ZEMedS

PROMOTING RENOVATION OF SCHOOLS IN A MEDITERRANEAN CLIMATE UP TO NEARLY ZERO-ENERGY BUILDINGS

Nearly Zero Energy Buildings (nZEB) Status Report in Mediterranean countries

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EXECUTIVE SUMMARY

Buildings represent the largest available source of cost effective energy saving and CO_2 reduction potential within Europe. The aim to reduce energy consumption in buildings has led to Zero Energy Building (ZEB) concept. Within the European legislative framework, nearly Zero Energy Buildings (nZEB) are arising much interest nowadays and European Union is committed to implement this target. This commitment requires efforts from all Member States to contribute to energy efficiency in the building sector, through the adoption of suitable regulatory and policy instruments.

Energy Efficiency Directive (**EED, 2012/27/EU**) adopted in October 2012, includes a requirement for Member States to develop long term renovation strategies for their national building stocks. EED was developed in order to help deliver the EU's 20% headline target on energy efficiency by 2020, as well as to pave the way for further improvements thereafter. Alongside EED, the Energy Performance of Buildings Directive (EPBD, 2010/31/EU)recast in 2010, sets out numerous requirements including energy performance certification of buildings, inspection regimes for boilers and air conditioning plants, and requirements for new buildings to be nearly zero energy. EPBD sets minimum energy performance standards for buildings undergoing renovation. According to Article 2.2 of the EPBD recast "nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I. 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".

Specifically Annex I states that "The energy performance of a building shall be determined on the basis of the calculated or actual annual energy that is consumed in order to meet the different needs associated with its typical use and shall reflect the heating energy needs and cooling energy needs (energy needed to avoid overheating) to maintain the envisaged temperature conditions of the building, and domestic hot water needs". EED complements Directive 2010/31/EU by focusing on existing buildings that undergo major renovation. Not only it ensures that their energy performance is upgraded but also increases the rate of building renovation. Buildings owned by public bodies are targeted as they account for a considerable share of the building stock and have high visibility in public life. At the 4th article of EED, the basic principles are described, in order Member States to establish a long-term strategy for mobilizing investment in the renovation of the national stock of residential and commercial buildings, both public and private. At the 5th article of EED, public bodies' buildings are given an exemplary role on the renovation strategy. Each Member State shall ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year to meet at least the minimum energy performance requirements that it has set in application of Article 4 of Directive 2010/31/EU. The 3% rate shall be calculated on the total floor area of buildings with a total useful floor area over 500 m² owned and occupied by the central government of the Member State concerned. That threshold shall be lowered to 250 m² as of 9 July 2015. Furthermore, the Energy Roadmap 2050, published on the 15 December 2011, goes beyond the 2020 goals and provides an analysis of the long term energy policy orientations: EU is committed to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050.

In Europe most renovation activity currently achieves only modest energy savings, perhaps 20-30%, but this needs to increase to profound renovations of at least 60% if the full economic potential is to be realized. Buildings Performance Institute Europe (BPIE) has studied impact of different renovation pathways on the resulting energy and carbon savings. The outcome shows scenarios where both the rate and the depth of renovation were substantially increased, rapid decarbonisation of the energy supply system, could be achieved. The qualitative definition and the different approaches worldwide to achieve net zero have led to discussion amongst experts. There have been attempts to tackle a wide spectrum of additional specifications and issues pertaining to terminology and definitions around buildings that consume very low or zero energy (or carbon), including those with net energy production – 'energy positive' (Ferrante, 2012). Torcellini et al (2006) have reported four well-documented definitions based on extensive data from existing low energy buildings: net-zero site energy, net-zero source energy, net-zero energy costs and net-zero energy emissions. These definitions of ZEBs are the following:

- Net-zero site energy: A site ZEB produces at least as much energy as it uses annually, when accounted for at the site;
- Net-zero source energy: A source ZEB produces at least as much energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site;
- Net-zero energy costs: In a cost ZEB, the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount of money the owner pays the utility for the energy services and energy used over the year;
- Net-zero energy emissions: A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources;

Moreover, many methodologies have been proposed. They deal with different features such as:

