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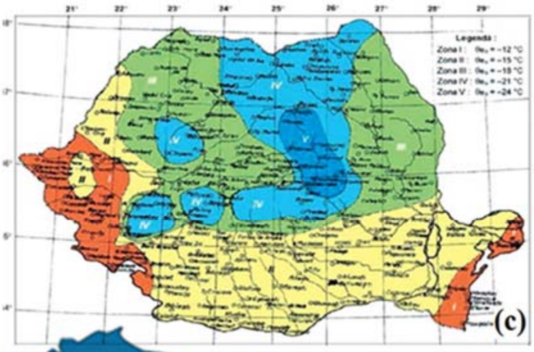

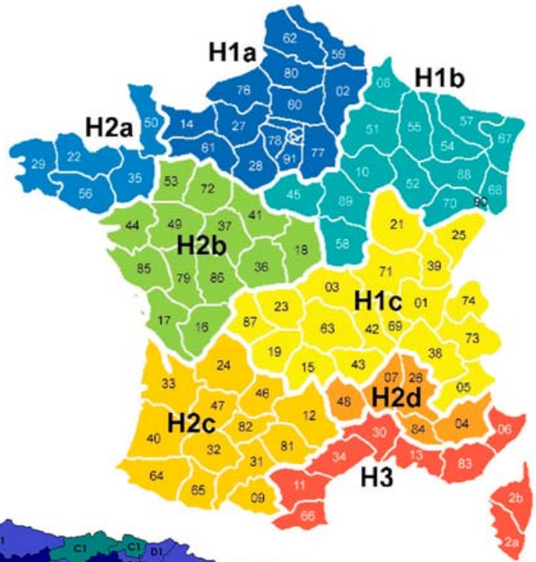

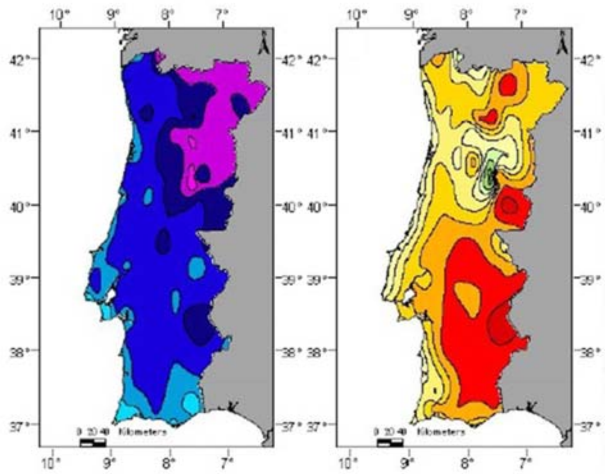

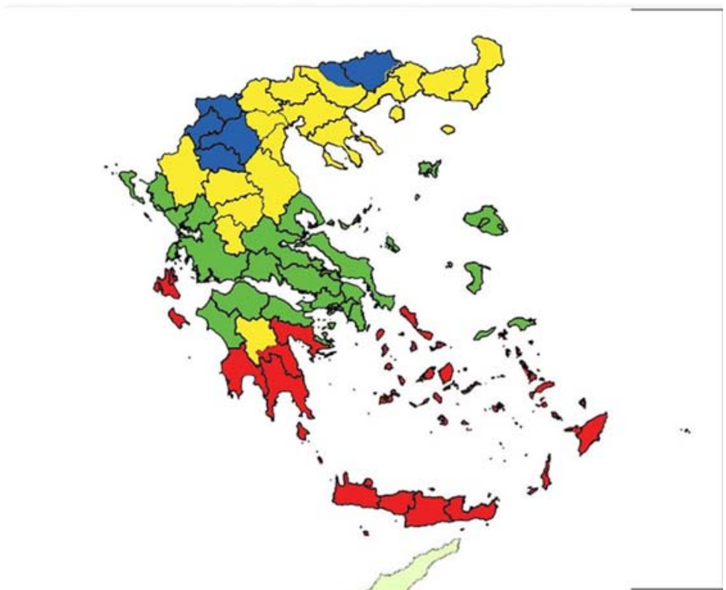

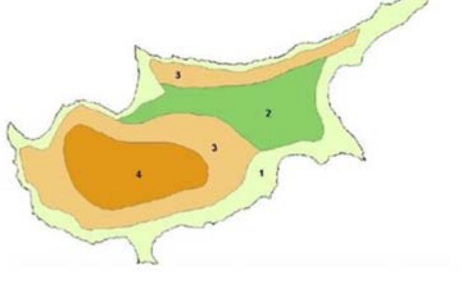

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OVERVIEW OF CHALLENGES OF RESIDENTIAL NEARLY ZERO ENERGY BUILDINGS (NZEB) IN SOUTHERN EUROPE

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Summary

Overview and future challenges of nearly Zero Energy Buildings (nZEB) design in Southern Europe

Abstract

In times of great transition of the European construction sector to energy efficient and nearly zero energy buildings (nZEB), a market observation containing qualitative and quantitative indications should help to fill out some of the current gaps concerning the EU 2020 carbon targets. Next to the economic challenges, there are equally important factors that hinder renovating the existing residential building stock and adding newly constructed high-performance buildings. Under these circumstances this report summarises the findings of a cross-comparative study of the societal and technical barriers of nZEB implementation in 7 Southern European countries. The study analyses the present situation and provides an overview on future prospects for nZEB in Southern Europe. The result presents an overview of challenges and provides recommendations based on available empirical evidence to further lower those barriers in the European construction sector. The paper finds that the most Southern European countries are poorly prepared for nZEB implementation and especially to the challenge/opportunity of retrofitting existing buildings. Creating a common approach to further develop nZEB targets, concepts and definitions in synergy with the climatic, societal and technical state of progress in Southern Europe is essential. The paper provides recommendations for actions to shift the identified gaps into opportunities for future development of climate adaptive high-performance buildings.

KEYWORDS

renovation, nearly Zero Energy Building (nZEB), Net Zero Energy Building (NZEB), fuel poverty, thermal comfort, EPBD, warm climate, construction quality.

NOMENCLATURE

AEC, Architectural, Engineering and Construction;
AC, Air Conditioning;
ACH, Air change per hour;
BEPOS, Bâtiment à énergie positive;
BPS, Building Performance Simulation;
CEN, European Committee for Standardization;
DBT, Dry Bulb Temperature;
DHW, Domestic Hot Water;
EE, Energy Efficiency;
EPBD, Energy Performance Building Directive;
EPC, Energy Performance Certificate;
EUI, Energy Use Intensity;
EU, European Union;
FIT, Feed-in Tariff;
HRV, Heat recovery ventilation;
HVAC, Heating, Ventilation and Air Conditioning;
IEA, International Energy Agency;
IEE Intelligent Energy Europe;
LCA, Life Cycle Assessment;
MS, Member States;
MVHR, Mechanical Ventilation with Heat Recovery;
nZEB, nearly Zero Energy Buildings;
NZEB, Net Zero Energy Buildings;
OT. Operative Temperature;
PE, Primary Energy;
PEF, Primary Energy Factor;
PH, Passive House;

PMV, Predicted Mean Vote;
PPD, Predicted Percentage Dissatisfied;
PV, Photovoltaic;
RES, Renewable Energy Systems;
SCOP, Seasonal Coefficient of Performance;
SEER, Seasonal Energy Efficiency Ratio;
SFP Specific Fan Power;
SHW, Solar Hot Water;
SME, Small and Middle Enterprise;
VRF, Variable refrigerant flow;
WWR, Window to Wall Ratio;

1 INTRODUCTION

The Climate-Energy Framework 2020 sets three key targets to cut 20% in green gas emissions (compared to 1990 levels), increase the EU renewables share by 20% and improve energy efficiency by 20% (EU, 2010). The main instrument to achieve those targets in the building sector is the Energy Performance of Building Directive (EPBD) recast that sets the standards for new and renovated buildings across Europe. The Directive 2010/31/EU (EPBD) at Art. 9 indicates that EU Member States (MS) must ensure that by 2021 all new buildings, and already by 2019 all new public buildings, are nearly Zero Energy Buildings (nZEB) and MS should draft plans and "*...encourage best practices as regards the cost-effective transformation of existing buildings into nearly zero-energy buildings*" (Atanasiu et al., 2011). Accordingly, most MS revised recently the existing rules, regulations and guidelines as well and started to set up the means for increasing the penetration of those high-performance buildings by setting up the nZEB definitions on a national level. However, there are significant differences in the progress and implementation of nZEB across the 28 MS. From one side, Northern MS managed to develop or adapt concepts, definitions and construction technologies of nZEB that are effective and correspond to their heating dominated climates. The PassiveHaus (PH) standard is an example for that. On the other side, Southern MS are still trying to find the most adequate solutions taking into account the local climate and local cultural, social, technical and economic context.

Therefore, the objective of this paper is to provide an overview on the technical and societal challenges of applying nZEB in Southern Europe. The overall aim is to provide a better understanding of nZEB and their market uptake barriers. The cost challenge is excluded from this study because it is discussed in other studies (Attia & Carlucci, 2015). The study focus is mainly on countries falling between latitude 35°N and 45°N and includes a literature review of more than 95 publications on nZEB implementation in Southern Europe. For this study, we have selected 7 countries, namely Cyprus, France, Greece, Italy, Portugal, Romania and Spain, for which we could have access to representative information and insights. We find the selected countries as significant regarding their population size and buildings stock proportions that represent more than 33% of the European residential buildings stock (see Figure 1.1). The originality of the paper is twofold. The paper provides a broad overview on the challenges of nZEB bringing insights from 7 Southern MS, which was not done before. Also, the paper identifies possible synergies between similar climate regions, which can bring a consensus for best practices in Southern European countries regarding deep renovation, to bridge the energy gap and increase the nZEB uptake.

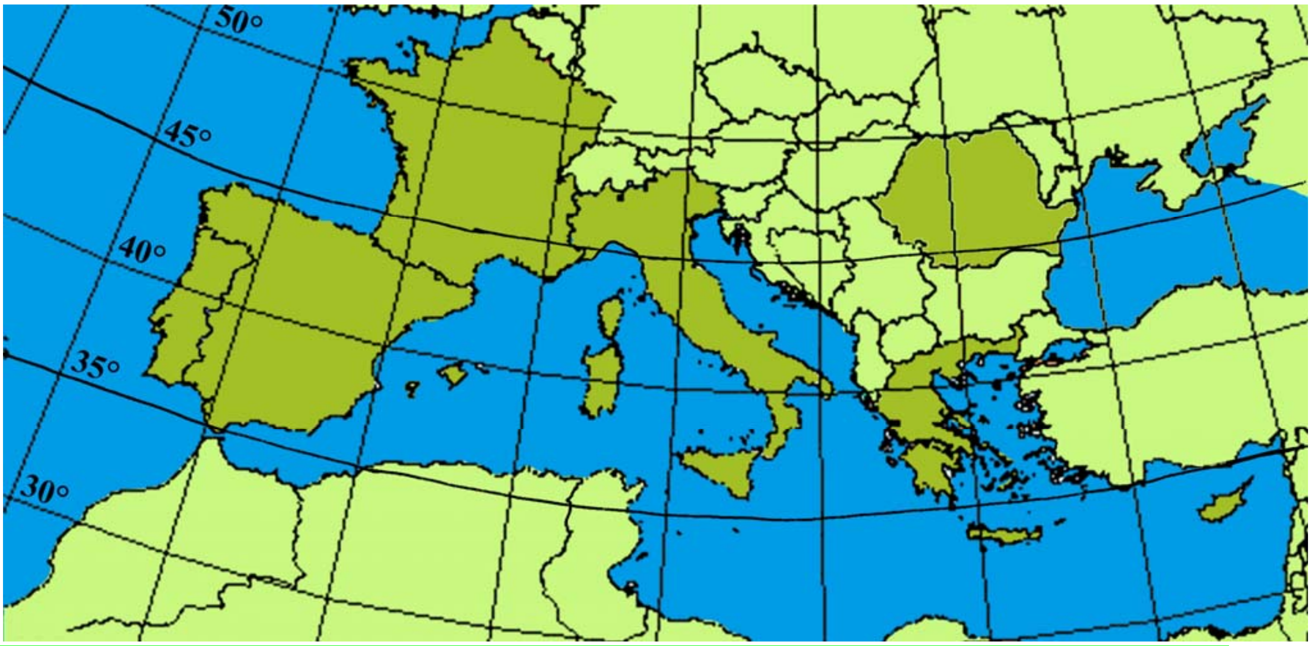

Figure 1.1: the participating countries in the study on nearly Zero Energy Buildings status in Southern Europe

The methodology used consists of reviewing the state of the art in the 7 MS. The first part of the methodology is based on a literature and case studies review. The second part is based on a questionnaire. By proposing five key questions to 14 national experts from Cyprus, France, Greece, Italy, Portugal, Romania and Spain we developed the report content with a focus on new and existing residential buildings. The five questions are listed below:

1. What is the minimum energy efficiency threshold for nZEB in your country?
2. What is the heating/cooling energy needs balance for nZEB in your country?
3. What is the thermal comfort limit for nZEB in your country?
4. What is the minimum renewables threshold for nZEB in your country? What are the recommendations for minimum EE and RET in your country? (EE energy efficiency, RET Renewable Energy Threshold onsite).
5. What is the construction quality for nZEB in your country?

A post processing phase followed the questionnaire results analysis. The analysis is based on facts tracing to allow the assessment of the existing possibilities and the status of the nZEB legislation and policies as they were applied in these countries in the last few years. By this analysis we do not pretend to predict the future, but we can identify the features of the current nZEB situation and assess its development trends. Therefore, we have adopted the method of analysis looking at the social/political and technical backgrounds behind nZEB in Southern Europe. Finally, the analysis provides guidance on the challenges and constraints in each MS and provides an overall list of recommendations and conclusion for nZEB in Southern Europe. This report is organized into four sections. The first section introduces the research and identifies the research problem, objective and significance. The second section provides an overview of the main challenges of nZEBs in Southern Europe from a technical and societal point of view. The third section summaries different approaches and barriers to implement nZEB in Southern Europe. The final section discusses and concludes the study outcomes, implications and limitation while providing useful recommendations.

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2 NEARLY ZERO ENERGY BUILDINGS IN SOUTHERN EUROPE

The zero energy buildings and zero carbon buildings goals seeking maximum efficiency derive from the notion of neutralizing the resource consumption and define this as zero energy consumption. The design process involves an integrative approach looking to:

1. reduce energy needs for heating and cooling by optimising the envelope and integrating passive heating and cooling techniques;
2. improve energy efficiency of active systems
3. and incorporate renewable energy.

Various potential definitions of Net Zero Energy Buildings (NZEB) were first discussed and proposed on an international level in 2008 (Attia, 2017). Many of those definitions require a zero-energy balance between energy used and generated (or imported from the grid and exported to the grid) over a certain time interval (e.g. a year or a month). Energy might be considered at the site ("delivered energy", in EN and ISO nomenclature) or at source ("primary energy", in EN and ISO nomenclature). The International Energy Agency (IEA) compiled and discussed the earliest definitions within Task 40: Towards Net Zero Energy Buildings comprising almost 20 countries (IEA, 2013). USA was discussing the definitions within the Energy Independence and Security Act of 2007 and the European Union was discussing the definitions within the recast of the EPBD adopted in May 2010 (Pless et al., 2009; EPBD, 2002; EPBD recast, 2010).
The recast of the EPBD introduced the notion of "nearly zero energy" buildings (nZEB) (EPBD recast, 2010). According to Article 2(2) of the EPBD an nZEB *"...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".* Annex I states: *"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*".
Hence the EU Directive introduces the requirement of acting first on the envelope of the building via the requirement that the building should have very low "*energy needs*".
All European Union (EU) MS had to engage in a more widespread deployment of such buildings by 2020. In addition, the MS are required to draw up national plans for increasing the number of nZEBs. These national plans can include differentiated targets according to the category of buildings. Recently, consultation and procedures have been held in the energy administrations of the national regions to respond to the European requirements. This makes the EU a leader in terms of introducing regulatory changes to adapt buildings to nZEB and NZEB. For this report, we are looking to distil the most important lessons learned from the Southern European Countries experience. Up till now, there is no Cross-European understanding and agreement on the national implementation of the overarching definition given by EPBD.
The status of Southern European countries, shown in Table 2.1 in particular, reflects a serious problem of definition adoption and consequently market uptake. Despite the requirement of Annex I of EPBD that: *"the methodology for calculating the energy performance of buildings should take into account European standards"* (Visscher et al., 2009); the nZEB definitions are subject to different market interpretations. This is in part due to the not sufficiently precise definition of "energy performance of a building" in annex I of the EPBD: *"The energy performance of a building shall be expressed in a transparent manner and shall include an energy performance indicator and a numeric indicator of primary energy use, …"*. This EPBD sentence requires the presence of two indicators but it is not completely precise in naming them. The Report "Towards NZEB" (European Commission, 2010) prepared under a tender of the EU Commission and a report by eceee (eceee, 2015) recommended that 1) the first performance indicator should be explicitly specified as "*energy needs for heating and cooling*" in order to adhere to the logical choice of first reducing energy demand in order to avoid wasting valuable energy be it fossil or renewable, 2) the term "*primary*" energy should be specified (total or only the non-renewable part), and as for the concept of (nearly) zero primary energy the annex should specify or give guidance on the issue of its calculation period (annual, monthly,..).

The following sections discuss the main challenges and their implications for setting a sustainable and practical nZEB definition and propose principles to be considered when setting up a practical definition.

Table 2.1: nZEB´s legislation current status in Southern Europe's Member states (Attia et al., 2016; ZEBRA 2020 Data Tool, 2016).

Country	Status
BULGARIA	Still to be approved. No information is yet available
CYPRUS	National Plan is in place. Numerical indicators have been set for nZEB for both residential and non-residential buildings. A minimum threshold for heating is set at 15 kWh/m^2.a. for residential buildings along with a PE of 100 kWh/m^2/a. No cooling threshold has been set. A PE of 125 kWh/m^2/a has been set for non-residential buildings, but no minimum thresholds exist for either heating or cooling.
FRANCE	National Plan "Energy transition for green economic growth" is in place. The minimum threshold for cooling and heating is set at 50 kWh/m^2.a. The PE ranges from 70 to 110 kWh/m^2/a. New labels regarding Positive energy building and low carbon (E+/C-) are currently set up and foreshadow the new regulation planned for 2018.
GREECE	No report is yet available, thus no final information is available.
HUNGARY	Still to be approved. No information is yet available.
ITALY	A national plan is available, prerequisite for NZEB is the achievement of energy performance higher than a reference building fixed by regulations, while several more requirements are required to be fulfilled, regarding thermal renewable generation from renewable sources (>=50% of energy use for domestic hot water, >= 50% of energy use for domestic hot water, heating and cooling), thermal systems efficiencies, overall average U coefficient, glazed areas/floor area ratio, energy needs for heating and cooling (lower than the reference building).
MALTA	National Plan is under development. Annual PEC should not exceed 40 kWh/m^2/a. for dwellings and kWh/m^2.a. for others buildings
PORTUGAL	National Plan is in place. However, numerical indicators are not exactly stated and they depend on several variables including technical viability, climate, type of construction, traditions, etc.
ROMANIA	National Plan is under development. Numerical indicators are not exactly stated and they depend on several variables including technical viability, climate, type of construction, etc.
SLOVENIA	Still to be approved. A National plan should consider nZEBs as the ones with an annual PE ranging from 45 to 50 kWh/m^2.a.
SPAIN	Still to be approved. A draft of nZEB indicators for Spain was published in December 2016, without specifying their limits. The proposed indicators aim to define: maximum net PE use, maximum total PE use, minimum renewable contribution for the DHW generation, maximum building global thermal transmittance, solar control considering the solar gains of July, maximum transmittances in housing enclosures, verification of moisture risk of the envelope, and minimum EE values for the HVAC systems and lighting.

Minimum threshold energy efficiency

For achieving high efficiency in buildings, an ambitious energy and carbon emissions reduction must be required for nZEB using commonly agreed and well specified indicators (Atanasiu et al., 2011). This would not limit the possibility to adapt the targets/thresholds level of those indicators to local conditions. On the other side, it would allow to have a common language across Europe which is essential for construction industry to develop solutions in a stable and coherent framework. This is essential since in 2020, all new buildings will have to demonstrate high energy performance and their reduced or ultra-low energy needs will be significantly covered by renewable energy sources (see Figure 2.1). Clear definitions of the energy levels and their calculation/measurement steps are presented in the European Standards, revised a few years ago in view of the EPBD application. As defined in EN15603:2008, evaluation of energy efficiency of new building and retrofits require the calculation of energy needs for heating, cooling and hot water and energy use for lighting and ventilation. The same calculation procedure, starting from energy needs and uses and ending with primary energy, is detailed step by step in the EU official "Guidelines establishing a methodology framework for calculating cost-optimal levels of minimum energy performance requirements. For calculation of primary energy with primary energy factors, EN15603 presents explicit formulas, with degrees of flexibility for MS. For example, in Italy a nZEB definition coherent with the objective of first reducing the energy needs has been adopted where the non-renewable primary energy accounting should be done month by month, and excess energy e.g. sold to the grid in summer, cannot be used to compensate for excess demand in winter.

Given the unsatisfactory situation described above, a number of ambiguities and discrepancies have materialised in the national implementation phase of the nZEB concept. 'Zero energy' is often interpreted as 'net zero energy': i.e. balance between the consumed and produced energy on site although this concept is not present in EPBD. Also, due to the lack of policy definition for ultra-low energy buildings, initially different definitions were introduced by business networks and mixed business/policy networks in the recent years (Annunziata et al., 2013).

