed at the building entrances. This is an added value and it gives a scale of energy quality and indicates the estimated consumption of the building with associated CO_2 emissions.

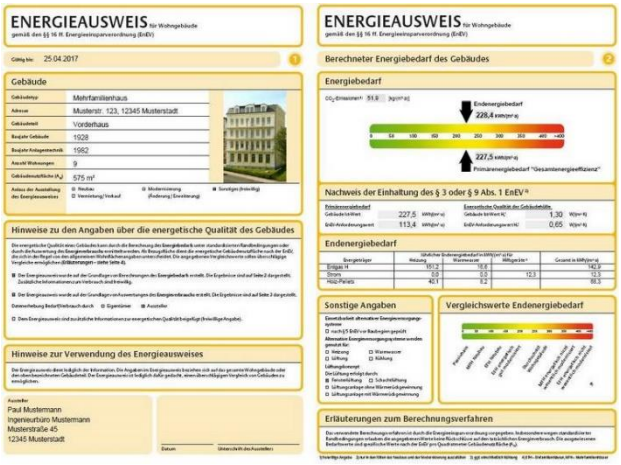

Figure 1. Certificate of a German building

The implementation of energy certification provide information on the energy performance of the building or property that a citizen intends to purchase on property or lease. But the certification will also informe of the building condition to the owner of the property. The peson or company that owns a building or housing with better energy class will have a more competitive real estate in the market, and he will be rewarded economically, in case of selling. On the contrary , the owner of a building with energy class G will be less competitive than other buildings of similar characteristics (place, size, etc.) but with an energy classification more favorable. In addition, the own Energy Efficiency Certified contains a series of recommendations for implementing measures that may be carried out to improve the energy efficiency of the building.

However, it is not only to assess the economic benefits of this instrument, since the social and environmental benefits of its implementation play a vital role. For example, in environmental terms, households with lower energy demand and with energy sources from renewable sources reduce emissions of greenhouse gases, and therefore, the impact of the industrial and non-industrial sectors in the fight against climate change. In addition, Spain must reduce by 2020 10% of the emissions from diffuse sources (which is the building) with with the basis of 2005.

Moreover, in social terms, a home with a low energy demand will reduce spending on energy bills and improve quality of life and health of people, by allowing this home keep at a suitable temperature, thus avoiding situations of energy poverty.

IV. THE LETTER OF A BUILDING

Currently in Spain, there is RD 47/2007 of 19 January, which approved a basic procedure for energy performance certification of buildings of new construction. Letters establish the energy rating: from A (best) to G (worst), following the same criteria as the electrical household appliances. This certification allows concepts like sustainability, green, ecological, and efficient may have real and objective value.

A recent study by the Polytechnic University of Madrid [6] estimated savings of moving from a score E to B could reach 76%. That is, saving is 5.36 €/m^2, which means that a house of 90 m^2 of type B will saved 482 euros in a year compared to house type E. In CO_2 emissions, these savings mean 2,700 kg of CO_2 per year. Once the energy cost of a building is evaluated and certified, it is possible to improve its score with an energy rehabilitation. In Spain, the road ahead is long. While most of our electrical household appliances are A, A+ or A++, 70% of evaluated buildings have received the letter D or worst (E, F and G).

Figure 2. Energy performance label

However, to obtain the qualify as A is not enough. Although both European legislation as the Spanish one say that buildings should produce the same energy that they consume, standards of each one (Europe and Spain) are different. A building of energy rating A, as defined by the RD 47/2007, has less requirements than Net Zero Energy Building or NZEB, established by the European Directive 2101/31 / EU. Therefore, the certification criteria should also be adapted.

V. CONSUMPTION OF A BUILDING

The Net Zero Energy Building can also be called Net Balance Buildings, as they consume the same energy that they produce. Such consumption is calculated in a similar way to the consumption of a vehicle. While for transport the consumption is divided by the traveled distance, in building the consumption is divided by the surface of the building. Consumptions of electricity, gas, oil, etc. are accounted and passed to the measurement unit of kWh/m^2 (Table 1).