- Metric of the balance: delivered energy, primary energy, CO_2 (equivalent) emissions, energy cost
- Period of balance: annual, monthly
- Type of energy use: operating energy, total energy and energy use and EE (embodied energy)
- Type of balance: generation/use, grid in/out
- Renewable supply options: footprint, on-site, off-site
- Conversion factors (for primary energy and CO_2 emissions)

Even with the recent methodologies and projects, the complexity of nZEB concept and the existing national and regional policies have led to this current situation, where only few countries have already set up a nZEB standard. At the end of November 2012, according to the Commission's report on the progress of Member States in drawing up national plans to develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into Nearly Zero-Energy Buildings (nZEBs), only 9 Member States (BE, DK, CY, FI, LT, IE, NL, SE and UK) had reported their nZEB national plans to the Commission as required. As regards the practical definition of nZEBs, only 5 Member States (BE, CY, DK, IE and LT) presented a definition that contains both a numerical target and a share of renewable energy sources. Fifteen Member States (BE, CZ, DK, EE, FI,

DE, GR, HU, IE, LV, LT, SL, SE, NL and UK) presented intermediate targets for improving the energy performance of new buildings by 2015, with most focusing on strengthening the building regulations and/or the energy performance certificate level. Although most Member States reported a variety of support measures to promote nZEBs, including financial incentives, strengthening their building regulations, awareness raising activities and demonstration/pilot projects, it is not always clear to what extent these measures specifically target nZEBs. National Plans should provide measures to ensure that the 2018 and 2020 targets are met in practice as well as on paper.

As the qualitative nature of the nZEB definition leaves some room for interpretation, Member States may follow different paths and uphold different standards in order to fulfil the directive.

ZEMedS project focuses on renovating schools to nZEB in the Mediterranean regions, an area which represents 17% of EU-27 population. This document presents the current situation in 4 Mediterranean countries (France, Greece, Italy and Spain) regarding nZEB approach and existing state of school buildings. In Mediterranean regions of Italy, Greece, Spain and France, there are around 87,000 schools and there is a great potential in promoting energy efficiency and achieving the nZEB targets.

Spain is gradually implementing the European Directives related to energy efficiency in buildings. As regards to nearly Zero Energy Buildings, a roadmap is still to be made available and no national voluntary labels exist in this approach or even in positive energy buildings. Concerning best practices, some initiatives are in place to reduce energy consumption in schools, regarding the use and management. However, no school has been identified to be renovated following a holistic approach and reaching low energy consumption. In Spain, the lack of data regarding energy performance of current buildings is an important barrier when it is time to renovate the built stock. Particularly in Catalonia, many public schools have been energy assessed by local municipalities in the framework of NREAPs. Unfortunately, this data is not automatically shared with the actual decision maker of public schools renovations, the Government of Catalonia. In addition, despite of current lack of indoor comfort in many schools (low ventilation rates, overheating, glare, etc.), indoor environmental quality has not been assessed in scholar buildings up to date. A program to carry out energy and IEQ assessments in schools would constitute a good option to provide data to a “Schools observatory” or even a “Buildings observatory”. In spite of this lack of energy data, some available information on mean energy consumption in Catalan schools have shown a wide range of values, 68-122 kWh/m^2/year for 354 schools, being the thermal contribution 60-90%. At first, buildings built before first thermal regulations in force are generally supposed to consume more energy than recent built. However increased comfort and new technologies use, may imply a major use of facilities that have showed so often that schools built last decades can consume more than that from the 60-70’s. Together with the energy demand one should consider the general requirements of indoor climate conditions, in order to avoid possible adverse consequences. The school buildings in general are characterized by a high density of people per unit area, which is associated with increased concentrations of certain pollutants and therefore with reduced attentiveness of students and less ability to learn.