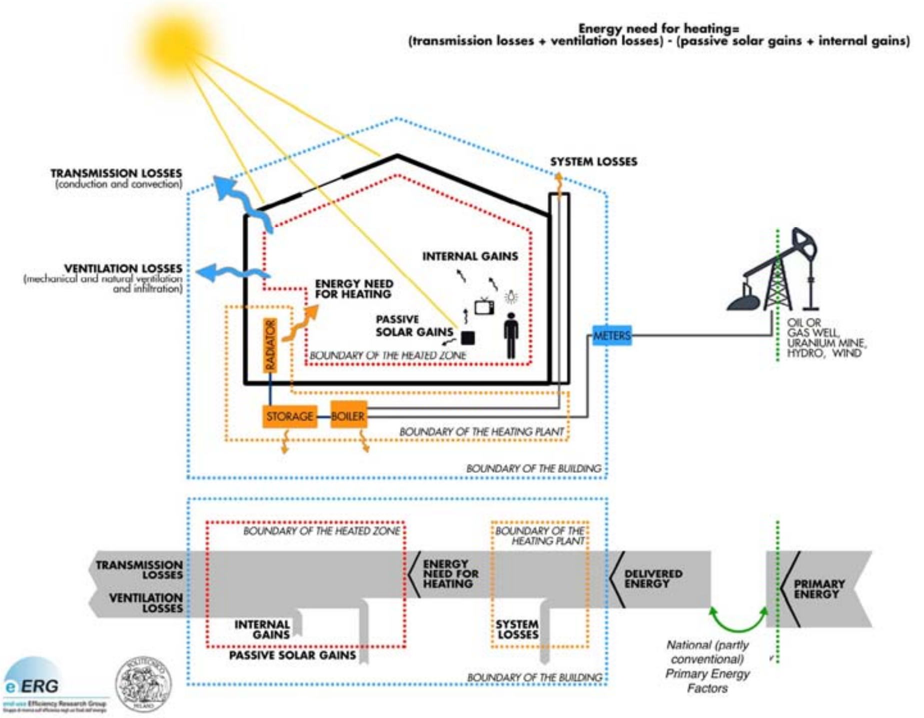

Figure 2.1: Representation of energy levels according to EN standards, limited to the case of heating for sake of clarity. (Source: eERG – Politecnico di Milano, eceee 2015)

There are significant differences in the definition of the minimum building energy efficiency threshold performance among the Southern European Member states. The disparity is mainly due to the climatic, social, technological and economic variation between the countries, and this is partly justified. But more importantly the terminology and the definitions are not the same so comparisons are difficult or impossible. Already several European countries opt to comply with the PH Standard to guarantee that energy needs for heating and cooling are both below 15 kWh/(m^2/year). However, the PH Standard is sometimes perceived as a high-tech building design in construction approaches and hence not feasible across all of Europe. Therefore, the challenge to implement and comply with nZEB performance requirements is high. The challenge is not only for new construction but also for renovation. A more precise definition of the indicators such as the one proposed in (Hermelink et al., 2013; eceee, 2017)would help in the future to move towards a stronger framework for the actors of the construction industry without restricting the flexibility allowed to MS.

Heating-Cooling balance

The characterisation of the balance of heating and cooling energy needs is important for high performance buildings to limit unnecessary space conditioning systems and distribution. For example, in heating dominated climates designers seek to eliminate active cooling by using passive cooling design measures. This can lead to significant costs cuts due to the use of a single active mechanical system. The reason for that is to reduce cost and provide simple control and maintenance. In Northern Europe, it is possible to achieve relatively easily summer comfort conditions and hence concentrate the largest part of the design effort to reducing the energy need for heating and to dealing with a single active conditioning system of which to optimize size and costs. However, in South Europe higher summer temperatures and solar radiation result, for most building typologies and designs in an equilibrium of heating and cooling energy needs, the necessity to solve potential conflicts between winter and summer comfort objectives, a higher probability of having to install both heating and cooling systems (active or passive or hybrid) and to bear the associated costs. The study of Badescu (Badescu, 2015) suggests that an active cooling and heating system should be used when PH buildings are implemented in the mixed mode and hot climates.

The implications of a symmetric or quasi symmetric balance of heating and cooling energy needs lead often to the choice of dual active systems with thermal and electric energy demand and can have a large impact on initial cost, operational cost peak loads and energy supply networks. Passive cooling systems such as earth buried pipes for cooling, ventilation air, evaporative cooling, night sky radiation is also available but need a careful design and adaptation to climate, air and outdoor conditions (pollution, noise, mosquitos etc.), which requires highly skilled and savvy architects, engineers and builders. In warm climates, low energy needs thresholds for heating, e.g. 15 or 30 kWh/(m² year), can be met more easily for heating than in cold ones (Schneiders, 2011 and 2015). This is due to milder weather and shorter extreme climatic cold waves. It is then possible to reduce heating needs even though various design parameters are not optimal (shapes, orientations, insulation, window sizes, performance of components, etc.). By reducing the envelop conductivity and infiltration and selecting optimal glazing and window openings, one can reduce heating energy demand significantly. In this context, aiming at "nearly zero energy heating" targets to achieve the optimum savings is technically feasible. The use of heat recovery ventilation (HRV), also known as mechanical ventilation heat recovery (MVHR), can provide adequate space conditioning with minimum additional energy input and allows heat distribution directly through the air supply. In the case of Southern European climates, this could then make it possible to reach low heating energy demand values around 5 kWh/(m² year). However, in Southern Europe limiting the energy need for cooling below 15 kWh/(m² year) is not always possible due to high solar radiation, high outdoor ambient temperature and heat island effect in cities. Therefore, any definition for nZEB should be aware about the heating-cooling balance for every climatic zone in Southern Europe and require energy efficiency thresholds and recommend passive or efficient active systems solutions accordingly. In our review of challenges of nZEB, we will focus on how the heating-cooling balance principle is addressed in the current definitions.

Thermal comfort limits

Figure 2.2 summarizes the evolution of comfort models in the last 50 years. The available models worldwide are mainly focused on office buildings, partly because of the limited number of surveys in the area of residential buildings, but the scope of these standards is then extended to "*other buildings of similar type used mainly for human occupancy with mainly sedentary activities and dwelling*" (EN 15251, 2007).

In 2007, the European Committee for Standardization (CEN) introduced the European standards EN 15251, which suggests the adoption of the Fanger's PMV/PPD model for mechanically heated and/or cooled buildings and Humphreys and Nicol's adaptive model for buildings without mechanical cooling systems. For nZEB short and long-term comfort indices should be calculated according to EN 15251, in addition to energy performance indexes. The connection between thermal performance and comfort is explicitly mentioned in EPBD (eceee, 2017). On the other hand, various organisations have made their own proposals for comfort targets, e.g. French regulation requires that in air conditioned buildings the set point temperature in summer should not be set below 26 °C; CIBSE Guide A defines 'overheating' as occurring when the operative temperature (OT) exceeds 28 C for more than 1% of the annual occupied hours in the living areas of (free running) dwellings or when the bedroom OT exceeds 26 °C for more than 1% of the annual occupied hours (unless ceiling fans are available). The PH standard requires as a summer comfort criterion that "*the number of hours in excess of 25°C may not exceed 5% of the time working*". This criterion is verified by using a dynamic simulation". However, comfort as defined by PH may be challenging to be achieved via the passive techniques traditionally adopted in good quality construction in Southern Countries and may not correspond to what are the expectations of building occupants based on the prevailing climate, clothing habits and culture (Hermelink et al., 2013; Givoni, 1998; Pagliano et al., 2009; Carlucci et al., 2013; Attia et al., 2015 and Pagliano et al., 2010). A discussion about the issue of definition of comfort objectives took place e.g. within the European project Passive-on, which involved experts from both northern and southern countries with the objective of exploring adaptation of the PH concept suitable for Mediterranean climates and lead to a recommendation to refer to EN15251, including the option to use adaptive comfort where suitable (Pagliano et al., 2007; Pietrobon et al., 2014 and Causone et al., 2014).

Recently, a discussion about sick buildings and risks of overheating has emerged. The number of studies addressing summer comfort in nZEB in Southern Europe based on measured data is by now limited. Some extensive simulation studies find overheating risks in conventional buildings and significant improvements when going to well-designed advanced buildings (Barbosa et al., 2015; Ridley et al., 2013; Mlecnik et al., 2010; Peacock et al., 2010 and E.E.I. Unit, 2013). In PHes "*summer comfort can be achieved only resourcing to passive improvements, without any active cooling system*", while "*with common building envelope solutions and construction materials, typically used in Portugal, simulations showed long periods of thermal discomfort for the heating season, as well as long periods of overheating during the summer*" (Figueiredo et al., 2016). The studies conducted in UK, Belgium and Netherlands (Barbosa et al., 2015; Ridley et al., 2013; Mlecnik et al., 2010; Peacock et al., 2010 and E.E.I. Unit, 2013) for different Passive House projects reported overheating periods during summer. The over focus on energy performance in nZEBs can lead to health and comfort problems. Badescu et al. reported excessive overheating hours in a Romanian case study and recommended the inclusion of active cooling systems for such high-performance buildings (Badescu et al., 2015). However, the existence of various definitions of overheating and explicit indexes, including the long-term comfort indexes proposed in EN15251, are rarely used for designing buildings or assessing their actual comfort performance after occupation (Carlucci et al., 2015). In this study, we consider adaptive thermal comfort standards helpful, to take advantage of the individual range of adaptive possibilities in an nZEB. This could support the application of a range of passive cooling techniques in buildings as well as the satisfaction of occupants, in coherence with EN15251 and a range of national and international analysis (Pagliano et al., 2010 and 2016; Carlucci et al., 2013, 2015 and 2016).

At present, the overheating phenomena in nZEB in Southern Europe is often attributed to some combination of air tightness, insulation, thermal mass, sometimes without offering in the analysis other fundamental information as: the presence or lack of solar protections, presence and quality of the connection to available passive cooling sources such as outdoor air in summer nights, soil, or sky vault at night, presence and quality of means for control of air velocity in the occupied spaces.

Finally, the nZEB uptake in Southern European countries is presently low and mostly poorly documented both in terms of energy performance and of thermal comfort and IEQ (see for comparison, the large monitoring project as EnOB in Germany (EnOB, 2015)).

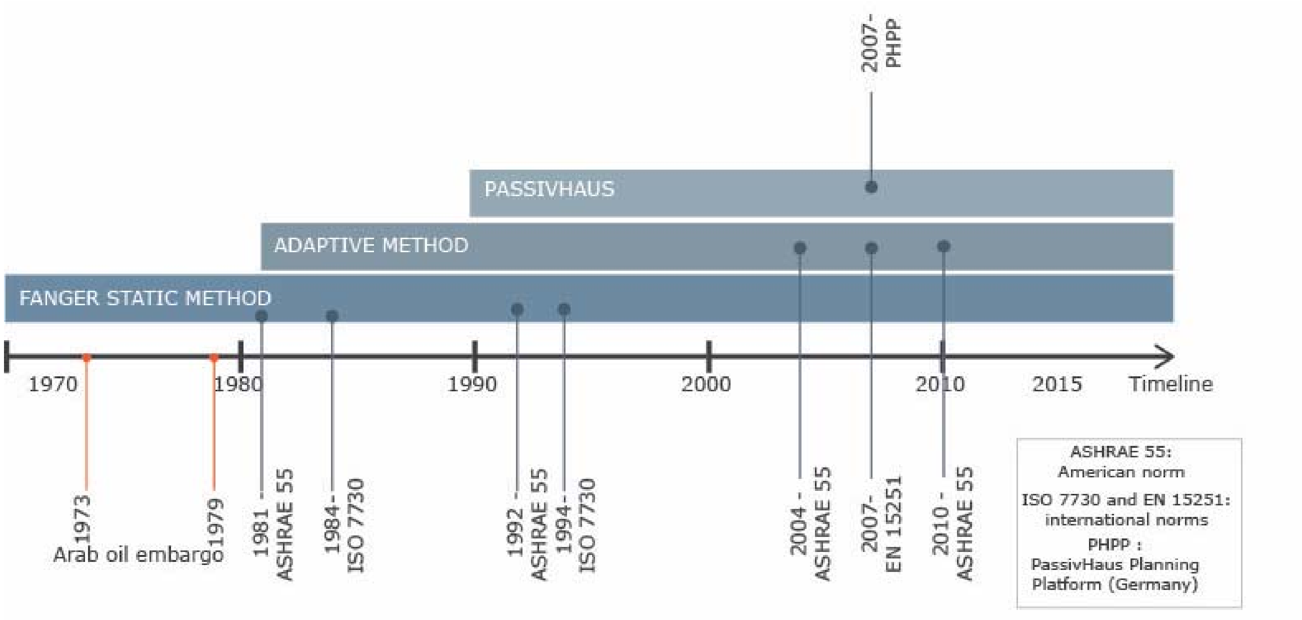

Figure 2.2: Evolution of thermal comfort standards in the last 50 years

Efficiency vs. renewables threshold

EPBD requires European MS to first reducing energy needs for heating and cooling and in a second step to cover a significant fraction of those needs by energy from renewable sources on-site or nearby. In Switzerland, the authorisation to install summer air conditioning is subordinated to showing that the envelope is well designed to minimise energy needs for cooling (presence and effectiveness of solar shading with g-values optimised based on facade orientation, adequate insulation and thermal mass, as specified in SIA382), and detailed verification procedures are in place. Thus, energy efficiency is an effective policy tool and together with cost-effective energy savings they can play prime role in meeting energy, climate, and economic goals. However, many new constructions in the Southern Europe fail to take up ultra EE and renewable energy measures that are cost-effective. Investments in building renewable energy technologies seem sometimes easier to implement and communicate to occupants, investors and media. There is evidence that some building owners invest and lean towards RES due to the legal and construction barriers in investing in energy efficiency (E.E.I. Unit, 2013). On the other side, the European recommendations for nZEB advise to include a share of renewable energy production on site (including the renewable share of heat pumps) (Atanasiu et al., 2011). For example, the Romanian government imposes for nZEB that at least 10% of energy is produced from renewable sources, according to the government ordinance No. 13/2016. But in dense urban areas, renewable energy sources (solar, imported biomass, etc.) have limitations regarding solar access and pollution associated with burning of biomass. For example, 70% of particulate emissions in Brussels are due to biomass burning (Bruyninckx, 2016); similar problems with air pollution from biomass burning is reported in Pianura Padana, Italy, and more generally described by the European Environmental Agency. Thus, the optimal balance between the minimum threshold performance for EE and the renewables onsite production share for nZEB remains a challenge. The impact of these parameters varies strongly depending on energy cost, legal, environmental and construction barriers and requires long term vision that would help overcome these challenges.

Construction quality

nZEB require high construction quality through new construction technologies, sometimes high-tech components, and specialised competences. To achieve nZEB levels, the use of energy efficient technologies and materials is necessary. These technologies and materials must respond to the requirements of the nZEB and satisfy the nZEB market demand. In most Mediterranean countries, there are barriers regarding the know-how of professionals and the number of architects and engineers that are able to deal with new technologies and standards (Da Silva et al., 2015).

For example, the Passive-On (Ford et al., 2007 and EERG, 2007)project published a guideline for the design and construction of Passive Houses in Southern Europe and considered the construction quality a serious challenge. The Passive House Regions with Renewable Energies project highlighted the importance of construction labor skills and their capacity of craftsmanship. Therefore, the SouthZEB project, that is an Intelligent Energy Europe (IEE) funded project, aimed to fill this gap and address the need to develop training schemes to professionals involved in nZEB building process, transferring successful practices and knowledge from front runners to target – Southern EU – countries that are less advanced in this area (Erhorn et al., 2015). In order to reach a level of super insulation and airtight envelope, all suppliers of construction components and builders need to adapt integral nZEB construction practices. On the other side, the standard configuration and components of high efficient buildings is most of the time designed for heating dominated climates. For example, certified high-performance windows are not offered as standard with (a choice of) integrated (or easy to integrate) external mobile shading. This should be changed in order to correctly reflect the needs and challenges of summer comfort in warm countries. The details of Passive House construction depend on the local climate, the shape and orientation of the building layout, the shading situation, etc. Therefore, it is crucial to determine the expected construction quality in each individual nZEB by assessing climate specific requirements and the local socio-economic and technical limitations of construction market (labour, suppliers, producers, architects and building service engineers).

Finally, we discussed the five technical and societal challenges that need to be addressed for nZEBs in Southern Europe. Our study goes further in analysing the situation in Southern European countries regarding energy efficient new construction and refurbishment of existing buildings. Europe's ambitious targets and the above-mentioned barriers make it difficult for many Southern European member states to step up to this policy plate. Today a limited number of nZEB are properly constructed and a very small part of the existing building stock is renovated every year. The actual technical and social barriers for nZEB implementation need to be identified through a cross comparative overview in order to find solutions to shift the identified barriers into opportunities and appropriate handlers for future development.

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3 OVERVIEW OF NEARLY ZERO ENERGY BUILDINGS STATUS IN SOUTHERN EUROPE

Following the challenges review in section 2 we present the results of interviewing national experts in the seven investigated countries namely Cyprus, France, Greece, Italy, Portugal, Romania and Spain, for which we could have access to representative information and insights.

3.1 CYPRUS

The near Zero Energy Buildings (nZEB) concept introduced by the EPBD recast in 2010 has been and still provides a major challenge for Cyprus. Considering the fact that the first legislation regarding the energy performance of buildings was first introduced in 2007 (Cyprus Gazette, 2006) and the Energy Performance Certification (EPC) of buildings with actual performance indicators regarding thermal transmittance coefficients, primary energy consumption, etc. were introduced only in 2010 (Cyprus Gazette 2009a, 2009b), one can imagine the challenges and the numerous debates phased in defining the key performance indicators constituting the near Zero Energy Building on the island.

The corresponding public Authority, Cyprus Energy Service, in charge of the implementation of the related legislation and regulations, following a public procurement and a study from the winner company EXERGIA (EXERGIA, 2012). (Provision of consulting services for the definition of the nearly Zero Energy Residential Buildings in Cyprus. Nicosia, NIC: Ministry of Energy Commerce Industry and Tourism.), has set minimum and maximum values for the key performance indicators defining the near Zero Energy Building for residential and non-residential buildings (ΚΔΠ 366/2014 – On the Regulation of the Energy Performance of Buildings) (Requirements and Specifications to be met by the near Zero Energy Building – nZEB, Decree 2014). For both cases, maximum requirements have been set regarding the thermal transmittance coefficient (U-value) of building elements that are part of the building envelope, such as walls, columns, beams, roofs, windows, etc. For opaque load bearing construction elements, such as the wall, beams, roof, raised floors, etc. a maximum thermal transmittance coefficient of 0.4 W/m^2K has been set ($U \leq 0.4$ W/m^2K). For floors in touch to the ground a maximum thermal transmittance coefficient of 0.6 W/m^2K has been set ($U \leq 0.6$ W/m^2K) while for doors and windows the requirement is for the mean thermal transmittance coefficient not to exceed the value of 2.25W/m^2K ($U \leq 0.2.25$ W/m^2K, i.e. the individual thermal transmittance coefficient of a single window or door can exceed the above-mentioned value as long as the mean thermal transmittance coefficient of all windows and doors is less than $U \leq 2.25$ W/m^2K).

Furthermore, minimum performance requirements have been introduced for technical systems which are to be installed in new buildings. In particular, the efficiency of new boilers for heating systems must be no less than 90%, while the seasonal coefficient of performance (SCOP) and seasonal energy efficiency ratio (SEER) of heat pumps must be at least 4.6 and 6.1 respectively. In addition, only for buildings used as office spaces, the installed lighting power must not exceed 10 W/m^2.

Also, energy efficiency thresholds have been set regarding the final primary energy use, as well, as for heating demand. Specifically, for residential buildings a minimum performance threshold of 15$kWh/m^2/a$ for heating demand has been set, in line with the passive house standard, and a minimum energy efficiency threshold of 100$kWh/m^2/a$ regarding primary energy use intensity. It has to be noted that this value reflects the net primary energy use of the building from fossil fuels (Cyprus Energy Service, 2009a and 2009b, 2014) and it is derived following the deduction of the contribution of renewable energy sources (RES) from the final primary energy consumption of the building. Also, one has to note as well that an energy efficiency threshold for heating demand is the only requirement adopted in line with the PH Standard. Furthermore, no requirements have been set regarding airtightness of the envelope nor thermal bridging, CO_2 emissions, even though these are directly linked to the primary energy consumption, neither did a minimum performance threshold for cooling demand was set, .On the other hand, no minimum performance threshold for heating or cooling demand has been set for non-residential buildings and the only restriction concerns a minimum energy efficiency threshold of 125$kWh/m^2/a$ regarding primary energy use intensity. Again, no requirements have been set regarding CO_2 emissions.

Finally, as far as the contribution of renewable energy sources is concerned, a minimum contribution threshold of 25% has been set. In addition, for residential buildings, a requirement of hot water generation from solar collectors is also in place for some years now.