The European requirement that buildings must be of almost zero consumption implies that they should consume 0 kWh/m^2. Energy rehabilitation actions aimed to achieve this goal differ according to the type of building, as not all buildings consume in the same way. The uses of the building and its type determine the current average consumption. For example, in the Table 2 [7] we can see some types of buildings with their average consumption.

Table 1. Comparison of consumptions between car and building

	In a car	In an office building
Consumption high	20 litres/100 Km	300 kWh/m2 and year
Consumption medium	10 litres/100 Km	175 kWh/m2 and year
Consumption low	5 litres/100 Km	50 kWh/m2 and year

Table 2. Different types of buildings with their average consumption

Hospitals	use 24 h	300 kWh/m^2 year
Museum	timely use	250 kWh/m^2 year
Offices	use 12 h	175 kWh/m^2 year
Residential	private use	150 kWh/m^2 year

Although average consumption also varies with the geographical location and orientation of the building, these figures can be used to have a reference of the current consumption and possible savings. An example: the energy bill of an office building of an area of 5,000 m^2 with an annual average consumption of 175 kWh/m^2 is 5000 m^2 × 175 kWh/m^2 × 0.15 €/kWh = 131,000 euros.

Before running the rehabilitation actions, we must carefully analyze the behavior of the building and of its users. The energy audits that monitor the consumption are an indispensable tool to know where and when building spends more. With the data of this audit, or with those data provided by the building manager (Facility Manager), we put in place an energy rehabilitation plan. This plan should report on possible actions to take, the price of these actions and the return on investment. The most economical and cost effective action is user awareness of how to optimize the use of building facilities, which may involve savings of 5% of the total bill. Other normal actions are to take into account the facade and the other building facilities.

VI. TRIANGLE: FACADE-HVAC-LIGHTING

Currently the HVAC (Heating, Ventilation, and Air Conditioning) is, by far, the building facility that most energy consumes. HVAC represents almost half of the entire bill of energy and double than the lighting, the second installment in importance. Controlling only the expense of these two facilities, it is possible to achieve significant savings.

The balance between comfort and energy savings is also very important, because it set the internal conditions of climate and lighting of a building. Remember that each degree of temperature, when you are cooling or heating your home or office, represents 6% increase in consumption, with a reference point of 25 ºC for cooling and 21 ºC for heating. The Regulation of Thermal Installations of Buildings of Spain sets some conditions that must be respected by users and implemented by the person in charge of the maintenance of the facilities. For HVAC and lighting, they are as following:

Temperature: Winter 21 ºC and Summer 26 ºC

Lighting: 500lux

However, to reduce HVAC consumption and lighting in any office building we cannot forget the third key element: the facade. The envelope or facade is our first energy-monitoring tool. Its functions include determining the architectural relationship with the environment and orchestrating the thermal, lighting, and sound response of the building, and also from the point of view of safety, sealing and solar radiation.

The new skin of our building has to give an optimal answer to external climate change and internal use or distribution. The facades should include a dynamic insulation that respects the architectural concept and that suits in real time to weather conditions. The largest challenge is to optimize the heat and/or cold input while the building takes as much natural light as possible. A facade that can manage both factors can achieve savings over 30% of our bill.

For example, an office building always needs cold. As electronics devices, lighting, and people inside generate enough heat, we must avoid heat input from outside, so the effect of solar radiation and the direct heat transmission through walls. This ability to react in real time to climate change and internal use-distribution turns the facades that incorporate dynamic solar protections into a fundamental to achieve the net balance. Its effectiveness depends of their integration into a single integral management system of the building.

In Europe, the bound energy project is already included both in new projects as in rehabilitation. The Facility Management will be the new energy manager to help control and optimize electric consumptions of the different systems and equipment. Also new energy services companies (ESCO) will be key in the new way to manage the buildings.

VII. ROADMAP TO THE BUILDINGS ALMOST ZERO CONSUMPTION

The energy rehabilitation process by which we reach the 0 Kwh/m^2 is called Roadmap. It is a plan that matches short-term and long-term goals and the actions that we will perform. These actions will be based on data provided by an energy audit. The layer theory argues that the most effective actions are made from the outside layer towards the inside of the building. The process or roadmap for getting it is based on four basic points.