In Greece, transposition of the European Directive 2009/28/EC took effect in June 2010 by the national law N.3851/2010 on RES (FEK 85/A/4.6.2010). All public buildings by 2015 and all new buildings by 2020 should cover their primary energy consumption from RES, combined heat and power, district heating or cooling, and energy efficient heat pumps. The latest Greek energy

regulation exacts from the 2010/31 EPBD recast was laid out on February of 2013. This law describes a more command and control approach and also encompasses the 2020's nZEB time-restriction. However serious research has to be done to define the Greek roadmap for nZEBs. A practical definition that presents both a numerical indicator for energy demand and a share of renewable energy sources that should be provided. So far there is not any national law that embodies the 2012/27 EED as far as renovation rates of public buildings are concerned. Greece currently has 15,446 schools of which 4,500 are over 45 years old. The total energy consumption of school buildings is around 270,000 MWh. As of 2011, in order to get a new building permit it is necessary to achieve an annual solar fraction of 60% for sanitary hot water production from solar thermal systems (Greek NREAP, 2010), or demonstrate the technical difficulties that prevented compliance. New buildings and existing buildings undergoing major renovation must be able to obtain a class B energy certificate upon completion and are required to have certain minimum U-values and heat recovery in central air-conditioning units. According to the scientific research and literature, the average energy consumption in Greek Secondary Schools was bill-based estimated at 16 kWh/m²/y for electricity and for space heating with oil at 68 kWh/m²/y. The mean energy consumption has been categorized per climate zone with a range from 49 kWh/m^2/year up to 90 kWh/m^2/year. For Greek Schools, the School Building Organisation (SBO) is credited by the national budget for all the expenditures related to infrastructure throughout the country. SBO is undertaking the construction of schools through the alternative finance method of PPPs. The responsibility for maintenance activities is assigned to the respective Municipality in which the school belongs to. When a need for refurbishment occurs the Head Teacher of each school contacts the Technical Department of each Municipality which takes over the repairing activities and is responsible for the formal procurement process. At the beginning of each year, officers from the Economic and the Education Department set out the total budget allocated for the schools maintenance, as a pre-planned budgeting program. During this plan execution the priorities for the entire school year are set as well.

Italy adopted the EBPD-Recast Directive in August 2013 but the decrees (action plan and definitions) are still missing. This is slowing down the diffusion of the NZEB concept and its application, as technical regulation in force is still the one related to the previous Directive 2002/91/CE – EPBD. Regulation constraints refer mainly to heating consumption, while for cooling consumption only few aspects are considered. School holidays in Mediterranean are mainly in Summer (2 months for teachers, 3 months for students) and this is why the almost the totality of schools has not a cooling system. As a result, schools have a not-too-high consumption, but this cause also a lot of comfort problems (from April to October) and inefficiencies (e.g. in mid seasons often happens that the heating system is on but school users open the windows). More than 60% of Italian school buildings were built without any energy-related regulation in force (before 1976) and less than 10% were built after the adoption of the Law 10:1991 which is the first regulation in Italy introducing clear constraints about energy efficiency. The great majority of schools are public in Italy, and this is causing problems as public bodies are having a lot of economical and/or financial problems in the last years (crisis). The status of school buildings is getting worse but there is a vast lack in funding for refurbishment. Furthermore, a lot of school buildings would need a seismic upgrading, that is considered more urgent than energetic upgrading, and however it is also a lot more expensive.

In France a series of targets have been set by the Environment Round Table and implemented in law as of 2009. The widespread development of new, low consumption buildings has been

encouraged, the next step being the development of positive energy buildings by 2020. Extensive renovations of the existing building stock are under way, with the goal being about 400,000 renovations per year (Ecofys, 2013) leading to a 38% reduction in primary energy consumption by 2020. Public buildings are to be renovated to achieve a minimum reduction of 40% in energy and 50% in greenhouse gas emissions within 8 years (French NREAP, 2010).

Local authorities are the decision makers when it comes to renovating a school. But they often do not have information about the energy consumption or indicators to assess comfort in their buildings. So, the decision to renovate a school is not always dependent on the level of consumption of the building but, in fact, a political choice. However, when a renovation project is approved, the local authorities set the goals of energy efficiency and comfort level and budget of the operation. They appoint a technical team (architects and consultants) for this project and to connect with companies that carry out the mission. In addition, other induced work is necessary and can have a significant impact on the budget of the operation. Indeed, other regulatory constraints related to the accessibility of the disabled or fire safety must be taken into account. Cities so often encounter funding problems and must set priorities.