Based on the above requirements and data related to the issued EPCs from the Cyprus Energy Service, the number of nZEB residential buildings that are currently in place in Cyprus is very limited. Furthermore, retrofitting towards nZEB is practically non-existent. This is mainly due to the high initial investment cost compared to the actual energy savings through the buildings lifetime (Xeni et al., 2016), something that makes such an investment financially infeasible from a private investor's (owner's) point of view.
A funding scheme subsidising energy efficiency measures for residential buildings had been imposed from March 2015 until March 2016 in Cyprus. In the context of this scheme, incurred, eligible costs for retrofitting towards nZEB were subsidized by the state to a top of 75%, with a maximum subsidy of 25000 euro. Based on data from the Cyprus Ministry of Energy, Commerce, Industry and Tourism that have been in charge of the program, 105 applications for retrofitting to nZEB level have been received but no real evidence are in place yet for the actual retrofits taking place, since the 12-month deadline for materializing the investment has not yet elapsed.
Considering the climate of Cyprus that can be described as intense Mediterranean (Department of Meteorology, 2016) with hot dry summers from mid-May to mid-September with temperatures rising as high as 40 °C, rather changeable mild winters from November to mid-March, separated by short autumn and spring seasons of rapid change in weather conditions, one can consider the option of a minimum performance threshold in heating demand for residential buildings rather odd and unnecessary (see Figure 3.1.1). This is more or less true and the above mentioned minimum performance requirement is quite easy to achieve on an energy performance certification level. In fact, experience, with energy performance certificates, shows that a heating demand performance level of 5kWh/m^2/a is still not at all difficult to achieve.

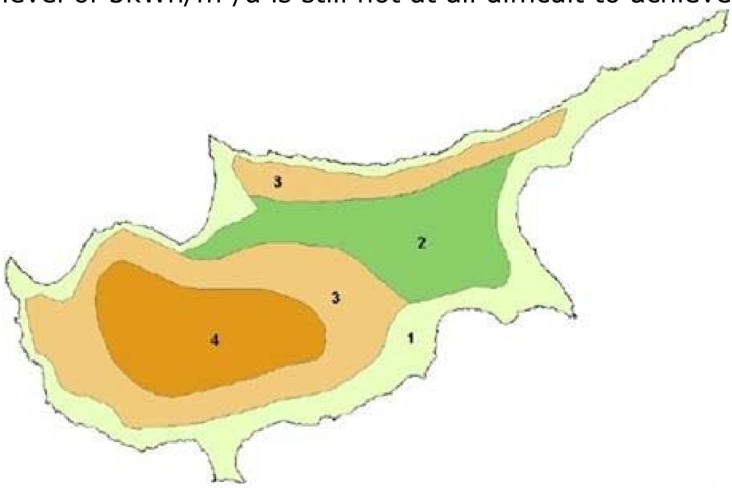

Figure 3.1.1: Climatic Zones of Cyprus (1 - coastal zone, 2 - inland zone, 3 - semi-mountainous zone, 4 – mountainous zone). (Cyprus Energy Service., 2014).

Taking also into consideration that the heating and cooling demand balance is greatly biased towards cooling (based entirely on an energy performance certification approach and the national methodology for the assessment of the energy performance of buildings which considers the heating and cooling systems always on, based on a dual set-point thermostat of 20 °C for heating and 26 for cooling °C) with a cooling to heating ratio near 3 to 10, based on the orientation and state of insulation of the building, one would consider a minimum performance threshold for cooling demand more appropriate Bearing in mind that, in residential buildings, the actual demand for cooling occurs only during the summer time (June to October) and only for the night periods, the actual energy consumption is off peak and limited. Furthermore, based on data from the national statistics agency of Cyprus, the actual primary energy consumption for space heating for residential buildings in Cyprus is nearly twice the primary energy consumption for space cooling (CyStat, 2009). These are the reasoning of not setting a minimum performance requirement for domestic cooling demand by the relevant authorities. Therefore, it is the authors' opinion that an energy efficiency threshold for cooling demand of 120 kWh/m^2/year could be applicable, and definitely this should be no less than 100 kWh/m^2/year.
Reduced cooling loads, and thus a strict cooling demand energy efficiency threshold, can be achieved through various bioclimatic design techniques such as shading of non-opaque envelope elements (e.g. windows), specific glazing G-values, limit on window to wall ratio, etc. However, there are currently no such quantitative performance indicators or recommended values in this aspect and all comes down to the experience and knowledge of the architect that designs the

building. The only legal requirement is that non-opaque envelope elements present a shading coefficient no higher than 0.63, as this is calculated based on the national methodology for the assessment of the energy performance of buildings. In addition, given the climate of Cyprus, bioclimatic design can reduce cooling loads but in order to maintain internal building temperatures within thermal comfort limits active cooling is necessary.

Nevertheless, one should be careful regarding air-tightness of residential buildings in Cyprus. Considering the dominant current construction techniques with the application of thermal insulation on the external side of the building envelope and high thermal mass brick walls on the internal, coupled with the fact that not all spaces are heated during the heating season (CyStat, 2009 and Xeni et al., 2016) and the operation of the heating system which is intermittent (Xeni et al., 2015), residential buildings are susceptible to humidity condensation in various critical elements and thus mould growth. In addition, a very strict airtightness limit value, taking also into account the requirements for the thermal transmittance coefficients (U-values) of the various building elements, can lead to undesired over-heating issues during the summer. Thus, a medium airtight envelope approach is suggested.

The above mentioned are strengthened by experience gained from the only residential building in Cyprus constructed in line to the passive house standard. It is a detached family house situated in a suburb of Nicosia and covering an area of 149 m^2. Based on two-year in situ measurements (Fokaides & Papadopulos, 2014), internal temperatures can reach as high as 29 °C (much higher than the 25 °C set by the standard) and overheating above 28 °C occurs for approximately 30%. One of the reasons behind this can be attributed to the high airtightness of the envelope.

On the contrary, the above do not apply for the majority of non-residential buildings, especially office spaces and hotels. These buildings present less heating needs than residential buildings, since they are either not operating during the night time (office spaces) where the highest heating loads occur or are closed during the winter (majority of hotels) due to high seasonal variations in the tourist arrivals. Thus, for a number of cases the authors of the current report agree with the absence of any performance threshold regarding heating demand, but they would suggest the application of a minimum performance threshold for cooling demand. These buildings exert great pressure on the electricity network and greatly increase the maximum electricity demand during the summer time due to intense cooling needs. Thus, a minimum performance threshold for cooling demand would make sense not only for increased energy savings but also savings from avoided infrastructure related to the electricity network's capacity.

One has to note here that the electricity grid is fairly stable and power cuts are lately very rare and a memory of the past. Cyprus has a relatively small isolated grid (installed capacity close to 1400 MW) that heavily relies on fossil fuels. Energy production from renewable energy sources is increasing step by step and has now reached a level close to 9%. Prolonged periods of sunshine favour solar technologies and the state has provided a number of incentives for RES penetration, accompanied by a favourable legal framework, as commanded by the related EU Directives. However, due to the grid's nature (small and isolated) there are limitations, both technical and economical, to the amount of RES penetration to the network as well as to the development of the necessary infrastructure to accommodate the necessary RES technologies for energy positive buildings. Current requirements dictate a 25% share of RES for nZEB buildings. It is the authors' opinion that this should be increased significantly in the future but with current grid limitations this cannot be more than 30% at the moment.

Despite a few drawbacks, the legislation and regulations in place regarding the near Zero Energy Buildings in Cyprus are quite firm and on the right track. However, no legislation or regulations exist regarding the thermal comfort in buildings. The majority of design engineers do take into consideration the ASHRAE 55 standard whenever needed, but as a general conclusion, no strict thermal comfort calculations are taken into consideration when designing buildings in general or nZEB in particular.

Adoption and application of requirements related to thermal comfort levels based on a suitable standard are the next logical step forward. But, applying an available international standard, such as the EN 15251, without fine-tuning key performance parameters is considered inappropriate. At first, there is the spring and autumn seasons in Cyprus that present special particularities as far as temperature variations is concerned. During this time of the year temperatures fluctuate between 15-28 °C most of the times with a few extremes such as temperatures close to 10 °C on the lower end or 32 °C on the upper side. Based on the above temperature fluctuations at the upper and lower end of the temperature range for spring and autumn, the operation of the heating or cooling system to raise/lower the temperature to the desired set-point is required. In practice,

this would never be the case and the heating or cooling systems would remain out of operation in both situations. Deviations of 2-3 °C from thermal comfort limits for relatively small-time intervals during the seasons of spring and autumn are usually accepted by the building users (residential or non-residential). In case of overheating they would simply open the window and in case of low temperatures they would simply use warmer clothing for a few hours during this time of the year. Furthermore, in cases where external temperature rises as high as 40 °C, in the absence of excess humidity, internal building temperatures as high as 28 °C are usually perceived as adequate by the majority of users.
Thus, following strictly the requirements of EN 15251 standard, excess energy (for heating or cooling) would be consumed to maintain thermal comfort levels and temperature limits depending on the case, otherwise the requirements would not have been met (e.g. the number of hours in excess of 25°C may not exceed 5% of the time working). It is therefore obvious that if a thermal comfort related standard would be applied, temperature and humidity limits, as well, as the allowed deviation margins, must be adapted to better suit the local residents' habits and needs.
In addition, when applying thermal comfort requirements, one should be careful in dealing with heating and cooling balance. Since with current climate conditions it is impossible to rely only on passive cooling, either due to very high temperatures reaching as high as 45 °C in the mainland, or due to very high humidity levels often surpassing 80% in the south and southwest coastline, and active cooling systems should be included, increased thermal insulation thickness (Fokaides & Papadopoulos, 2014) or air tightness can lead to overheating issues and excess energy consumption for cooling purposes.
Therefore, special attention should be paid both on the design of a building (envelope construction and thermal insulation, glazing sizing, orientation, etc.), as well, as the selection of the most suitable electromechanical equipment to be installed. Local engineers working in the buildings and building services sector are pretty much familiar with the majority of issues related to the good quality of a near zero energy building, but mainly on a theoretical level. Given the fact that legislation and regulations regarding the energy performance of buildings were first introduced in 2007 and calculation methodologies in 2010, it is quite evident that practical experience and know how is still missing. Nevertheless, workshops and seminars are constantly organised by various associations and authorities (Cyprus Scientific and Technical Chamber, Universities, private institutions, etc.) and the gap is closing. It is the skilled and unskilled labour force at the moment that lack behind with regards to knowledge on new technologies, materials, and proper installation procedures.
The Cyprus human resource authority has organized various workshops related in developing the necessary skills that are needed in the construction of high energy efficiency buildings (application of thermal insulation, windows and glazing, etc.), capitalising EU funding as well, but still there is a great gap to bridge. The main issues that are currently observed relate to poor application of thermal insulation, humidity condensation and mould growth, airtightness issues, integration of renewables, especially in combi systems.

Own recommendation on the minimum EE and RET in Cyprus (EE energy efficiency, RET Renewable Energy Threshold onsite):

Here are presented the Thereshold for EE and RET in Cyprus (Table 3.1.1)

Table 3.1.1: Different Minimum Performance Thresholds for nZEB

Category	EE Threshold		RES Threshold	Country
	Heating	Cooling		
Residential buildings	15kWh/m².a	100-150kWh/m².a	30%	**Cyprus**
Non-residential buildings	--- kWh/m².a	60-80 kWh/m².a	20%	

The largest cities in Cyprus are the capital of Nicosia, with a population of around 300000 people (city and suburbs), the city of Limassol, with a population of around 200000 people (city and suburbs), and then are the cities of Larnaca and Paphos, with each having around 50000 inhabitants (city and suburbs). Nicosia is situated in the mainland and climatic zone "two" based on the classification of the Cyprus Meteorological Service. It presents very high temperatures during summertime with extremes reaching or surpassing 40 °C, while the winters are relatively mild, with temperatures sometimes dropping near 0 °C. Limassol, Larnaca and Paphos are all situated along the south and southwest coastline of the country. They are located in climatic zone

“one”, based on the classification of the Cyprus Meteorological Service, and due to their proximity with the sea temperatures are a couple of degrees Celsius lower during summertime and higher during the winter.

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3.2 FRANCE

1. What is the minimum energy efficiency threshold for nZEB in your country?

In France, the regulation (RT 2012 Th-BCE method's imposed by the Law 20/07/2011, according to the amended Law of 26/10/2010, see Table 3.2.1) sets a mean level of primary energy consumption at below 50 kWhep/m².year for all new constructions. The basic principles rely on three types of performance requirements for new building construction and generalizing the construction of Low Energy Buildings: Bioclimatic design, favour renewable energies (in particular in private houses) and optimize equipment used.

In term of results requirements, it relies on 3 global indicators:

Bioclimatic design (Bbio) which targets the maximum of efficiency for the building envelope. The indicator limits the energy requirements for central heating, cooling and lighting of the building, apart from the systems subsequently implemented. Expressed in points (no unit), the Bbiomust be lower than a Bbiomax level, modulated according to the geographical zone, altitude, type of use and inhabitable surface area. The designer is expected to strengthen insulation, the treatment of thermal bridges, the envelope water tightness, the structural inertness, adjacent housing, orientation, compactness, solar contributions and the suitable distribution of the rooms. He also has to tackle the treatment and measuring the level of air permeability of the building envelope under 4 bars, below:

- 0.6 $m^3/(h.m^2)$ of deperditives walls surfaces, excluding low-floor in house or joined;
- 1.0 $m^3/(h.m^2)$ of deperditives walls surfaces, excluding low-floor in collective residential dwellings.

Primary energy consumption (Cep) concerns consumption in terms of central heating, cooling, lighting, domestic hot water production and auxiliary systems. The maximum of conventional primary energy consumption of the building (CepMax indicator for conventional uses 5), defined by the average value of 50 kWh_EP/m².year. A derogatory modulation is authorized and regulated by geographical location, altitude, type of use of the building, the average area of housing and the technology emitting least CO2 like wood energy and district heat networks. This requirement imposes further optimization Bbio, the mandatory use of renewable heat energy (contribution of renewable energies to Cep at least 5 kWh_EP/m².year) and efficient energy equipment high efficiency. For housing, local renewable electricity remains permit with derogation of 12 kWh_EP/m².year additional on CepMax, before deduction of the entire renewable energy production, in order to achieve the goal of Buildings Positive Energy's generation (BEPOS) as a response in transcription at national level of the EU nZEB, introduced during the recasting of Energy Performance of Buildings Directive 2010/31/EU. The BEPOS (cooresponding to EU NZEB => see figure 3.2.1) will be introduced as a required target for new french building regulation in the RT2020. It may be that the Cep is negative and therefore that the building produces more energy than it consumes on one-year assessment. But let put this interpretation in its context of RT2012: the first BEPOS generation does not take into account all the consumptions (specific uses of electricity in particular), but only 'conventional' consumptions cited above.

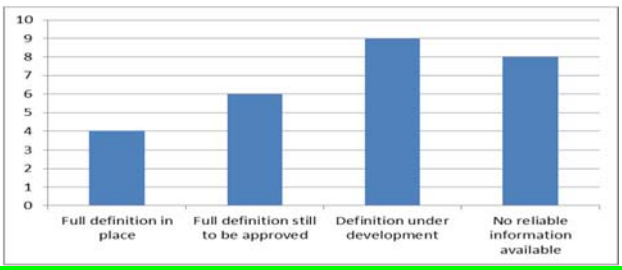


Figure 3.2.1: Status of the NZEB definition in the EU Member States at the end of 2013 (COM / 2013/0483 Final/ 2)

Note: the transformation coefficients of the final energy in primary energy in France by convention are taken equal to:

- 2.58 for electricity consumption and local electricity productions

- 1 for other consumption

Summer comfort (evaluated by Tic) as to be guarantee a suitable interior temperature (lower than a reference temperature Ticref), not to be exceeded even after a consecutive period of five very hot days. The designer is encouraged to work on innovative solutions for the walls, solar protection and night cooling by ventilation combined with building thermal mass. The summer comfort in non-active air-cooled buildings, is characterized by the maximum hourly value of the operative temperature during the occupation period (Tic) reached in the rooms (all day for residential, for example) during of 5 very warm days without the need of active cooling.

One can notice that having a requirement max Bbio max of 80 points or even 60 points instead of 50 "encourages" the degradation of thermal performance envelope of new buildings and causes a strengthening of the compensation phenomenon by systems and equipment rather than the envelope buildings.

To fulfil both Bbio max and Cep max is done without difficulties for buildings with good compactness factor, and the most compact buildings and for the most compact buildings include envelope with benefits of the thermal resistance R of less than 2 (m²K) / W. The change in the calculation of the Bbi max o by introducing a compact modulation coefficient would correct that too much flexibility in the level of insulation of residential buildings (Tchang & Desmars, 2015).

Many intensive works on the Environmental Performance of New Buildings (PEBN) have been to this day engaged with ministries of Housing, Environment and Energy to prepare the next environmental regulations (RE2018) in order to integrate requirements of Directive 2010/31 / EU on the energy performance of buildings (Article 9b particular, the obligation of nZEB after 31 December 2018 for new occupied and owned by public authorities' buildings). Paradigm shift: moving from a pure energy approach with the RT2012 to an environmental assessment with an approach in Life Cycle Assessment with the future RE2018.

The guidelines of this work concretely deal with the increased demands with respect to current regulations (RT 2012) using significantly to renewable energy (consumption and production), contributing to the emergence of Territories Positive Energy (Article 1 of the law on the energy transition to green growth) and the development of a local energy policy. They will also and simultaneously meet the requirements on emissions of greenhouse gases and target the low-carbon throughout their life cycle.

The new rules must generalize the Building Positive Energy, targeting all building consumptions (any use, including electrical households, computers... and not just 'conventional' consumptions), and will strive to balance their consumption non-renewable energy and renewable energy exported for efficient deployment of renewable energy (future energy mix, including renewable electricity).

The generalization of buildings positive energy will be based on the gradual greening of local energy networks. That explains why different levels of BEPOS are planned so they can be accessed by the various territorial contexts. In foreshadowing of these different levels of possible regulatory BEPOS the BEPOS label will be experienced on 2017 following 4 levels:

- "1 star" BEPOS level: regulatory requirement RT 2012 -5%
- "2 stars" BEPOS level: regulatory requirement RT 2012 -10%
- "3 stars" BEPOS level: regulatory requirement RT 2012 + compensation of non-renewable energy consumed for the 5 regulatory 'conventional' uses (up to 50 kWh_EP/m².an). The self-consumption has a real job to play in this configuration, favoring integration criteria to the built environment of the solutions (including thermal and solar electric), while limiting the overcost.
- "4 stars" BEPOS level: regulatory requirement RT2012 + compensation of non-renewable energy for all uses included. Besides the additional cost of the solution that will lead to the Project Owner, the experiment will have to consider the balance of power grids in the multiplication of this configuration and its probable reinforcement at long terms (or at under a new management of the energy exported – SmartGrid development). Collectivities have a real job to play in locally fixing part of this production through their planning documents and knowledge of local renewable energy potential.

Table 3.2.1: Modulation coefficients requirements - Annex VIII - Modified Order of 26/10/2010

Modulation coefficients requirements - Annex VIII - Modified Order of 26/10/2010				
	CE2 Class in case of all the rooms other than temporary occupancy rooms of the building are classified CE2, that to say namely **provided with an 'active' cooling system** and:		CE1 Class on the other hand	
Buildings or building part as 'Residential' use	- The building is located in climatic zone H2d or H3 at an altitude less than 400m - Windows are exposed to noise (BR2, BR3)[1]			
	BBioMax average value	Mctype For CepMax average value	BBioMax average value	Mctype For CepMax average value
Collective dwellings, Individual houses	80	1,2	60	1,0
Young worker homes, university rooms	90	2,1	60	1,8

The new regulations must also generalize the building Low Carbon. Noting the almost equivalent impact of building construction and operation of its energy systems on emissions of greenhouse gases, the calculation method offers complete measuring the overall impact of the building by a sub indicator on the impact of construction. This distributes the force between the operational phase and the construction phase in particular highlighting the constructive or manufacturing processes have reduced their emissivity in greenhouse gases. Therefore, they envisage two levels in the label Low Carbon:

- Level "Carbon 1" overall impact of the building (building + exploitation)
- Level "Carbon 2" impact of the construction only (non-operating)

Note: First simulation of the working-group following: Figure 3.2.2

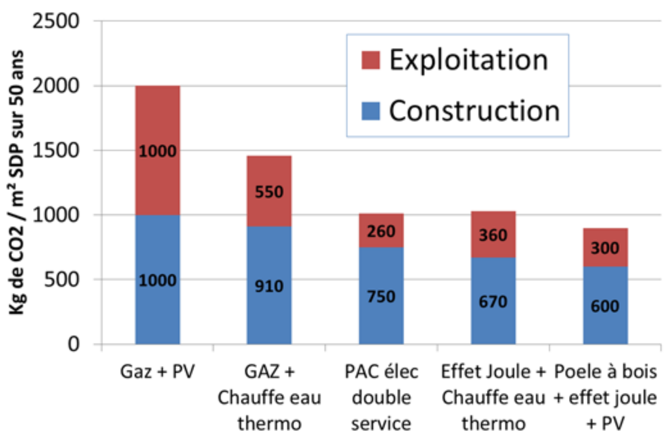


Figure 3.2.2: First simulation of the working-group

Still several possibilities:

1. A single global threshold (building + exploitation)?
2. An overall threshold + GES threshold on the envelop (construction)?
   - Individual houses: 700 to 800 kg CO2 / m²
   - Residential dwellings: 850 to 950 kg CO2 / m²
   - Office buildings: 1100 to 1300 kg CO2 / m²

[1] The noise exposure class (BR) is defined by the distance from the facade to the land transport infrastructure (modulation if the window is in direct view, partial or masked by protective barriers infrastructure), or by the area of the noise exposure of the aerodrome for air transport.