A. Limiting Energy Demand

Together with performances in heating and air conditioning and lighting, rehabilitation of the facade is the most important energy control of the building. If we act only inside, for example, to improve performance of air conditioning machines, the solar radiation in our building will continue to force us to use extra electrical power in order to reduce the temperature.

B. Integrate Facilities to Manage them Together

Currently the facilities of a building are a sum of equipment and machinery acting individually with their own protocol of management. The European Directive recommends us to integrate all building facilities under one management or control system to optimize their management. In the initial phase of the project, so that the suppliers, manufacturers, and installers can integrate into that management system, it is necessary to specify the language of the system.

C. Generate all Possible and Renewable Energies

After reducing consumption and integrating facilities, and if we still have to generate energy to reach the net balance, this energy must be generated with renewable sources. Therefore, the rehabilitation project must also provide the physical space suitable for the integration of the equipment and facilities of renewable energies into the building management system.

D. Save and Export the Power

In the future, the net balance buildings will offer a new energy framework in which buildings can store and export their excess of energy. This phase of the roadmap is still an idea.

VIII. INITIATIVES FOR ENERGY REHABILITATION

The roadmap runs through actions that extend the useful life of buildings and eliminate the environmental impact of its replacement or demolition. Furthermore, they directly improve the quality of life and economy of users because they directly reduce CO_2 emissions.

The most common actions for energy rehabilitation are divided into 2 groups: the generic measures, which offer a global constructive solution, and particular measures, which are performances in a particular place of the building. Generic measures for building energy rehabilitation:

- Decalogue of good practices and habits for users
- Improve the thermal insulation of the facade and cover
- Incorporate solar protection for facade and cover
- Incorporate management and control systems in solar protection of the façade
- Incorporate management and control systems in lighting
- Incorporate management and control systems in the HVAC
- Improve performance and energy efficiency of equipment and facilities
- Replacing fuel and no-renewable systems by renewable energies like thermal solar, biomass, geothermal for HVAC
- Optimize the bill (negotiate the rate) with the utility.

Particular measures for building energy rehabilitation:

- Replacing individual heating by central heating, but individually controlled
- Using low temperature boilers and/or condensation boilers
- Replacing conventional heating systems by low-temperature heat transmitters
- Use of energy saving lamps in the lighting systems
- Use of low-power devices and timed for water managing taps and appliances
- Incorporation of rainwater collection tanks for later use in irrigation, toilets, and cleaning

IX. CONCLUSIONS

Buildings are one of the most important consumers of energy in our society. In 2011, the energy in the overall spending of a building assumed 30% of the total operating cost. Buildings should respond with energy optimum in real time to the user requirements, considering external weather conditions and using technology to optimize traditional systems and solutions.

Nowadays, energetic engineering and studies of architecture are working in so-called Net Zero Energy Building. A NZEB conceives globally sustainability energy efficiency, ecology, certification energy, ISO 14001, etc. of a building, unifying all concepts in a single energy project, where architecture integrates energy from its initial phase. The NEZB has a clear objective: the building must generate all the energy required for its operation.

In this paper, some initiatives are proposed inside a roadmap in order to improve the energy efficiency of the buildings. The implementation of these measures will lead to a scenario where you get to use resources efficiently and reduce the negative impact of a building in the environment, improving our welfare, comfort and productivity both in our workplace and in our home: they will be buildings for better living.

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BIOGRAPHIES

Javier Bilbao obtained the degree in Industrial Engineering from University of the Basque Country, Bilbao, Spain, in 1991. He is Ph.D. in Industrial Engineering and Professor at the Department of Applied Mathematics of that university. He has been General Chairman of some conferences of WSEAS organization. He is the General Chairman of the International Conferences on Engineering and Mathematics (ENMA) and member of the committees of International Conferences of "Technical and Physical Problems of Electrical Engineering" (ICTPE). His research interests are distribution overhead electrical lines compensation, optimization of series capacitor batteries in electrical lines, modeling of a leakage flux transformer, losses in the electric distribution networks, artificial neural networks, modeling of fishing trawls, e-learning, noise of electrical wind turbines, light pollution, health risk of radio frequencies.

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