Unfortunately, thermal regulation for existing buildings does not go far enough. The owners will therefore merely comply with regulations without considering doing more. So to achieve a NZEB goal, it's up to the owner to set the target at the beginning of the project. But they might lack the expertise in this domain. The owners as well as the designers (Architects and consultants) might lack the expertise. Overall cost analysis would be a great tool for decision makers that would identify the best solution. Training of decision makers as well as designers is necessary to raise awareness of these issues.

In France, especially in Languedoc- Roussillon, the first examples of successful renovation are becoming increasingly known. They were initiated and financially supported by the Languedoc - Roussillon and ADEME through calls for proposals. They gave a good example of how the project should be managed in terms of energy performance and how to take into consideration summer comfort. However, the accurate results are slow to arrive and quantitative indicators are lacking. These elements along with ZEMedS case studies are therefore essential for familiarizing decision makers and designers with NZEB methodology. ZEMedS would therefore meet these expectations through financial and technical guides, trainings, user guides or the implementation that will be developed.

Setting the priorities for building renovations will be based on different needs (safety, maintenance, spatial requirements, energy savings, etc.) and will profoundly depend on the budget availability and the existing funding channels. Nowadays, the economic crisis in most of Mediterranean countries has led to very reduced self financing capacity, being the budgets allocated to cover only urgent needs and significantly reducing the capacities of municipalities and regional administrations. This fact highlights how overlooked are other funding opportunities, such as the use of ERDF funds.

The funding sources for a public building renovation (schools in the present case) will vary depending on national and regional specificities. However, in the region of Catalonia renovation costs and energy efficiency solutions funded in the most part with own resources. This fact, poses a significant pressure upon municipalities and the regional government since the availability of resources has significantly decreased in the last years. Setting the priorities for building renovations will be based on different needs (safety, maintenance, spatial requirements, energy savings, etc.) and will heavily depend on the budget availability and the existing funding channels. Nowadays, the economic crisis in most of Mediterranean countries

has led to very reduced self financing capacity, being the budgets allocated to cover only urgent needs and significantly reducing the capacities of municipalities and regional administrations. This fact highlights how overlooked are other funding opportunities, such as the use of ERDF funds. Funding renovation costs and energy efficiency solutions through ERDF could be done following process. In this sense, the provision of ERDF funding mechanisms will be based upon the definition of national and regional priorities set in the operational programmes. The former will indicate the amount foreseen for funding in each priority area, thus setting the amount available for specific actions. Based, thus, on the regions' administrative and organisational structures the responsibility for setting the priorities in public buildings renovation would lie in different actors and thus will reduce the pressure experienced by any specific agents. As a general introduction, the region complies with the mean cost values for the construction of a new school observed in the 4 participant regions, a value ranged between 1300-1400 €/m^2. On the other hand, and as observed in the rest of the regions, renovation costs vary largely depending on the measures applied and there is not a reference value.

The majority of the regions with Mediterranean climates have relatively mild winters and hot summers. Although significant variations can be found among the places that satisfy the Mediterranean climate criteria, the countries bordering the basin share some similarities: in almost all the coastline cities, the minimum yearly average temperature is between 5–10^{o}C and the maximum is between 27–34^{o}C. Another characteristic of the Mediterranean climate is that the higher the maximum air temperature, the wider the average temperature fluctuation of the hottest month is. Moreover, inland locations tend to have a more severe climate, with lower temperatures during winter and higher temperatures during summer.

For the past few decades there has been a sizeable increase in summer cooling demand in the Mediterranean area, especially in urban areas. Global warming is expected to adversely affect both the environment and human activities in the Mediterranean area, with scenarios for average yearly air temperatures predicting an increase between 2.2 and 5.1ºC by 2100, or even sooner than that. According to the IPCC (2007), an average temperature rise above 1.5^{o}C is likely to have severe impacts in local environments and ecosystems, while increased temperatures are expected to bring about longer heat waves, decreased precipitation and a longer summer in general. These predictions should be taken seriously into consideration when renovating buildings and, particularly, schools.

A holistic approach should combine cost optimal measures to achieve energy performance and indoor environmental quality (IEQ) in schools. ZEMedS project will pave the way for a complete renovation path, tackling strategies for the envelope, the systems and renewable energy applications as well as the energy management and users' behaviour of Med Schools.