3. Thresholds differentiated according to energy?

Future environmental regulations will strengthen the current rules by two indicators: the indicator BEPOS balance sheet and the indicator on a maximum threshold of greenhouse gas emissions (being defined). This will be the "energy-carbon" basement. These low-carbon and buildings positive energy concept will be created by drawing on existing labels (BEPOS-Effinergie, Effinergie+, Passivhaus, Minergie, BREEAM) and implemented through a voluntary experiment that will evaluate collectively technical and economic feasibility issues requirements and evaluate the learning curve by the actors.

a) If there is no minimum threshold, which threshold do you suggest for your country and why?

Method for determining the current thresholds are currently in discussion with ministries and ad hoc working groups. However, one can observe that the threshold of Bbio max with the modulated value of 60 points, can easily be reached with a gain of 20% in most configurations with proven and correct construction practices and moreover with a negligible cost compared to the previous fench regulation RT 2005. This is link to the fact that this indicator is new and the french government had decided to set the level of requirements in a flexible way to prevent penalization of some architectural typologies. At that stage the feedback mentioned in several studies indicate that it should be refined. (Tchang & Desmars, 2015).

b) Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?

It is indeed probable, knowing that the share for the DHW will be finally the most important in the order of 'conventional' consumption (5 regulated uses).

Note: In the new construction, heating consumption is 9-22 kWh_EP/m².year following heating energy for BEPOS Effinergie label (according to BBC observatory - www.observatoirebbc.org). By integrating consumption related to other uses, estimated at 70 kWh_EP/m².year, heating accounts for more than 17% of total consumption and no longer remains the main challenge. In the tertiary sector, the key depends on the presence of an 'active' cooling system and the type of use of buildings (offices or education). The three major consumption items are lighting, heating and ventilation. The level of air tightness of buildings has also improved over the years with the stringent requirements in the labels to reach values below 0.4 m^3/h.m² in individual housing / collective dwellings on Effinergie + projects (0.32 m^3/h.m² on BEPOS-Effinergie)

2. What is the Heating-Cooling balance for nZEB in your country?

France dominant climate regarding the Köppen-Geiger classification is mainly temperate (C) and more especially classified as fully humid with warm summer (Cfb). The Mediterranean Sea area present low precipitations and hot summer (Csa) or warm summer (Csb). The mountain (Alps, Pyrenees, Massif Central) areas are cold. These areas are considered through a modulating coefficient depending of altitude. The standard divides into three zones for winter (heating period): H1, H2 and H3, and four summer areas (non-heating period): a, b, c and d (see figure 3.2.3).

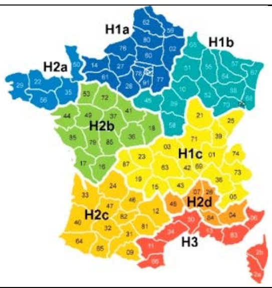
<table>
<tr><td>
</td><td>CE1 Class
(Individual houses and
Collective dwellings)</td><td>CE2 Class
Tertiary sector</td></tr>
<tr><td>H1a</td><td rowspan="8">Heating only
No Cooling needs thanks to
optimization of BBio and Cep
indicators project</td><td rowspan="5">Heating (needs) >> Cooling</td></tr>
<tr><td>H1b</td></tr>
<tr><td>H1c</td></tr>
<tr><td>H2a</td></tr>
<tr><td>H2b</td></tr>
<tr><td>H2c</td><td rowspan="2">Heating # Cooling</td></tr>
<tr><td>H2d</td></tr>
<tr><td>H3</td><td>Cooling >> Heating</td></tr>
</table>

Figure 3.2.3*:* Climatic zones of France based on cooling or heating or cooling and heating *dominance*

a) Do you agree with the above statements? Can you reach nearly zero heating demand?

There is not enough experience feedback in the BBC (Low Energy Building) observatory to generalize, but actually it has been drawing a strong link between BBio indicator to characterize the impact of bioclimatic design on the energy performance of buildings and the heating needs. In a first extraction, it is noted that more BBio indicator is optimized relative to its maximum regulatory value (BBioMax), more the primary energy consumption of the heating equipment (Cep) is reduced:

- 40% gain on BBioMax induces Cep_$_{heating}$ of about 20 kWh_EP/m².year
- 50% gain on BBioMax induces Cep_$_{heating}$ of about 15 kWh_EP/m².year
- 60% gain on BBioMax induces Cep_$_{heating}$ less than 10 kWh_EP/m².year
- Gain greater than 70% on BBioMax induces Cep_$_{heating}$ less than 5 kWh_EP/m².year.

The impact is particularly important, when the building is heated by a renewable energy source (geothermal heat pump in particular). The air tightness index on the envelopes seems to impact lesser on consumption for heating.

b) Should we opt for highly airtight envelopes or medium airtight envelope in your country?

The first returns on the documentary base of the BBC Observatory, the air tightness index is not as much weight as the gain on the BBioMax. The Bbio helps promote bioclimatic building design valuing parameters such as solar gains, compactness or contributions in daylight. The mean Bbio max is of 60 points. However, some Bbio max value can be quite far for this value due to the various existing modulations (Tchang & Desmars, 2015).

First response could therefore to think that an average coefficient should be adequate, if one has to simplify the approach.

c) What is the influence of the heating/cooling balance on your energy supply network capacity in regard to the electric or thermal demand?

This influence is measured by planning the development of the district heating / cooling networks, complete the chart indicator of performance of networks (subscribed demand, power called rate, discontinuation rates for the supply, energy mix, average price per MWh ...). The approach of an Energy-Environment-Air Master-Plan for the definition of priority development areas materializing through the classification of heating networks, is an energetic planning tool for the collectivises. Each of them can articulate with their skills in urban planning and development, as well as its territorial Climate-Energy-Air Plan (PCEAT) to contribute to the achievement of its local targets for reducing emissions of greenhouse gases and renewable energy development.

3. What is the Thermal comfort limits for nZEB in your country?

In order to globally answer, the RT2012 designers already committed in the way of passive cooling, playing on optimizing Bbio (compactness, windows surfaces, orientation, thermal inertia, airtightness ...). The single-family homes and multiple dwellings of Housing should be designed (unless special noise exposure), without using 'active' cooling systems (CE1 Class). Tertiary buildings must to the extent possible to cling to the ranking CE1, except for establishments using the 'necessary' cooling (accommodation for the dependent elderly (nursing homes) and health institutions in particular) (Tchang & Desmars, 2015).

Summer thermal comfort is an important part of the overall quality of use of the buildings, which are evaluated by continuity with the RT2005 and RT2012, through the Conventional Indoor Temperature (Tic) in BEPOS referential. The future RE2018 will resume this indicator, which will be associated with the calculation of a new indicator (the hourly time and over the year), evaluating discomfort in summer and in absolute terms, the discomfort Playing time Summer Statistics (Dies - unit hour). The Dies relies on the concepts of adaptive comfort and percentage of dissatisfied. This indicator accounts both the duration and intensity of the discomfort felt. It is based on standard EN 15251 concerning the adaptive comfort and ISO 7730 standard.

The principles of the calculation method of the Dies indicator are as follows. Each hourly time is calculated:

- The operative temperature of the group (Top);
- The 'warm' comfort temperature limit, calculated based on outside temperatures of the previous day, according to NF EN 15251.
- Note: It is bounded at the bottom by the set temperatures of the RT2012 and at the top by the same set point temperature + 2 ° C. There is no adaptive comfort for sleeping period.

From the comparison of these two temperatures follows the calculation of the Dies index.

- If the operative temperature is less than or equal to the temperature limit of comfort: the occupant is in the comfort zone;
- If the operative temperature is above the temperature limit of comfort, one calculates the difference between the two temperatures and one deduces the percentage of dissatisfied PPD (h) calculated according to the ISO 7730 standard.

The Dies indicator represents the cumulative percentage of dissatisfied outside the comfort zone every hour.

$$Dies = \int PPD_{corrigé}(h)$$

With PPDcorrigé(h), PPD (h) corrected to disregard unsatisfied persons of the comfort zone.

4. What is the minimum renewables threshold for nZEB in your country?

a) Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

Subsidies exist in both sectors (EE or RES), but there is a conducted energy conservation policy that guides priority investments towards energy efficiency.

b) Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50 or 70% of the demand?

With the BEPOS label, we will seek to maximize the rate of self-consumption photovoltaic, to the extent that the self-consumption presents real opportunities of general interest:

- Substitute majority fossil and fissile energy of the French electricity network to replace electricity from 100% renewable locally produced (limitation of line losses, improvement the efficiency of the solution);

- Limit the reinjection of intermittent energy, penalizing at term the network manager (security of supply, maintaining the voltage / frequency) and costly for the collectivises (very likely strengthen the existing electrical network);
- Secure one part of the electricity bill: LCOE fixed on 25/30 years without purchase price, with costs reduction of connection and now the option to directly sell the overflow of electricity to another consumer through the deployment of communicating counters 'Linky' by means of new business models offered by the Energy Transition Act for Green Growth (Order n°2016-1019 of 27/07/2016);
- Participate in the deployment of renewable energies and contributing to the reduction of emissions from electricity generation fleet by improving the RES share in the French energy mix, relay of photovoltaic power plants (ground-mounted systems) and wind power plants;
- Revive the impulse of PV rooftop installations, which allows excluding conflict with land use, taking advantage of integration constraints to the building frame to capture and also promote solar thermal energy as free contributions to habitat (BIPV and PVT modules) preserving architectural and landscape integration.

Photovoltaic and self-consumption is a real awareness vector from the producer to its electricity consumption and therefore an economic development vehicle for the players in the photovoltaic sector.

Note:
Rate of self-consumption photovoltaic = production of photovoltaic electricity consumed in-situ / total generation of photovoltaic electricity produced in-situ
Rate of self-production photovoltaic = production of photovoltaic electricity consumed in-situ / total consumption of electricity of the site (grid + PV)

c) Are regulations and policies ready for encouraging energy producing buildings in your countries? Is your energy grid ready for that?

The next building regulation, RT 2020, will obviously go further than RT2012 since it should impose that any new construction generates more energy than it requires to operate: BEPOS (Ministry of ecology, Sustainable Development and Energy 2004). Several initiatives have emerged in order to prepare the implementation of this future regulation. Effinergie association (http://www.effinergie.org) that has been created 10 years ago, has implemented a pilot Bepos-effinergie (Effinergie, 2013).

The French government initiates National program on Experimental BEPOS labels that will be launched in 2017. Among this, the Investment Program for the Future (AIP), led by the General Commission for Investment since 2010, has been created to finance innovative and promising investments on territory. On the global amount of 47 billion euros, some is dedicated to innovation on BEPOS, Smart Cities and also Positive energy territories.

Regarding renewable energy, since 2009 the Renewable Heating Funds program (Fonds chaleur Renouvelable), is managed by the ADEME since 2009 (1,12 billion euros from 2009 to 2013). It contributes to the development of renewable heat production and is intended for collective housing, communities and businesses.

These are complementing from Regional programs and EU FEDER.

5. What is the construction quality for nZEB in your country?

The French regulation, RT 2012, is based on an obligation of result, regarding the overall performance of the designed building. This results in a thermal binding study to initiate upon the deposit of the building permit. The obligation of results is based on two certificates of conformity to provide upon filing of the building permit and completion.

Reaching the required level of airtightness of the envelope still remains delicate. Even if the majority of stakeholders are now aware of the problem and competent to deal with it, tests highlight recurrent problems such as: joints defective exterior joinery, poorly caulked penetrations ducts and networks floors, leaking masonry defects in concrete, ... The best practice is to favour a construction ongoing test to take corrective action as early as possible.

With the European project named QualiCert (2008), France has begun work on this component and set up eco-conditionality of subsidies since 2011, in order to meet the European Directive 2009/28/CE on the promotion of the use of energy from renewable sources (amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC).
Currently, the qualification of professional skills "Recognized Guarantor of Environment (RGE)" allows by the French law to specify the training standards and the required references necessary to judge the skill of installers in order to enrol them in this virtuous quality approach, applied both in RES and EE (building construction).

6. **What should be (your own recommendation) the minimum EE and RET in your country?** (EE energy efficiency, RET Renewable Energy Threshold onsite):

The following table (Table 3.2.2) shows the EE and RET thereshold for France:

Table 3.2.2: Different Minimum Performance Thresholds for nZEB

Category	EE Threshold		RES Threshold	Country
	Heating	Cooling	50%	**France**
Energy efficient	20kWh/m².a	20kWh/m².a		
Low-energy	10 kWh/m².a	10 kWh/m².a		
Ultra-low energy	5 kWh/m².a	5 kWh/m².a		
Passive Standard	10 kWh/m².a	10 kWh/m².a		

7. **Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.**

The following table (Table 3.2.3) shows the largest cities in France, underlining their population and the climatic zone.

Table 3.2.3: Main Cities in France and their Regulatory Climatic Zone

Source: INSEE 2013	• Population	• Regulatory climatic zone
Paris	• 2 229 621	• (H1a)
Marseille	• 855 393	• (H3)
Lyon	• 500 715	• (H1c)
Toulouse	• 458 298	• (H2c)
Nice	• 342 295	• (H3)
Nantes	• 292 718	• (H2b)
Strasbourg	• 275 718	• (H1b)

There is also specific regulation for French overseas territories, i.e. Guyana, Martinique and Reunion islands. For these geographic zones there is a Thermal, Acoustic and Ventilation specific standard. The design of the dwellings has to limit energy consumption through a bioclimatic design and limiting the air-conditioning thanks to solar protection and the use of natural ventilation. The residential house or buildings has to be equipped with a system producing domestic hot water from solar energy (Ministry of ecology, Sustainable Development and Energy, 2004).

8. **References/Key publications**

Effinergie association (2013), "Règles techniques applicables aux bâtiments faisant l'objet d'une demande de Bepos Effinergie". Version 3, 6 pages. September 8th 2015.

Ministry of ecology, Sustainable Development and Energy (2004), Energy efficiency action plan for France -2014. 116 pages. 2004.

Tchang, N. & Desmars, N., (2015). "Etude sur l'évolution des prestations thermiques des bâtiments avec la RT 2012", Collectif Isolons la Terre contre le CO2.

3.3 GREECE

In Greece, current adaptation status of nearly zero energy buildings is still at early stage. The energy performance of buildings was initially introduced in Greek legislation with the Greek Law 3661/2008 "Measures to reduce energy consumption in buildings and other provisions", which integrates the European Directive 2002/91/EC. Based on this law, in 2010 the Regulation for Energy Efficiency of Buildings was issued, which established the implementation of inspections in buildings for issuing the Energy Performance Certificates and the methodology for the conduction of inspection. The recast Energy Performance of Buildings Directive (EPBD, 2010/31/EU) was integrated in the Greek legislation under the Greek Law 4122/2013 "Energy Performance of Buildings – Transposition of Directive 2010/31/EU" (WP2 – Deliverable 2.1, 2014). In this law, terminology is provided mainly as per the European Directive, whereas no thresholds and concrete definitions are set. More specifically, the minimum energy efficiency threshold regarding nZEBs has not been defined yet either regarding end use or primary energy. Moreover, no thresholds have been defined for CO_2 emissions. According to the Greek Law 4122/2013 a National Plan is to be developed which will include the technical characteristics of the nearly Zero-Energy Buildings, targets so as to improve the energy performance of the new buildings till 2015 and information concerning the promotion of the nearly Zero-Energy Buildings. However, the National Plan has not been defined yet. It should be mentioned that according to the New Building Regulation (Greek Law 4067/2012) a category of buildings named "low energy buildings" is defined, which includes all buildings displaying annual primary energy 10kWh/m2 including heating, cooling, lighting, ventilation and DHW (Domestic Hot Water). Though this target seems quite optimistic.

Regarding the renovations of the residential buildings in Greece to nZEBs it should be stated that no records exist till now, taking into account the fact that the term nZEB has not been official defined. Regarding the renovations in general in the residential buildings, the following Figure 3.3.1 presents the energy class per percentage of total renovations and new buildings and per year of renovation. It is highlighted though that the Figure 3.3.1 refers to both the radically renovated and new-built residences, whereas a discrimination between them could not be detected based on the available relevant statistics.

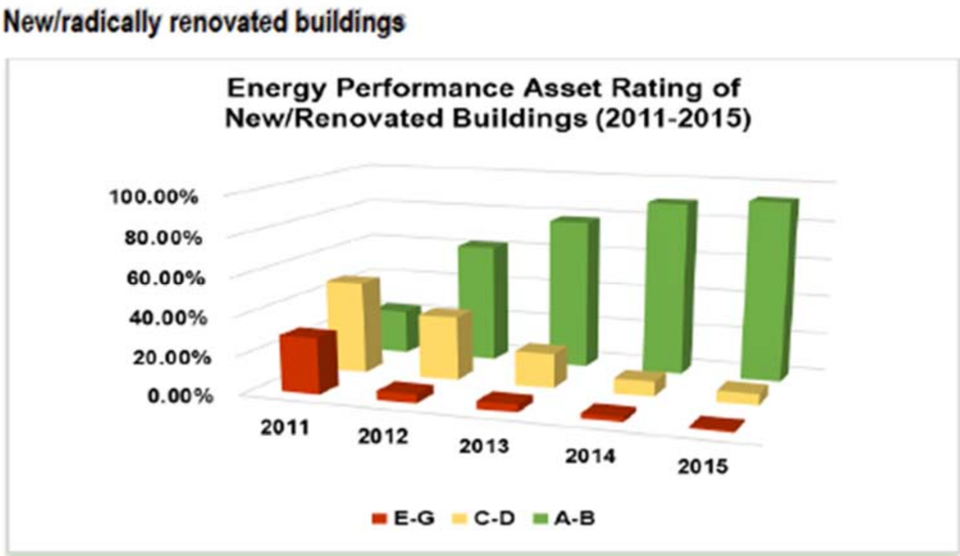


Figure 3.3.1: Energy class of new/radically renovated buildings per year (G.D.E.C.E.M.I, 2016)

As per the recast EPBD (2010/31/EU) the minimum energy performance requirements should be set based on cost-optimal levels, which should be calculated by each Member State based on a comparative methodology provided by the Commission. Currently, Greece has not proceeded to a cost-optimal analysis. Therefore, it is proposed to refer to the thresholds set by Cyprus for nZEBs. This approach is mainly justified due to the climate of Cyprus, which bears more similarities to the Greek climate since the Mediterranean climate is the dominant climate in both countries than the climate of the other countries - Member States of the European Union which have defined the minimum energy requirements for nZEBs. Based on the indicators of Cyprus it is recommended for nZEB residential buildings a maximum primary energy of 100 kWh/m^{2}y and for non-residential buildings 125 kWh/m^{2}y. For several European countries the PassiveHaus Standard is followed in order to guarantee a minimum performance threshold of 15 kWh/m^2/a for heating demand. According to the Passive House Institute, 11 buildings have received the relevant certification in Greece. Most of the passive houses are detected in Volos. One example is a semi-detached house, consisting of 3 apartments, which was constructed in 2012. The building is of masonry construction and it achieved an annual heating demand of 12 kWh/m2a. Another case-study is a detached single family house in Penteli (Attica) of mixed construction type, constructed in 2011. The building achieved an annual heating demand of 15 kWh/m2a.[2]

In Greece under ideal circumstances the threshold of 15 kWh/m2a could be achieved, taking into account the fact that the climate of Greece during winter is mainly mild. However, it should be noted that the materials used in buildings in order to achieve PassivHaus Standard are not in common use in Greece but are mainly used in Northern Europe (e.g. wood). Moreover, the achievement of this threshold depends highly on the orientation of the building and its surroundings, whereas in Greece the urban area does not provide most of the time ideal design conditions. Thus, the PassivHaus Standard is not proposed to be followed in Greece as supplementary or guidance for nZEBs. Other main issues regarding the implication of the passive house are the insulation of the envelope, the openings, the air-tightness, the thermal bridges and the ventilation systems with heat recovery. The main issue is the insulation of the building's envelope, which should be appropriately designed combined with the ventilation of the building, so as to prevent any overheating or uncomfortable indoor conditions. In general, modifications should be done in order the principles to be properly adjusted in the Mediterranean climate, thus this Standard is not proposed to be followed. A major factor in a nZEB is the heating and cooling balance in a building. Based on the Greek Regulation for Energy Efficiency of Buildings, issued as the Ministerial Decision Official Gazette Bulletin B' 407/09-04-2010 4 different climate zones (A, B, C and D) are defined based on heating degree days (HDD) dividing the country in 4 regions. Climate Zone A corresponds to regions in South Greece, whereas Climate Zone D to regions in Northern Greece. The rest of the regions are classified respectively to Climate Zone B and C. Figure 3.3.2 presents the climate zones in Greece.

Based on the aforementioned map, it is stated that the largest cities per climatic zone (in terms of its population based on the population census conducted on 2011) are the following:

- Climatic Zone A: Iraklio
- Climatic Zone B: Athens
- Climatic Zone C: Thessaloniki
- Climatic Zone D: Kozani

[2] More information can be detected in http://www.passivhausprojekte.de/index.php?lang=en#k_Greece.

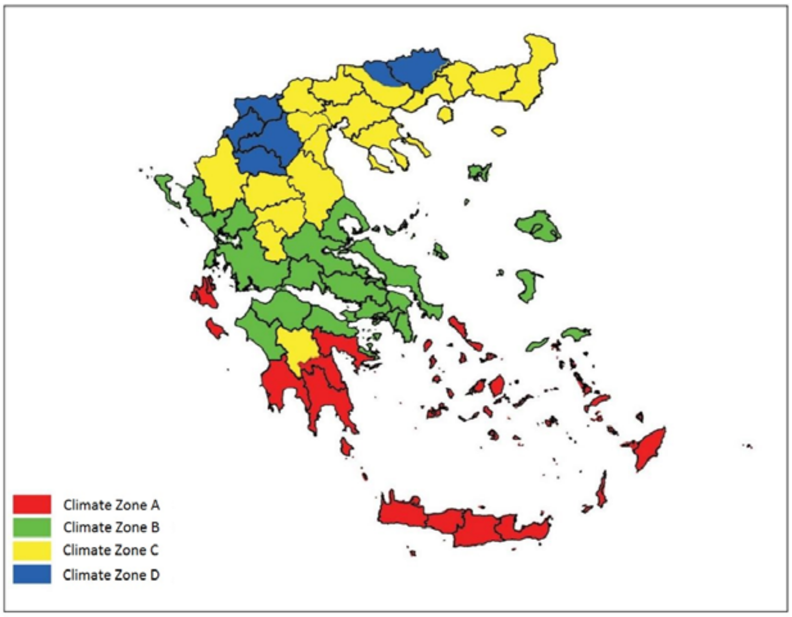


Figure 3.3.2: Climate zones in Greece (www.Microboiler.eu 2013)

Regarding the Mediterranean climate of Greece, it is mentioned that the summers are usually hot and dry, and the winters can be quite cold and wet. The northern part of Greece can be very cold during the winter and snow is not uncommon. However, for the south of Greece and the islands, the winters can be milder. During the winter a big part of Greece may have snow, and much snowfall can be expected in the higher mountains of Greece. As per Koeppen-Geiger classification, the climate of Greece is classified as Csa, which is translated to a warm temperate Mediterranean climate with dry, warm summers and moderate, wet winters with the warmest month above 22°C on average. Thus, it is most likely that the heating demand to be relative low in nZEBs, however cooling demand would be greater. It should be noted that till now no cost-benefit analysis has been implemented in Greece regarding nZEBs and relevant studies also have not been issued, thus it is not possible to provide any recommendations on the heating-cooling balance of nZEBs in Greece.

In principle it would be possible to achieve low heating demand and cooling demand in countries with Mediterranean climate, through proper bioclimatic design and careful choice of building envelope elements. However, in terms of refurbishing existing building stock this might be hard to be achieved. The reason is that it is strongly connected to the architectural design of the building, as well as its surroundings and its orientation, which besides its surroundings and under circumstances cannot be modified in case of renovation, unless the building is constructed from scratch. Recent statistical data regarding cooling demand in Greece is not available, however based on the "SURVEY ON ENERGY CONSUMPTION IN HOUSEHOLDS, 2011- 2012" (Hellenic Statistical Authority, 2012) it is mentioned that 63.7% of total energy consumption is used for space heating whereas 1.3% is used for space cooling. It should be stated that the aforementioned statistics do not include the tertiary section, which is crucial for the cooling space consumption especially when the demand is high (usually at midday hours on working days). Based on statistics according to Building Performance Certificates by the Ministry of Energy the following tables present the current situation on the consumption of primary energy for heating and cooling purposes in residences and non-residences per year when the inspections were conducted, presenting the high cooling demand in relation to heating demand in tertiary section in comparison to the residences (see Table 3.3.1).

Table 3.3.1: Average annual primary energy for heating/cooling in residences and tertiary section according to energy inspections (G.D.E.C.E.M.I., 2016)

Year	Residences		Non-residences	
	Average Annual Primary energy – Heating (kWh/m^2)	Average Annual Primary energy – Cooling (kWh/m^2)	Average Annual Primary energy – Heating (kWh/m^2)	Average Annual Primary energy – Cooling (kWh/m^2)
2015	171.18	31.04	108.41	137.17

2014	193.32	31.83	113.15	146.32
2013	177.84	30.88	118.77	148.97

According to the aforementioned it is not quite clear whether the indicators mentioned for nearly zero heating demand and relative cooling demand could be achieved in case of refurbishment. Air tightness is another quite important issue that should be appropriately addressed in nZEBs. In northern countries it is noted that high efficient buildings should be high air-tight in order to achieve minimum energy requirements. However, in southern European countries airtightness should not be high and ventilation should be properly designed in order to avoid issues during space heating in winter time. Space cooling presents also issues regarding the normal operation of the energy grid in Greece. Due to the rapid increase of air conditioning systems in the residences and the increase of temperature during summer time the peak power of the system is highly increased in days with heatwave. The following Table 3.3.2 presents the increase in the air-conditioning systems in households since 2010 as a percentage.

Table 3.3.2: Percentage of distribution of households by main heating means, 2010-2014 (Hellenic Statistical Authority 2015, Greece in figures).

	2010	2011	2012	2013	2014
Central heating	65.9	64.4	55.7	38.1	35.3
Natural gas heating	7.2	7.7	8.1	8.9	8.8
Gas oil stove	5.0	4.2	3.4	2.2	3.0
Gas liquid stove	1.4	1.5	2.0	2.3	1.8
Firewood stove	5.4	6.7	7.9	11.6	12.4
Thermal accumulator	2.6	2.3	1.7	1.9	2.1
Electric heater appliances (stove, fan heater, heater)	4.7	4.4	6.9	11.5	13.0
Air-conditioner	4.8	4.7	5.8	12.6	12.2
Other means	2.3	3.8	7.8	9.5	9.7
No heating	0.5	0.2	0.8	1.5	1.6

Regarding the increase in the temperature, the following Table 3.3.3 presents the average monthly and annual temperatures in Athens and Thessaloniki, based on a relative study (Hellenic Statistical Authority, 2015). According to the study the total increase of the annual average temperature from the first to the third decade was 1.2oC and 1.1oC for Athens and Thessaloniki respectively.

Table 3.3.3: Average monthly and annual temperatures of 1983-1992, 1993-2002 and 2003-2012 decades in Athens and Thessaloniki (Papakostas et al., n.d.)

	Athens			Thessaloniki		
Period	1983-1992	1993-2002	2003-2012	1983-1992	1993-2002	2003-2012
Jan.	9.44	9.73	9.83	6.13	6.34	6.81
Feb.	9.32	10.48	9.50	6.86	7.84	7.34
Mar.	11.47	11.97	12.62	9.83	10.06	10.81
Apr.	15.77	15.74	16.25	14.58	14.17	14.74
Mai	19.93	21.34	21.40	18.86	19.62	20.05
Jun.	24.42	26.34	26.31	23.31	24.22	25.02
Jul.	27.13	28.79	29.42	25.93	26.54	27.46
Aug.	26.77	28.30	29.20	25.53	26.17	27.27
Sep.	23.50	24.16	24.13	21.92	21.69	22.34
Okt.	18.32	19.43	19.45	16.16	16.85	17.35
Nov.	13.88	14.64	15.14	10.91	11.58	12.41
Dec.	10.13	11.18	11.64	6.60	7.47	8.30
Annual	17.50	18.51	18.74	15.57	16.04	16.66

According to the study of Papakostas (Papakostat et al., n.d) , the total cooling demands from the first to the third decade is 10.6% in Athens, whereas in Thessaloniki is 10.4%.

Many projects have been implemented in order to enhance the stability of the grid, however there are issues that still influence the normal operation of the grid at that days, such as the distance where the production of power is mainly realized (North Greece) in contrast to the area where the greatest part of load is gathered (region of Attica). In case other incidences also occur simultaneously at that day, for example a unit in a power plant factory to be set out of grid then blackouts may also happen (RAE, 2004). Another important issue in the stability of the energy grid relates to the fact that the majority of the cooling space devices are air conditioning systems in Greece, which consume reactive power besides active power. Reactive power is highly connected to the grid stability and more specifically to voltage stability of the system (Electrical Engineering Portal, 2011).

In Greece the guidelines for the construction and the full renovation of existing buildings, developed based on European standards, have been set in force under Ministerial Decisions and complete the Regulation for Energy Efficiency of Buildings, issued on 2010. The European standard EN 15251 on thermal comfort has already been taken into account to provide design conditions for each type of building during the design of a new building. Thus, it is considered that the adaptive comfort model should be used for the development of nZEBs, since thermal comfort is a major concept in the nZEBs. The comfort levels set through legislation in Greece refer to the combination of temperature and relative humidity during summer and winter time. The levels are different based on the use of the building. Thus, for example for the residences during winter time the defined temperature and relative humidity is 20oC and 40% respectively, whereas during the summer time the defined temperature and relative humidity is 26oC and 50% respectively. These values refer to the majority of the cases studied, whereas differentiations are detected in specific buildings, such as hospitals. Thermal comfort is also strongly related to fuel poverty. In Greece, due to the financial crisis fuel poverty indicators are quite high. The following Figure 3.3.3 present the situation in Greece in 2012.

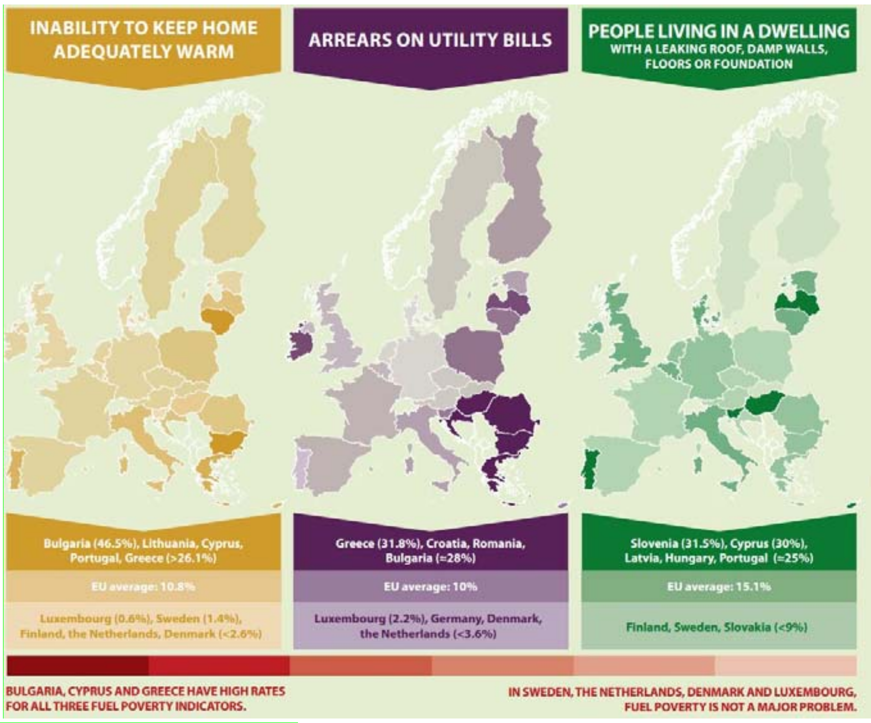


Figure 3.3.3: Fuel Poverty in Europe in 2012

Fuel poverty (BPIE, 2015) can have strong impact and may act as a barrier on the implementation of nZEBs. Therefore, the government already has provided a quite big amount of subsidy in order to enhance actions on the improvement of the energy efficiency of buildings. Another issue that should be taken into account and influences the thermal comfort in the southern European countries, such as Greece is the risk of overheating. Overheating refers not only to high temperatures in the inside of the buildings but also to a combination of lack of air movement and sustained exposure to high temperatures. Overheating is highly related to the insulation of a building as well as its airtightness, since improved airtightness and high insulation may lead to the retention of unwanted heat gains inside the building during the summer (NHBC Foundation, 2012). Both though factors are quite important for a nZEB, thus it is most important to highlight the necessity of proper insulation and ventilation design of the building. As mentioned beforehand, the climate of Greece, especially during summer, is characterized as hot and dry, thus cooling is a major factor for achieving thermal comfort. Passive cooling could be used in nZEBs, however it should be properly designed taking into account not only the building's characteristics but also the climate of the surroundings. Especially in urban areas passive cooling may not be as efficient as in rural areas and thus adequate for achieving thermal comfort inside the building, due to the effect of heat island. For instance, one way of implementing passive cooling is through natural night-time ventilation, which however would not be so effective in case the air temperature of the surrounding air during night remains high, which is the result of the effect of heat island, due to the type of construction materials and the great number of buildings. In Greece the majority of the population lives in urban areas thus active cooling in designing nZEBs in these areas may be imperative in order to achieve thermal comfort. The levels are proposed to remain the same as already stated in Greek legislation for the design of the buildings according to the Energy Efficiency Regulation.

According to the aforementioned, till now no indicators for renewables on the characterization of a nZEB have been provided for Greece. However, investing in renewables is not considered to be quite easy in Greece. The construction of buildings is mainly focused on multi-store buildings (block of flats) in urban areas, thus the implementation of renewables is not facilitated due to the available space and legislative obstacles. More specifically, the harvesting of the geothermal and solar thermal energy requires space which most of the times is not available. Regarding wind energy, the potential is not adequate for the wind energy to be effective in financial terms (e.g. payback period). Moreover, the potential is highly associated with the topography of the area and the obstacles that exist (e.g. buildings). Furthermore, there are yet legislative guidelines to be issued (Technical Chamber of Greece, 2014). CHP (Cogeneration Heat and Power) in Greece is not considered to be economically feasible for space heating due to short winter period, thus trigeneration (Power, Heat and Cooling) would be necessary for an economic operation (Small-scale CHP Factcheet Greece, 2007). For this operation an absorption chiller is mainly used. However, this application is effective mostly on tertiary buildings, in which there is great need in simultaneous production of electricity and heating/cooling. As a consequence, solar energy is mainly used as the most effective RES technology. However, barriers regarding the available space in urban areas still exist especially in multi-family buildings. Thus, the investment in energy efficiency might be easier to be achieved, taking into account the subsidy programs promoted by the government.

For a nZEB there should be a minimum threshold on energy production for onsite renewable sources, which is proposed to be 25%, following the indicators set by Cyprus. However, in case this minimum threshold cannot be achieved then it should be possible to be lower, but the interested person/owner should provide adequate justification (e.g. cost-benefit analysis based on the capabilities of the building) to support this request. Current policy and existing relevant regulation encourage the energy production in the building. However, legislation exists only for the implementation of PV installations through the net-metering scheme, whereas the legislation was defined on 2014 with the Greek Official Gazette 3583/2014. Regarding small-scale wind generation legislation is yet to be defined.

The energy grid of Greece presents some peculiarities. The continental grid consists of the interconnected electricity system, whereas in the majority of the islands a local grid system exists, based on diesel generators and RES, thus these islands are referred as non-interconnected islands. Consequently, regulations set defining the maximum power of the PV installations differentiated for each type of connection and taking into account the capability of each system. Especially in the non-interconnected islands, as well as in specific regions of interconnected system in which the grid is considered to be saturated (e.g. in regions of Evia) the maximum power to be installed in lower than in other regions. Also, studies have been conducted by RAE (Regulatory Authority for Energy) in order to examine whether the energy grid is capable of connecting RES and the pace that should be followed in order to achieve the targets set by European Directives for the reduction of CO_2 emissions and the enhancement of RES percentage in the energy grid (e.g. as per Technical University of Athens, 2011).

A major concern for the development of nZEBs in Greece is the construction quality of these buildings. Barriers have been identified in the market of high-tech components and new construction technologies but mostly in the know-how of professionals responsible for the design and construction of nZEBs. It should be mentioned that this lack has been observed in the southern European countries, thus a European-funded project initiated on March 2014 called "SouthZEB project" and aims to develop training material on proper designing of nZEBs and train professionals in the building sector in order to be capable of designing nZEBs, taking into account the climate and building regulations in each country. In the project the target countries in which it is estimated that 1500 professionals will be trained are: Greece, Italy, Cyprus and Portugal (http://www.southzeb.eu/el). In nZEB the use of high-tech components is crucial in order to achieve the minimum energy requirements, since they can provide higher efficiency, whereas low-tech nZEB solutions (e.g. RES technology) are quite difficult to achieve the targets of an nZEB. In order to address more efficiently high-tech components professionals in the design section should be properly trained, since these are the driving force for the implementation of high efficient buildings. Moreover, key-persons in rest positions, such as evaluators or policy-makers in order to enhance the financial support of energy efficiency measures. In Greece, as mentioned before, the main barriers of high quality nZEB construction is the gap in the know-how of the professionals at the design phase and the lack of investing interest mainly due to the lack of awareness in the general public. Furthermore, the real estate market, which affects the construction of new buildings in general has also shrunk considerably over the past years and is characterized by low demand, against a background of high rates of unemployment, heavy taxes on real property and a shortage of liquidity, thus posing a barrier in the construction of nZEBs in Greece (Bank of Greece, 2016).

What should be (your own recommendation) the minimum EE and RET in your country? (EE energy efficiency, RET Renewable Energy Threshold onsite):

Regarding the minimum EE and RET in Greece it is proposed to follow the indicators set by Cyprus, since no relevant data exists for Greece and no cost-optimal analysis has been implemented. It should also be noted that the heating and cooling energy is included in the primary energy defined as the maximum threshold for an nZEB, whereas it is not possible to provide separate indicators for these. Thus, it is proposed in the following Table 3.3.4:

Table 3.3.4: Minimum EE and RET threshold proposed for Greece (NEARLY ZERO ENERGY BUILDINGS DEFINITIONS ACROSS EUROPE FACTSHEET, BPIE 2015)

Country	EE Threshold (primary energy- kWh/m2a)		RET (% of primary energy)
	Residential	Non-residential	
Greece	100	125	25%

Based on the aforementioned proposal, it is clear that the thresholds set for energy efficient buildings (heating: 80 kWh/m^{2}a and cooling:80 kWh/m^{2}a) is satisfied as a sum.

Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.

- Athens – Climate Zone B (population: 3.218.218)[3]
- Thesaloniki – Climate Zone C (population: 789.191)
- Iraklio – Climate Zone A (population: 153.655)

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[3] Based on the population census conducted by Hellenic Statistical Authority in 2011.

3.4 ITALY

1. What is the minimum energy efficiency threshold for nZEB in your country?

In Italy, nZEB is defined as a building which has a better performance (in terms of energy needs for heating and cooling, total primary energy use - non-renewable primary plus renewable primary - ...) than a "reference (virtual) building" which has the same shape, function, window/wall ratio as the actual real one and properties (e.g. U value ...) as fixed in the law in the definition of the reference building. Moreover, some of the said properties of the reference building (e.g. U-value) depend on Surface/Volume, so there is no explicit fixed value in kWh/m^{2}y for being classified as an nZEB. Perceptual coverage of demand by renewables is set at about 50%

One indirect indication of the level of ambition of the definition comes by the fact that the reference U-values established by the law for the reference building are higher than those recommended for PH certification (0,15 W/m^{2}K) and there is no explicit requirement on air-tightness, hence the reference building results to generally have energy needs for heating higher than a Passivhaus.

An explicit target value which has been proposed for Italian climates is a total energy need (for heating and cooling) of 30 kWh/m^{2}y or less, with upper limits of 15 kWh/m^{2}y energy need for heating and 15 kWh/m^{2}y for cooling; these values have been shown to be achievable across the country by dynamic simulations e.g. in the EU Passive-on project (Pagliano et al., 2007) (http://www.eerg.it/passive-on.org/en/) on prototype buildings; and have been verified in actual buildings (see e.g. the 4 case studies proposed below, Table 3.4.1), via PHPP calculation (Pietrobon & Pagliano, 2014). Detailed monitoring is ongoing in some of those buildings and first data confirm the expected performances.

Table 3.4.1: Performances in terms of energy needs, primary energy use and renewable generation of representative nearly zero energy buildings in various Italian climates; Source: (Pietrobon & Pagliano, 2014).

Building	 *Progetti Botticelli* Mascalucia (Sicilia)	 *Villa del Sole* Lonato (Lombardia)	 *Coop Casa Brescia* Lonato (Lombardia)	 *Scuola Raldon* S.Giovanni Lupatoto (Veneto)
building type	single family house	single family house	multi family dwelling	public school
treated floor area**	150 m^2	140 m^2	560 m^2	1 503 m^2
energy need for heating **	11 kWh/(m^{2}y)	5 kWh/(m^{2}y)	13 kWh/(m^{2}y)	9 kWh/(m^{2}y)
energy need for cooling **	4 kWh/(m^{2}y)	9 kWh/(m^{2}y)	< 15 kWh/(m^{2}y)	< 15 kWh/(m^{2}y)
total primary energy use**	88 kWh/(m^{2}y)	96 kWh/(m^{2}y)	120 kWh/(m^{2}y)	< 120 kWh/(m^{2}y)
construction type	masonry	timber	timber and masonry	timber + concrete structural part
U_{wall} W/(m^{2}K)	0,13	0,11	0,11 – 0,15	0,11 - 0,22
U_{roof} W/(m^{2}K)	0,13	0,10	0,07	0,11
$U_{basement}$ W/(m^{2}K)	0,23	0,11	0,13	0,13
$U_{windows}$ W/(m^{2}K)	0,90-1,10	0,66-0,85	0,85	0,74-0,85

n_{50} [1/h]	< 0,60	0,27	< 0,60	< 0,60
ventilation system	mechanical ventilation with heat recovery and bypass for free cooling	mechanical ventilation with heat recovery and bypass for free cooling	mechanical ventilation with heat recovery and bypass for free cooling	decentralised mechanical ventilation with heat recovery and bypass for free cooling
solar thermal system	•	•		
PV system (primary energy production)	88 kWh/(m^{2}y)	89 kWh/(m^{2}y) 35 m^2 south faced	114 m^2 south faced 20 kW peak power	120 m^2 south faced 20 kW peak power
heating/cooling generation	heat pump (air to water)	heat pump (air to water)	heat pump (air to water)	heat pump (air to water)

** according to PHPP calculations

The above-mentioned case studies show that the PassivHouse standard (in its extended version which includes the energy needs for heating and for cooling) can be reached in Italy. This target is not included (at least explicitly) into the recent Italian regulation about new NZEB. On the other hand, there are some parts of *Decreto 26 giugno 2015* which push for a significant reduction of energy use:

- There are limits on total primary energy (non-renewable primary plus renewable primary, that is including primary energy content of renewables)
- Renewables exported to the grid do not count in the calculation of net yearly primary energy, and the calculation has to be done on a monthly basis (i.e. the designer cannot use summer overproduction to compensate for winter use; compensation is electricity for electricity, heat for heat...). So, a model of building with poor envelope (large energy needs) and oversized renewables to compensate for the large energy needs is not encouraged. This can be expressed by setting the parameter k_{exp} of EN ISO 52000 to zero.
- The Energy Performance Certificate should present both the global primary energy performance and the performance of the building envelope towards winter (energy needs) and summer conditions (prescriptions on thermal mass per square meter of facade or periodic thermal transmittance of facade and roof, total solar transmittance (g value) of the combination of windows and solar shading).

The requirements for a retrofitted building to be labelled as NZEB are essentially the same as for a new building according to the the *Decreto 26 giugno 2015*.

2. What is the Heating-Cooling balance for nZEB in your country?

The heating and cooling demand balance is very important for high performance buildings. In cooling or heating dominated climates, building designer seek through bioclimatic and passive strategies to deal with *only one active conditioning system* to reduce cost and achieve maximum possible comfort. However, in warm South European climate this balance is sometime symmetric. The implications of a symmetric or quasi symmetric balance lead to dual *active conditioning* systems with thermal and electric demand and can have a large *impact* on the energy supply networks. In warm South European warm climates, reaching low heating energy efficiency thresholds, e.g. 15 or 30 kWh/m².a, can be met more easily than in cold ones. It is then possible to reduce heating needs even though various design parameters are not optimal (shapes, orientations, window sizes, performance of components, etc.). It may be interesting to aim at "zero energy heating" targets to achieve the savings optimum.

Since energy need for heating as defined in EN and ISO standards, e.g. En ISO 52000:2017 corresponds to transmission and ventilation losses minus solar and internal gains (see Figure 2.1), it is unlikely to keep those exactly to zero, since both losses and gains depend on weather and occupants, besides design and construction choices. In the Italian climates they might be reduced to a level significantly below 15 kWh/m^{2}y (obviously on average, e.g. monitoring a number of

buildings you might have an average of 8 kWh/m^2y, with some buildings having higher, others having lower values, and varying year by year).
The reduction of energy need for heating to values lower that the 15 kWh/m^2y required by the PH standard may be achieved in Italy via:

1) reduction of transmission and infiltration losses to very low values (e.g. similar prescriptions as in center - northern EU) by high performance thermal insulation and air tightness (e.g. n50 in the range 0,6 to 1,0)
2) heat recovery on mechanical ventilation,
3) accurate use of winter solar gains via the – correctly sized – glass openings on southern facades; this requires a very careful design of fixed and/or movable shading The Italian traditional "persiana" with the variant that allows lifting the lower part (persiana Genovese) is well suited to allow the entrance of diffuse light while blocking direct radiation and are robust and require low maintenance (Figure 3.4.1).
4) preheating of air via ground exchange, where conditions allow for this.

Figure 3.4.1: The Italian traditional "persiana" with the variant that allows lifting the lower part ("persiana genovese")
http://mojour.blogspot.it/2012_06_01_archive.html
https://www.flickr.com/photos/woodycheese/28880803044/

This could then make it possible to reach low heating demand values around 5 kWh/m^2.a in the case of Mediterranean climates. However. a 15 or 30 kWh/m^2.a for cooling can be more difficult due to high solar radiation and high outdoor ambient temperature in warm cities.

As for summer in the Italian climates it is generally a very effective cooling strategy to ventilate at high rates (in the order of 5 to 10 ach) during summer nights, when external temperature is relatively low. During the day in summer, air temperature is higher outdoor than indoor (unless solar gains are badly controlled), and hence both voluntary ventilation and involuntary air-infiltration are adding to the cooling energy need; hence they are to be avoided as much as possible. Good air-tightness levels between have been found effective for energy and comfort performance, with levels of n50=0,6 in the northern regions and higher elevations and n50=1 in southern regions (Pagliano, et al., 2007 and Causone et al., 2014). Moreover, good air-tightness is necessary for prevention of moisture penetration and control of condensation risks.

In a building with sufficient thermal mass, night ventilation and effective solar protections, air temperature indoor tends to the daily average outdoor value (e.g. if minimum temperature is 20 °C maximum is 32 °C, indoor tend to 26 °C). Hence during the hot hours of the day infiltration and opening of windows are bringing indoor undesired energy and the building should be possibly kept completely closed to external air. This is only apparently contradictory with the idea of openness which is often attached to southern architecture. It has been long time customary in Italy to close all windows and solar protections during the hot hours of midday and let them largely open when external air is cool.

In the case that, due to internal gains from people and appliances and uncontrolled solar gains the indoor temperature would result to be higher than outdoor even during the day, and effective response would be to increase ventilation (either natural or mechanical) since the transfer of energy via the walls would be much slower, much smaller and much more uncertain.

If present, the same ground exchanger used for preheating in winter may be used for daily ventilation with precooled air during hot days in summer.

As for noise issues connected with night ventilation, one must distinguish between commercial and residential buildings. In commercial/service buildings occupation is concentrated in the daytime, hence night natural ventilation via windows or specialized openings does not pose any problem connected to exposure to external noise, e.g. in active urban areas. In residential buildings for rural and quiet urban areas natural ventilation is normally practiced in Italy and could be ameliorated by improvements of the openings with simple means to take into account protections from intrusion and insects. Examples of architecturally well designed anti-intrusion barriers are present in traditional architecture in Italy and other southern countries. In active urban areas night natural ventilation might be substituted by mechanical ventilation (designed for low Specific Fan Power (SFP) and with carefully designed low-noise diffusion terminals and dust filtering). The alternative solution, air conditioning, poses the same noise control challenges as mechanical ventilation and is much more power intensive.

Italy shows a variety of mountain, coastal and plane environments extending 1 500 km from North to South and hence it is subject to considerable different climate conditions. Italian legislation (law 10/91) identifies six official winter climate zones based on heating degree days (HDD) from the warmest Zone A (HDD < 600) to the coldest Zone F (HDD > 3 000) (Fig. 3.4.4).

Even though the climate variety is very remarkable also during the summer period, Italian legislation presently don't give a detailed subdivision of the territory in summer climate zones. The only parameters for which minimum requirements are differentiated by climate are thermal mass (or alternatively periodic thermal transmittance) for which more stringent requirements are imposed by the law for locations where the average horizontal solar irradiation is higher than 290 W/m2 during the month of maximum irradiance. In order to fill this gap, one can refer to a CNR proposal which, in 1990, identified seven summer climate zones (from the coldest one, n. 7, to the hottest, n. 1, Fig. 3.4.3). CNR analyzed the main climate local parameters (relative humidity, wind speed, air temperature and solar radiation). Below is shown the variety of dry bulb temperature and the main climate features in four cities in Italy: Milano, Roma, Palermo and Foggia (Fig. 3.4.2 and Tab. 3.4.2).

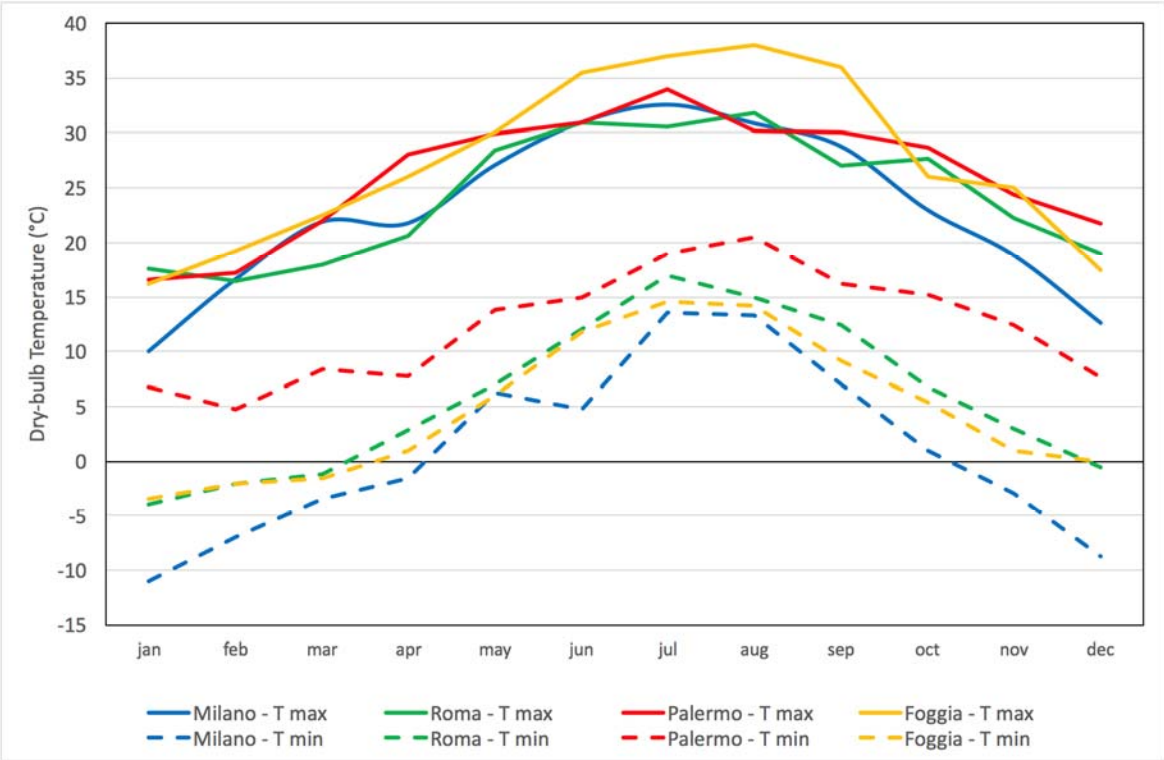


Figure 3.4.2: Dry bulb air temperature of the considered climates, Source: STAT files of IWEC (Milan, Rome, Palermo) and IGDG (Foggia), elaboration by the authors.

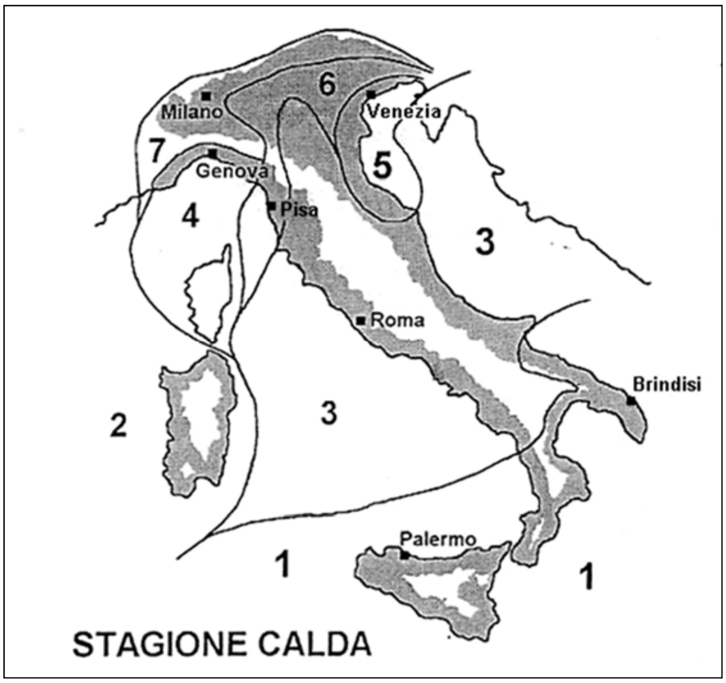


Figure 3.4.3: Classification of summer climate in seven zones (excluding mountains) proposed by the National Research Council (Source CNR 1985)

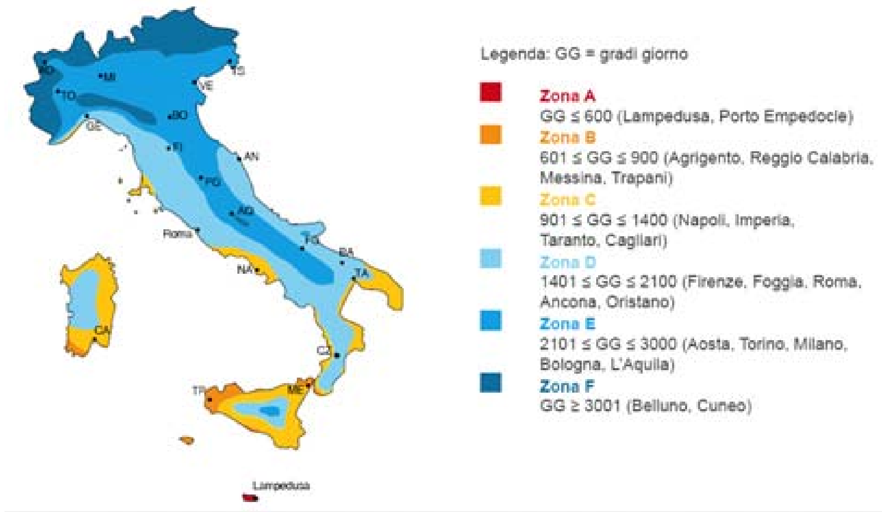


Figure 3.4.4: Classification of winter climate in six zones by Italian legislation (D.P.R. 412/93) GG= Gradi Giorno or Heating Degree Days (HDD)

Table 3.4.2: Features of the considered climates in the main cooling period (from1/June to the 31/August) Source: STAT files of IWEC (Milan, Rome, Palermo) and IGDG (Foggia), elaboration by the authors.

City	**Summer Climatic Zone (CNR)**	**Mean Hourly Air Temperature** [°C]	**Max Hourly Air Temperature** [°C]	**Mean Daily Range of Temperature** [°C]	**Mean Wind Speed** [m/s]	**Mean Relative Humidity**
Milan	7	21,7	32,6	8,9	1,0	71%
Rome	3	23,3	31,8	7,5	3,3	75%
Palermo	1	25,1	34,0	4,0	3,3	74%
Foggia	3	23,9	38,0	11,7	3,3	58%

The EU Thermo Project did perform a parametric analysis about the influence of several parameters on summer comfort under various Italian climatic conditions by dynamic simulation of a large office building (Table 3.4.3) (Pagliano & Zangher, 2010; EU IEE funded Thermco project). Comfort over the summer season was evaluated by calculating PPD weighted index value (method C of EN15251) of each office room and summing it up for the entire building, for each building variant.

Table 3.4.3: Parametric analysis about the influence of several parameters on summer comfort under various Italian climatic conditions by dynamic simulation of a large office building

Key Action		Variation			
Thermal Insulation (U-value), **Uv** and air permeability **(AP)**	o	Italian New (DGls 311)	Roof (Rome)	0.36	W/m2K
			Wall (Rome)	0.32	W/m2K
			Basement (Rome)	0.36	W/m2K
			Window (Rome)	2.4	W/m2K
			Air Permeab	5	m3/h/m2
	+	SIA Refurbishment: target values	Roof	0.2	W/m2K
			Wall	0.2	W/m2K
			Basement	0.2	W/m2K
			Window	1.2	W/m2K
			Air Permeab	0.5	m3/h/m2
Solar Factor, **SF**	-	Existing typical	Façade N	-	-
			Façade NE-NO	0.7	-
			Façade E-SE-S-SO-O	0.7	-
	o	Medium	Façade N	-	-
			Façade NE-NO	0.4	-
			Façade E-SE-S-SO-O	0.4	-
	+	SIA Refurbishment	Façade N	-	-
			Façade NE-NO	0.27	-
			Façade E-SE-S-SO-O	0.15	-
Thermal Mass, **TM**	-	Low Internal Thermal Mass	External Wall	4.0	Wh/m2K
			Ceiling	11.0	Wh/m2K
			Floor	4.1	Wh/m2K
			Internal Wall	2.3	Wh/m2K
			TOTAL	20	Wh/m2K
	o	Medium Internal Thermal Mass	External Wall	15.4	Wh/m2K
			Ceiling	18.6	Wh/m2K
			Floor	12.7	Wh/m2K
			Internal Wall	8.9	Wh/m2K
			TOTAL	50	Wh/m2K
	+	High Internal Thermal Mass	External Wall	15.4	Wh/m2K
			Ceiling	22.1	Wh/m2K
			Floor	22.4	Wh/m2K
			Internal Wall	18.8	Wh/m2K
			TOTAL	80	Wh/m2K
Natural Ventilation, **NV**	-	No ventilation	% openings / window area	0%	-
	o	Medium ventilation	% openings / window area	25%	-
	+	Large ventilation	% openings / window area	50%	-

Parameters where varied one at a time, while the remaining parameters were kept constant. Combinations that physically make little sense (e.g. insufficient solar protections, no night ventilation and high thermal insulation) were excluded. In this way it was estimated the maximum (i.e. for good combinations) effect of each parameter on improvement of comfort conditions. The following graph (Figure 3.4.5) summarizes the percentage of discomfort reduction compared to the baseline due to variations of each parameter.

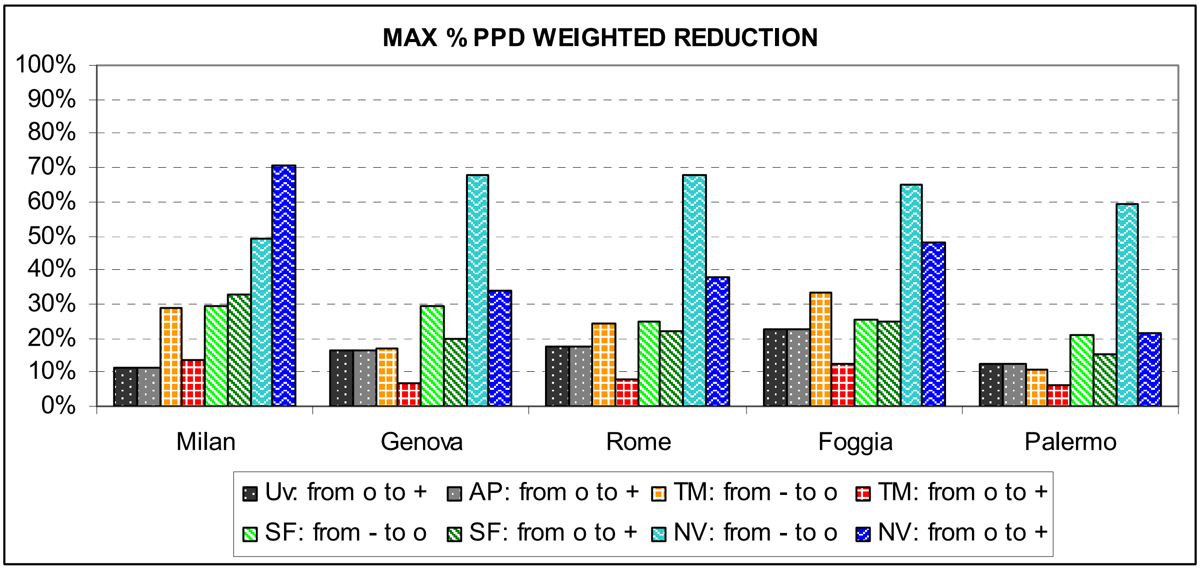


Figure 3.4.5: highest discomfort reductions, evaluated by PPD weighted criteria (method C of EN15251).

The synthesis in Figure 3.4.5 can suggest some observations.

- Night natural ventilation has a large effect in improving comfort thermal conditions in all climates. The percentage amelioration over baseline is higher in the climate of Milano which has the minimum summer night temperatures, and lower in Palermo which has a small day-night temperature swing
- Increasing thermal insulation and decreasing the envelope air permeability has positive effects on summer indoor comfort conditions, except when thermal insulation isn't combined with solar gain reduction (solar protection of transparent surfaces) and particularly with an adequate ventilation strategy.
- Solar protection of transparent surfaces is beneficial in all climates.
- Increasing Thermal mass gives benefits in all climate locations. In locations with low day-night temperature excursion, like Palermo, the influence of thermal mass is less pronounced.

The above simulations have been performed on a large office building and the thermal insulation levels have been chosen as uniform over all opaque surfaces. For small rise buildings (1 -2 floors) in southern regions (e.g. Sicily) multi-objective optimization based on dynamic simulation (Causone et al., 2014 and Carlucci et al., 2015) shows the effectiveness of differentiating the insulation level (higher on roof and walls, lower on basement) in order to take profit in summer of a certain level of thermal coupling with the soil without excessive penalization in winter (soil temperature being more stable than air). The ongoing growth of average and peak temperatures in summer in the southern parts of the country and also in the planes and valleys of the north (Po valley and some low-level valleys in the Alps), the loss of some traditional solar protection practices of the past, the growing installed power for air-conditioning, are producing relevant consequences e.g. the shifting of the peak load of the electric system from winter to summer (see Figure 3.4.6).

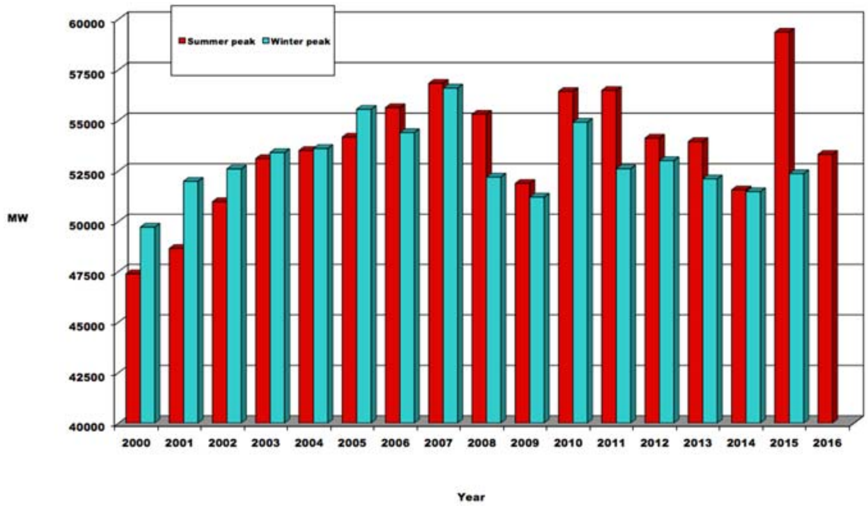
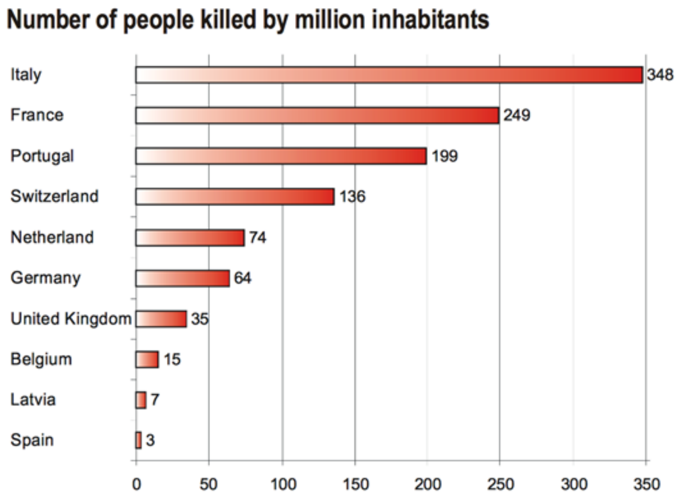


Figure 3.4.6: Evolution of peak electricity demand in summer and the shift from winter-peaking to summer-peaking (Source Terna – manager of Italian electricity grid - http://www.terna.it/en-gb/sistemaelettrico/statisticaldata.aspx; elaboration by the authors)

Extended or local black-out has taken place in occasion of heat waves. In 2003 a heat wave took place during a long dry summer, with very low water level in the rivers, which forced the shutdown of many thermal power plants due to the difficulty of cooling the condensing exchanges. The stress on the system and the service to users was very high. The health consequences of the combination of high temperature and low-quality building envelopes (see Figure 3.4.7) were quite heavy with 20000 deaths (United Nations, 2003; Robine et al., 2008).



Number of people killed

Italy	20000
France	14947
Germany	5250
United Kingdom	2045
Portugal	2007
Netherland	1200
Switzerland	975
Belgium	150
Spain	141
Latvia	15
total	46730

UN/ISDR - Information group
Data Source: EM-DAT : The OFDA/CRED International Disaster Database.
Www.em-dat.net, UCL - Brussels, Belgium
Istituto Nazionale di Statistica - Swiss Federal Statistical Office
Map Source: NASA's Earth Observatory, July 31, 2003

Figure 3.4.7: Number of people killed due to heat waves by million inhabitants

The high electricity demand in summer is poised to grow in the decades to come, unless significant improvements of the envelope of existing buildings and passive cooling measures for buildings and cities are taken up. Simulations performed to analyses the performance of the zero energy retrofit of a school in Milano, show the extent of the shift to be expected from energy needs for heating to energy needs for cooling, even in high performance buildings (see Figure 3.4.8).

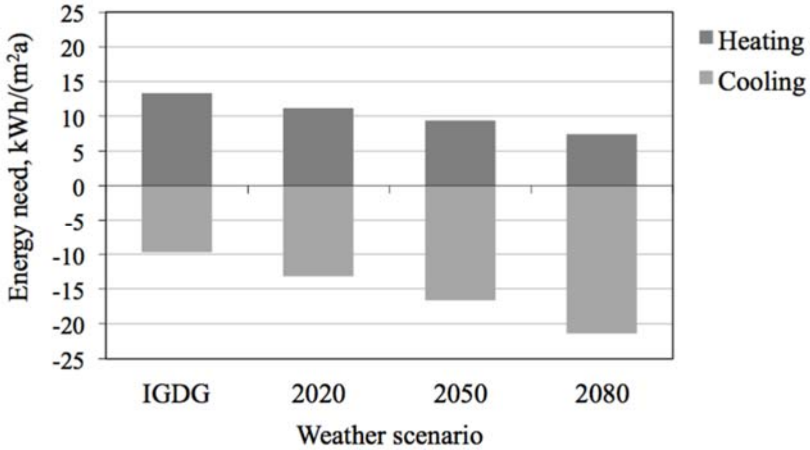


Figure 3.4.8: Evolution of yearly energy need for heating and cooling (per unit floor area) as a consequence of expected climate changes in Milano, for zero energy retrofitted school; source: (Pagliano et al., 2016).

What is the Thermal comfort limits for nZEB in your country?

In Italy the diffusion of mechanical compression cooling in the residential sector started relatively late compared to other countries and is still relatively low; according to the national Statistical Office (ISTAT) 7 out of 10 families don't have less air conditioning and part of the installations are single room mobile air conditioning units. Use of solar protections, night ventilation, clothing adjustment are still prevailing to achieve summer comfort to the extent allowed by the specific building fabric, with older massive buildings preforming better than some of the apartment blocks built in the 60' and 70' with poor envelope features. The latter would need retrofit actions to increase thermal insulation, air tightness, solar protections and night ventilation capabilities (with sound protection features in part of the cities; sound protection would not generally be required in office buildings).

In most climates, with good envelope features it would be possible to achieve adequate comfort according to the adaptive model. As an example a single family house (Fig. 3.4.9) located in Mascalucia (Sicily) in the zone 'Csa' characterized by a temperate climate with dry summer, also called Mediterranean climate, has been designed using an automated optimization procedure, consisting in (i) in identifying the design parameters of the building to be optimized, (ii) in identifying the options for every design parameter, (iii) in running the dynamic energy simulations of the building in free-floating mode via EnergyPlus, (iv) in driving the selection of the design parameters via an optimization engine (Carlucci et al., 2013).

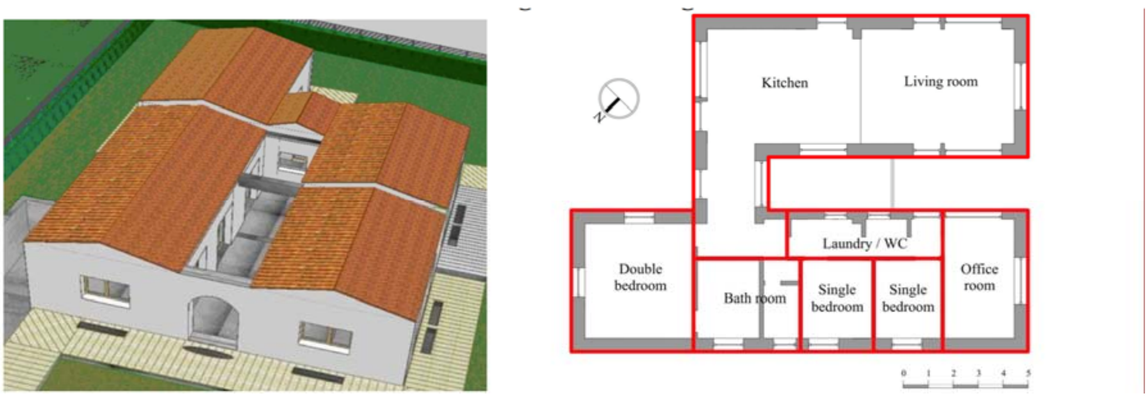


*Figure 3.4.9: **Left** Three-dimension model, **Right** plan and indication of thermal zones of the house*

The optimization engine GenOpt release 3.1.0 was used to minimize specified seasonal thermal discomfort objectives. The Long-term Percentage of Dissatisfied (LPD) in the ASHRAE Adaptive version was used to quantify predicted long-term thermal discomfort by a weighted average of discomfort over the thermal zones and over time. This index, calculated for both summer and winter, constitutes the two objective functions of the optimization problem.

The optimization procedure identified an optimal solution that provides both winter and summer aforementioned Long-term Percentage of Dissatisfied lower than 10% when the building is in free-running mode during the whole year. The optimized building has walls, roof and windows with very low thermal transmittance (high insulation thickness) and is air tight, to the Passivhaus level (it is in fact Passivhaus certified). Additionally, it has good movable solar protections, window openings allowing reasonably good night ventilation and an air to earth heat exchanger for precooling ventilation air during the day. This optimal building variant, in free-floating mode, offers indoor operative temperatures compatible with the 80% acceptability class of the Standard ASHRAE 55; only few exceedances occur outside the Adaptive comfort zone defined in such standard (Fig. 3.4.10, Left). When conditioned (Fig 3.4.10, right), the energy need for heating is 11 kWh and for cooling 4 kWh. Lower performances are expected if the building would be located at sea level rather than at 400 m altitude.

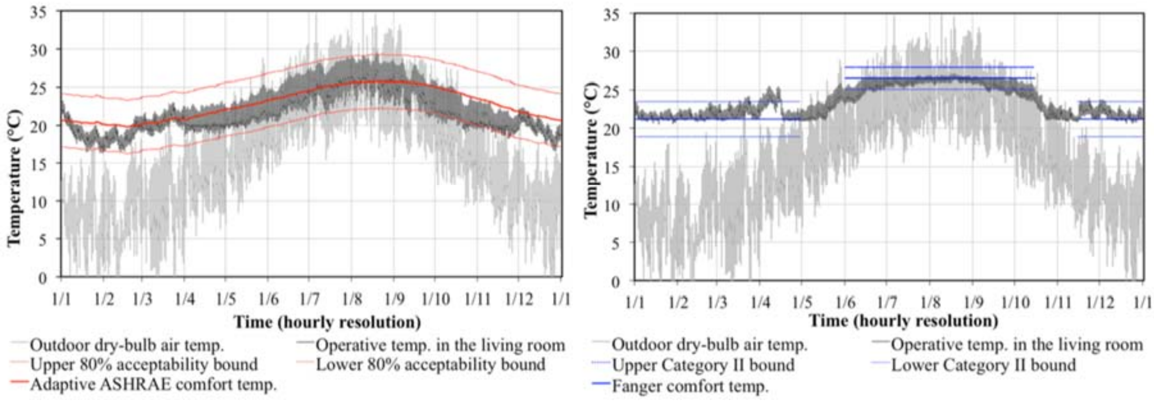


Figure 3.4.10: Operative temperature profiles inside the living room (Left) in free-floating mode compared with the 80% acceptability range of the ASHRAE Adaptive model and (Right) in conditioned mode compared with the Category II range of the Fanger model.

Data monitoring in 2015 (by eERG of Politecnico di Milano) confirm that adaptive comfort is achieved in free floating mode thanks to the envelope features (the ground exchanger seldom used during summer 2015); see Figure 3.4.1:

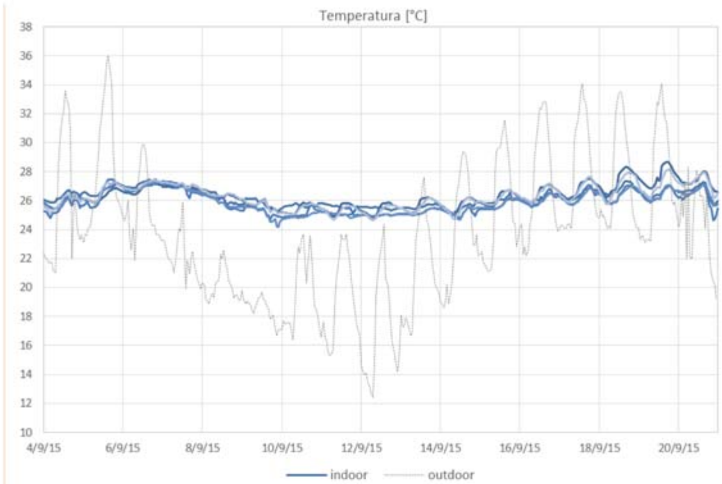


Figure 3.4.11: Monitored outdoor air temperature and indoor air temperature in various rooms in the Botticelli house in Mascalucia in September 2015. Source: eERG of Politecnico di Milano, unpublished data.

This case study shows that high thermal insulation in combination with solar protection and night ventilation allows reaching good comfort performances in free-floating mode (Fig. 3.4.14, Tab. 3.4.4). Active cooling might be used, if deemed necessary, only in a limited number of days in which night temperatures remain elevated. A better use of the ground exchanger during the day would still improve the situation. During cool nights night ventilation if not properly controlled would even "undercool" a building below the adaptive comfort range (or bring it fully within the Fanger comfort range, Fig.3.4.13), as shown in Figure 3.4.12 (Pagliano & Zangheri, 2010).

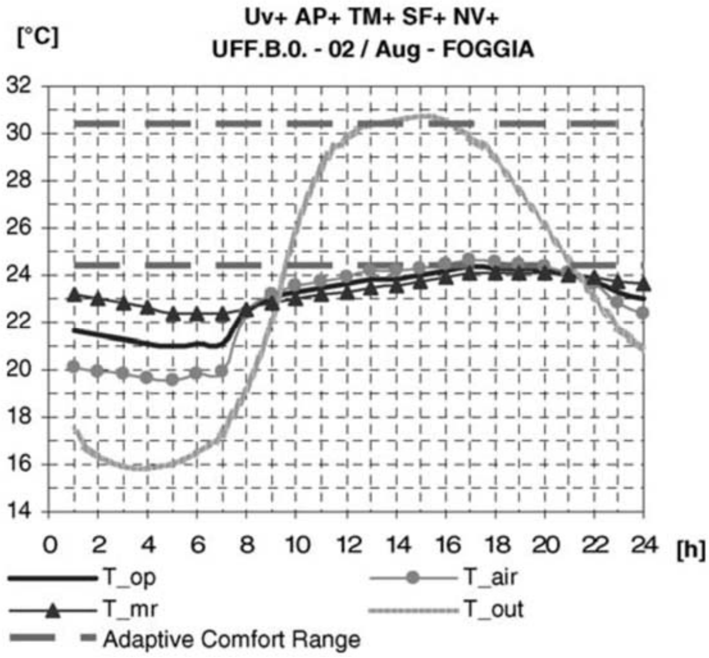


Figure 3.4.12: A large office building simulation in the climate of Foggia (Puglia). A good envelope with high thermal insulation, solar protections and high levels of night ventilation. Source (Pagliano & Zangheri, 2010).

Fuel poverty is an issue in Italy, where part of the population lives in dwellings with poor envelope performance and can't afford air conditioning installation and use, as shown by the summer 2003 death toll. The retrofit of the envelope of low performance part of the building stock would need hence a public support scheme. The white certificate scheme in place allows accounting for energy savings accrued in an 8-year period, while an envelope retrofit has positive effects for various decades; hence the economic incentive is insufficient to promote action. Tax deductions of 50 to 65% are also available but not clearly defining summer performances, not tightly related to performances, and lacking a reliable verification process. Both mechanisms should be improved in order to significantly promote deep renovation of a significant fraction of the building stock.

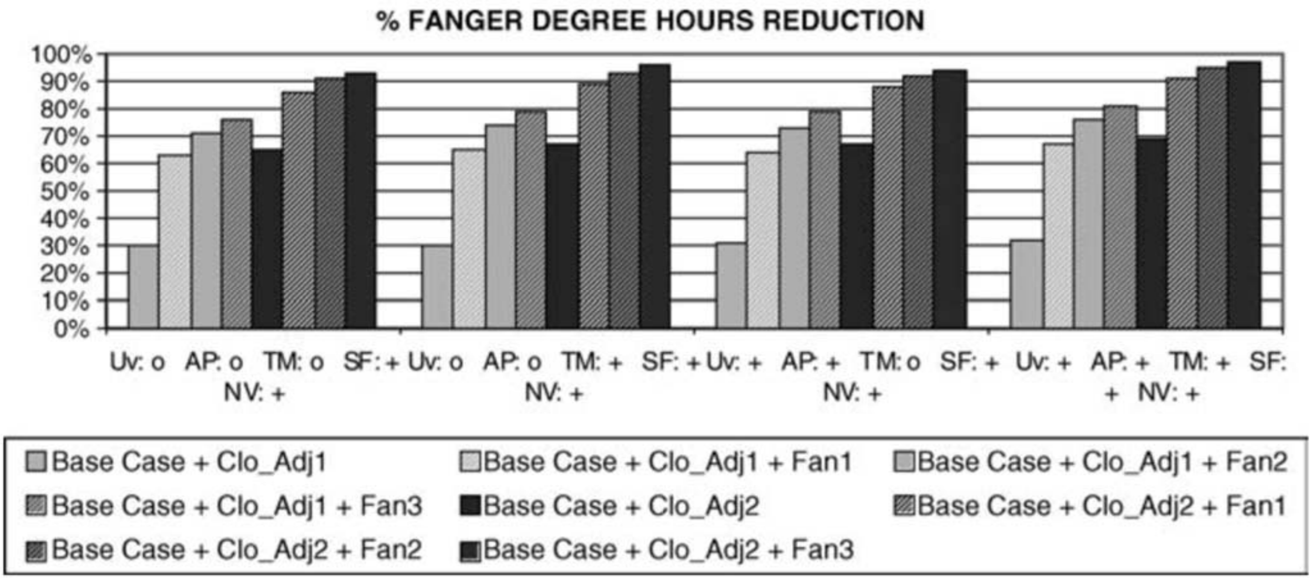


Figure 3.4.13: Calculated reductions from base cases in the value of the index degree hours (method B) in the Fanger variant, as a consequence of changes in total insulation value (from 1.0 to 0.85 and 0.65 clo) and air velocity (from 0.1 to 0.4, 0.6 and 0.8 m/s)

Table 3.4.4: Comfort set points

SIM.	T_{op}	R.U.	v	PMV	clo	met
	°C	%	m/s	-	-	-
Optimal combination	26	60	0.01	0.5	0.5	1.2
Case 1	25.7	70	0.01	0.5	0.5	1.2
Case 2	27.3	70	0.5	0.5	0.5	1.2
Case 3	27.6	60	0.5	0.5	0.5	1.2

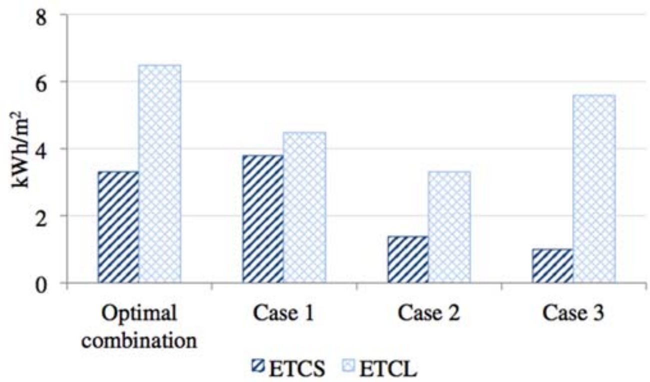


Figure 3.4.14: Influence of Comfort set point

NZEB Polimi IBPSA UK shows influence of type of comfort on energy consumption

3. What is the minimum renewables threshold for nZEB in your country?

Renewables are more visible and backed from a more concentrated industry. Construction industry involved in envelope retrofit is highly fragmented. Intervening on plants is less complex than intervening on envelope, in occupied buildings. There is already an obligation (roughly 50% onsite for nZEB). Italian legislation is struggling for the step of moving towards low energy and nZEBs (e.g the incentives for retrofit called Conto Termico were utilized only to a tiny fraction of few %; a new version of Conto Termico has just been issued and its effectiveness hopefully ameliorated). No explicit provision for positive energy buildings is explicitly in place.

4. What is the construction quality for nZEB in your country?

Low tech
Training, lack of public investments in training and controls
Hence difficulty for building owners to find a reliable infrastructure

5. **What should be (your own recommendation) the minimum EE and RET in your country?** (EE energy efficiency, RET Renewable Energy Threshold onsite):

The following table (Table 3.4.5) shows the EE and RET thereshold for Italy:

Table 3.4.5: Different Minimum Performance Thresholds for nZEB

Italy (recommend by authors based e.g. on Passive-on study and recent retrofirt case studies)	Energy need for heating	Energy need for cooling
RES threshold onsite 50%	15 kWh/m2 y	15 kWh/m2 y

6. **Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.**

Milan

- Area (total) 181,76 km2
- Elevation 120 m
- Population (31 December 2015)
    - Total 1 359 905
    - Density 7 500/km2

Milan has a humid subtropical climate (Cfa), according to the Köppen climate classification, or a temperate climate (Doa), according to the Trewartha climate classification. Milan's climate is similar to much of Northern Italy's inland plains, with hot, sultry summers and cold, foggy winters. However, the mean number of days with precipitation per year is one of the lowest in Europe. The Alps and Apennines mountains form a natural barrier that protects the city from the major circulations coming from northern Europe and the sea.
Source and more info: https://en.wikipedia.org/wiki/Milan#Climate

Rome

- Area (total) 1 285 km2
- Elevation 21 m
- Population (2014)
    - Density 2 232/km2
    - (City) 2 869 461
    - Metropolitan area 4 321 244

Rome enjoys a hot-summer Mediterranean climate (Köppen climate classification: Csa), with cool, humid winters and hot, dry summers.
Source and more info: https://en.wikipedia.org/wiki/Rome#Climate

Palermo

- Area (total) 158,9 km^2
- Elevation 14 m
- Population (31 January 2013) (total)
    - 676 118 (city)
    - 1 300 000 (metro)

Palermo experiences a hot-summer Mediterranean climate (Köppen climate classification: Csa). Winters are cool and wet, while summers are hot and dry. Temperatures in autumn and spring are usually mild. Palermo is one of the warmest cities in Europe (mainly due to its warm nights).
Source and more info: https://en.wikipedia.org/wiki/Palermo#Climate

Foggia

- Area (total) 507 km^2
- Elevation 76 m
- Population (31/12/2013)
    - Total 153 143
    - Density 300/km^2

Source and more info: https://en.wikipedia.org/wiki/Foggia

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3.5 PORTUGAL

1. What is the minimum energy efficiency threshold for nZEB in your country?

The Portuguese regulation (Portugal, 2015). has been adapted with the EPBD recast updates and presents a definition for nZEB in which a nZEB building is a building that uses the cost-optimal solutions for the envelope and where the renewable energy harvested on-site or nearby is used to fulfil a significant part of the remaining energy needs. Additional information regarding the meaning of "on-site or nearby" and "a significant part" is still lacking.

The cost-optimal value of the primary energy use for heating, cooling and domestic hot water preparation for new residential buildings is 33kWh/m^2.y, as calculated in 2014 (Ferreira et al., 2014). This value is a weighted average for all the new residential buildings in Portugal, considering single and multi-family buildings and all the climate zones.

As the definition of nZEB building is not yet fully defined, the current regulation does not present any specific requirements for this kind of rehabilitation and there are no specific renovations towards nZEB. Regarding the interventions on the existing building stock, if a renovation is considered a major renovation, it has to comply with the same requirements of the new buildings.

PassivHaus Standard is not considered to become a reference in Portugal mainly because of its dependence on mechanical ventilation with heat recovery and high airtightness of the building envelope. Both these requirements are not usual due to a strong cultural habit of using natural ventilation and open doors and windows to promote a connection between internal spaces and the exterior, at least in residential buildings. Additionally, because of mild winters in a significant portion of the country, the investments for these requirements are most of the times not cost-effective.

Nevertheless, some examples of passive houses in Portugal have been built during recent years, certified by the Passive House Institute (Figure 3.5.1 and Figure 3.5.2).

Figure 3.5.1: Passive House in Ílhavo, Rua do Mar - House B, certified in 2012

Figure 3.5.2: Passive House in Costa Nova, certified in 2016

2. **What is the Heating-Cooling balance for nZEB in your country?**

The heating and cooling demand balance is very important for high performance buildings. In cooling or heating dominated climates, building designer seek through bioclimatic and passive strategies to deal with only one acclimatization system to reduce cost and achieve maximum possible comfort. However, in warm South European climate this balance is sometime symmetric. The implications of a symmetric or quasi symmetric balance lead to dual acclimatization systems with thermal and electric demand and can have a large impact on the energy supply networks. In warm South European warm climates, reaching low energy efficiency thresholds, eg. 15 or 30 kWh/m².a, can be met more easily than in cold ones. It is then possible to reduce heating needs even though various design parameters are not optimal (shapes, orientations, window sizes, performance of components, etc.). It may be interesting to aim at "zero energy heating" targets to achieve the savings optimum. This could then make it possible to reach low heating demand values around 5 kWh/m².a in the case of Mediterranean climates. However, a 15 or 30 kWh/m².a for cooling can be more difficult due to high solar radiation, building envelope airtightness, high thermal mass and high outdoor ambient temperature in warm cities. Moreover, increasing infiltration level, in contrast to heating demand, reduces cooling demand. In contrast to central and north European countries, which require maximum air tightness levels, NZEBs in warm climates should not be fully airtight.

Mainland Portugal, between latitudes 37° and 42°N, is located in the transitional region between the sub-tropical anticyclone and the sub polar depression zones. The most conditioning climate factors in mainland Portugal are, in addition to latitude, its orography and the effect of the Atlantic Ocean. As regards altitude, the highest values are between 1000 m and 1500 m, with the exception of the Serra da Estrela range, which peaks are just below 2000 m. As regards continentally, the regions furthest from the Atlantic Ocean are around 220 km away.

In spite of the fact that the variation in climate factors is rather small, it is still sufficient to justify significant variations in air temperature and, most of all, in precipitation. While the northwest region of Portugal is one of the wettest spots in Europe, with mean annual accumulated precipitation in excess of 3000 mm, average rain amounts in the interior of the Alentejo (southeast) are of the order of 500 mm and show large inter-annual variability.

The spatial distribution of the mean annual air temperature, based on observations made during the 1961-1990 period, vary between 7°C in the inner highlands of central Portugal and 18°C in the southern coastal area. The mean monthly air temperature values vary regularly during the year, reaching their maximum in August and minimum in January.

The average minimum temperature in winter varies between 2ºC in the mountainous interior zone and 12ºC in the Algarve (south coast) (Figure 3.5.3_A). In summer, the mean values of maximum temperature vary between 16ºC in Serra da Estrela and 32-34ºC in the inner Central region and eastern Alentejo (Figure 3.5.3_B).

The number of days of the year with a minimum temperature below 0°C ("frost days") reaches a peak in the highlands of the northern and central interior, with more than 100 days/year, and is nil in the western coastal and southern zones (Figure 3.5.3_C). The number of days with minimum temperature above 20ºC ("tropical nights", Figure 3.5.3_D) and maximum temperature above 25ºC ("summer days", Figure 3.5.3_E) and above 35ºC ("hot days", Figure 3.5.3_F) is higher in the inner centre of the country, the eastern part of Alentejo and the seaside Algarve (Miranda et al., 2002).

From the described data, it is possible to understand that the effect of the Atlantic Ocean and the orography in the north, significantly attenuate the temperatures during summer, reducing the cooling needs when compared with many other Mediterranean regions. Therefore, with the exception of the interior of the Alentejo which is a heating and cooling zone, the mainland Portugal is heating dominated.

In Portugal, some experiences with passive solar buildings have been done, at least since the 70's of the twentieth century, experiencing the combination of a good orientation, good insulation level, south facing glazing and the use of some passive solar system (direct gain, massive walls, Trombe walls, sunspaces) and cooling strategies (solar protection, movable or fixed shading devices, cross and night ventilation, and ground and evaporative cooling) (Gonçalves et al., 1998). Since these first experiences, it became clear that it is possible to reduce to a very significant extent the heating demand. Although, the reduction of the heating demand beyond a certain level implies the use of techniques that increase the cooling demand and increase the risk of overheating. So, a careful balance between the two types of measures (reducing heating and cooling demands) has to be made.

Additionally, in projects SIAM, SIAM_II and CLIMAAT_II (Santos et al., 2002; Santos & Miranda, 2006; Santos & Aguiar, 2006), the climate change scenarios for Portugal were analyzed using simulations of climate models and for the period 2080-2100 is predicted an increase in the maximum temperature in summer on the mainland, between 3 ° C and 7 ° C in the coastal zone and in the interior, accompanied by an increased frequency and intensity of heat waves. The increases mean a larger number of hot days (maximum exceeding 35 ° C) and tropical nights (minimum above 20 ° C), while decreases are expected in indices related to cold weather (eg., less days of frost or days with lower minimum temperatures around 0 ° C).

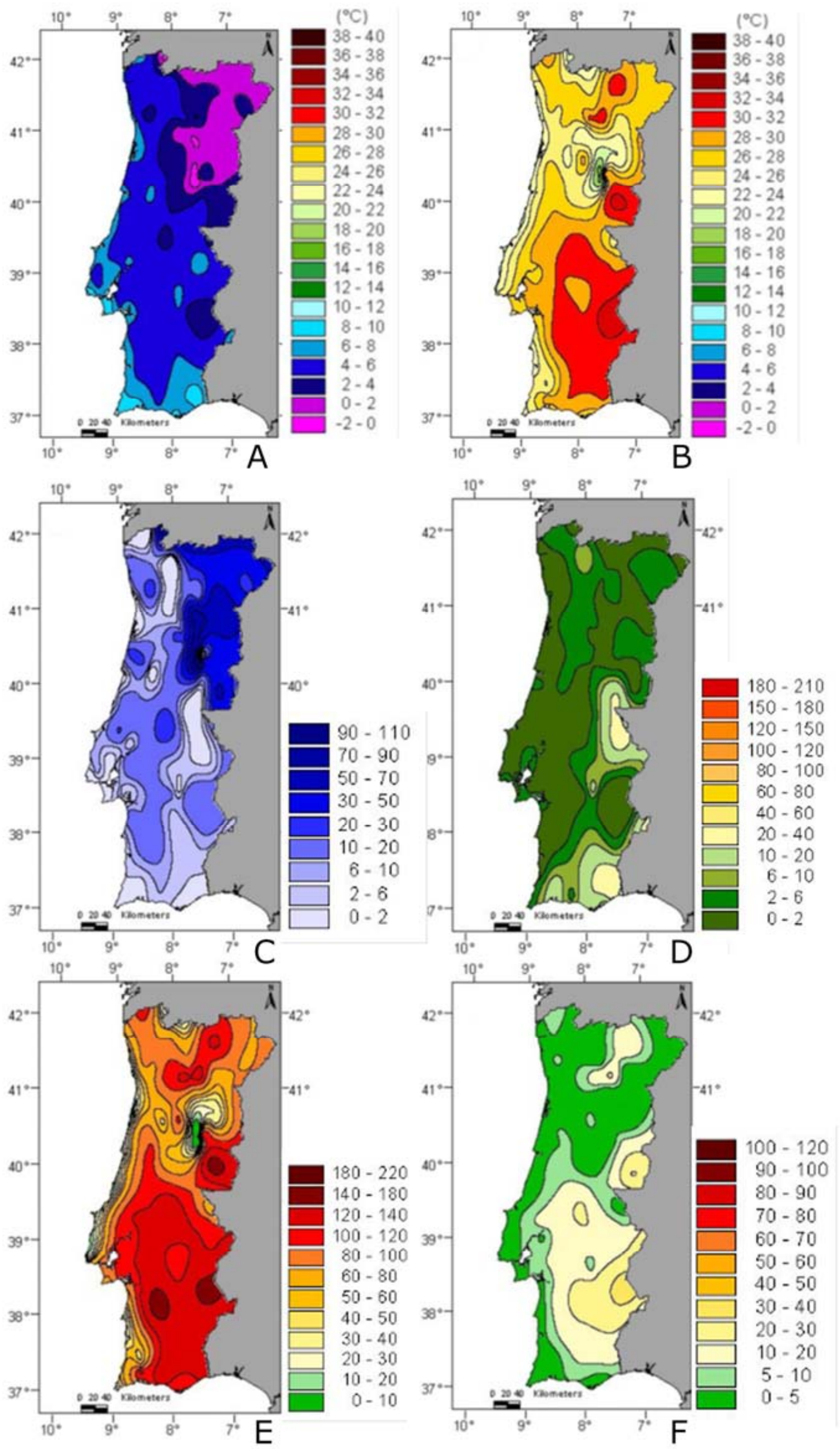

Figure 3.5.3: Climate in Portugal overview of maps (see next page) (Miranda et Al, 2002)

A. Mean minimum temperature in winter (December, January, February) and
B. Mean maximum temperature in summer (June, July, August). Data from 1961-1990 observations
C. Average annual number of days with minimum temperatures below 0ºC ("frost days"). Data from 1961-1990 observations.
D. Average annual number of days with minimum temperature exceeding 20ºC ("tropical nights"). Data from 1961-1990 observations.
E. Average annual number of days with maximum temperature ≥ 25ºC ("summer days"). Data from 1961-1990 observations.
F. Average annual number of days with maximum temperature ≥ 35°C ("hot days"). Data from 1961-1990 observations.

Although climate change seems to be leading to a rise in the temperatures in mainland Portugal (Miranda et al., 2002; Santos et al., 2002; Santos & Miranda, 2006; Santos & Aguiar, 2006), at the moment it is more likely to target to nearly-zero cooling demand than to nearly-zero heating demand. Recent studies based on the thermal environment monitoring of examples of vernacular architecture (Fernandes et al., 2015) and also considering the calculation of the overheating risk based on the heating gains coefficient (Cortez, 2016) as provided in the current thermal regulation (Portugal 2015), demonstrate that it is possible to achieve indoor thermal comfort by passive means and by the occupants' action during the summer period. The heavy thermal inertia of the envelope, a correct solar orientation, shading devices and the adequate organization of the internal spaces are fundamental aspects to control the indoor air temperature within the thermal comfort range. It should also be noted that the action of the occupants is fundamental in the regulation of their comfort conditions (e.g., promotion of night ventilation, activation of shading devices, etc.).

Even if in a few decades the climate conditions will be more demanding in summer and the current targeted nearly-zero cooling demand will not be enough to ensure passively the summer comfort, with these measures the future increase of energy use for cooling will be less relevant, meaning a building stock more resilient to climate change.

Portugal has a mild climate, strongly influenced by the more than 1200 Km Atlantic coast, with a quite good solar radiation and with considerable high daily temperature amplitude. This type of climate, with mild temperatures in winter and good sunshine conditions is quite favourable for the use of passive solar systems and night ventilation strategies.

This type of climate leads to the non-existence of central heating or cooling systems as well as mechanical ventilation systems in most part of the residential buildings. Although this scenario has been changing in the last decades, there´s still a strong cultural habit of using natural ventilation and open doors and windows to promote a connection between internal spaces and the exterior and heating and cooling systems are rarely used permanently.

Not only because of these habits, but also considering the climate conditions, air tightness of the envelopes must be adjustable by the occupants or sensors. Highly airtight envelopes are necessary during winter but during summer it is necessary to increase significantly the air changes during night. In residential buildings, natural or hybrid ventilation will certainly continue to prevail.

In Portugal, 21,5% of the energy used in residential buildings is for heating while only 0,5% is for cooling. All cooling is provided by electricity while for heating 67, 6% is provided by wood, 14, 1% by oil and 13,9% by electricity. The electricity use for heating in residential buildings is 9,1% of the total electricity use in these buildings and the electricity use for cooling represents 1,6% (INE, I.P./DGEG, 2011).

3. What is the Thermal comfort limits for nZEB in your country?

In 2007, the European Committee for Standardization (CEN) introduced the European standards EN 15251, which suggests the adoption of the Fanger's PMV/PPD model for mechanically heated and/or cooled buildings and Humphreys and Nicol's adaptive model for buildings without mechanical cooling systems. In 2008, the PassivHaus standard required comfort levels complying with the EN 15251 respecting the following rule:

> -The number of hours in excess of 25°C may not exceed 5% of the time working. This criterion is verified by using a dynamic simulation.

In Southern Europe, there are no studies that investigated to correlation between the variations of minimum performance threshold and suitable or fit to purpose comfort models in warm climates.

The National Laboratory of Civil Engineering (LNEC) has developed an adaptive model of thermal comfort (Matias, TPI65, 2010), which is an adaptation to the Portuguese context of the model specified in the ASHRAE Standard 55 (2010) and EN 15251 (2007).

For the development of this model, the authors carried out field tests all over the country in buildings with different uses (office, residential, educational and elderly homes), assessing and measuring in situ the main indoor environmental parameters during all seasons and evaluating occupant's thermal perception and expectation through surveys. The results obtained in this study show that: occupants may tolerate (under wider comfort conditions) broader temperature ranges than those indicated in current standards, in particular in the heating season; the outside temperature has strong influence on the occupants' thermal perception/sensation (Matias et al., 2009).

The LNEC model is an adaptive approach aimed at defining the indoor thermal comfort requirements applicable to Portuguese buildings, considering the typical Portuguese (Mediterranean) climate, ways of living, designing and operating buildings and therefore its use could be more accurate than the European adaptive comfort model. Considering the results from the measurement campaigns that lead to the development of the model and the recommendations from the World Health Organization a minimum temperature of 18ºC is suggested for winter and a maximum temperature of 26ºC is suggested for summer.

Among European countries, since many years now, Portugal is consistently identified as the country with the highest number of excess winter mortality, whether in scientific publications (Healy, 2003; ASRO, 2006), as well as in the European monitoring of excess mortality for public health action (http://www.euromomo.eu/). This mainly results from the combination of low energy performance of the residential building stock and the high energy costs, particularly when compared with the low incomes. This context should influence, not only the nZEB objectives, but also the nZEB definition, with the criteria for the building envelope design being established for a minimum comfort level that assures the minimization of the risks of negative health effects once it is not possible to relay on the use of heating systems by a significant part of the population. In Portugal, this is a public health problem and not only an energy related issue.

Following an adaptive comfort approach, the current thermal regulation (Portugal, 2015) uses the gain utilization factor as an overheating risk index with the introduction of a reference gain utilization factor that assume a minimum value as a function of latitude. The overheating risk index is integrated in the protocol to calculate the maximum value for cooling energy needs, depending on a few reference values, established at national level for each climatic zone (window-to-floor area ratio, window g-value and integrated solar radiation). This has resulted into more restrictive rules that are expected to improve buildings thermal performance during the summer and reduce the number of building units requiring air conditioning systems (Panão et al., 2011).

In the case of existing buildings, the transition to nZEB introduces additional constraints for the control of overheating risks. In these cases, the solar orientation, the organization of the internal spaces, the window-to-floor area ratio are difficult or impossible to optimize limiting the scope of building elements to work with. Additionally, the reduction of the thermal transmittance of walls and floor reduces the capacity of the building to lose heat and significantly increases the overheating risks.

As previously described, with heavy thermal inertia, a correct solar orientation, shading devices and the adequate organization of the internal spaces, together with the occupants' action activating night ventilation and shading devices, it is possible in Portugal to control the indoor air temperature within the thermal comfort range without the use of active cooling systems.

4. What is the minimum renewables threshold for nZEB in your country?

Energy efficiency and renewable energy technologies provide important opportunities to reduce greenhouse gas emissions. Efficiency is a policymaking principle that recognizes the central role that cost-effective energy savings can play in meeting energy, climate, and economic goals. However, many new constructions in the Southern European countries fail to take up many clean energy investments that are cost-effective, while investments in building renewable energy technologies seem easier and profitable.

All new buildings and major renovations in Portugal have to comply with a minimum energy efficiency level for its building envelope. That minimum energy efficiency level is currently levelled by the results from the calculation of cost-optimal levels of minimum energy performance requirements for residential buildings (Ferreira, et al.,2014). Beyond this cost-optimal level, further investments in energy efficiency measures are not cost-effective and present small reductions of the final energy use, which, beyond a certain point can even be annulled by the embodied energy of the additional materials. Furthermore, the cost-optimal energy efficiency envelope presents very small variations with the use of the different possible energy sources and technical systems (Ferreira, Almeida & Rodriguez, 2014). Thus, the rational option is to build or renovate targeting to a cost-optimal building envelope and use energy from renewable sources to move to near zero-energy.

In the case of building renovation, additional flexibility is necessary for the definition of the energy efficiency level. In fact, many of the existing buildings present specific technical, functional and economic constraints that put into question the cost-optimal levels calculated for reference buildings. It is therefore necessary to foresee how to identify these cases and allow reducing energy efficiency measures that can be balanced by additional use of energy from renewable sources.

A minimum energy from renewable sources, produced on-site or imported (such as in the case of biomass or electricity from nearby sources) is highly recommendable. Preliminary calculations from a study being developed in University of Minho indicate that, for residential buildings and for the energy uses of heating, cooling and domestic hot water preparation, the most cost-effective combinations of a cost-optimal building envelope with the mandatory use of energy from renewable sources are found with at least 50% of renewable energy.

Portugal's photovoltaic sector is mainly driven by small installations, namely micro and mini installations. Since 2014, significant cuts were made in the feed-in tariff (FIT) for these types of installations, and the aim is to bring micro and mini generation FIT prices down to market prices. The main incentive is now given to the self-consumption regime, by the elimination of almost any bureaucracy to allow its installation.

5. What is the construction quality for nZEB in your country?

The current Portuguese regulation defines a nZEB as having an envelope with the minimum thermal performance that matches the cost-optimal, as calculated according to the EPBD recast guidelines, and the energy use for heating, cooling and domestic hot water preparation to be significantly supported in renewable energy produced on-site or nearby.

This means that, from the regulatory point of view, nZEB will not imply a significant change on the way buildings are constructed in Portugal. Additionally, the climatic conditions, the economic constraints and the cultural habits, all point to the use of low tech instead of high tech nZEB solutions.

In this context, the main barriers are that even with low tech solutions, the design of an nZEB requires an integrated design approach to minimize the building's energy consumption while meeting all the occupants' needs, within a coherent combination of passive and active measures achieved with reasonable investment and running costs.

However, this integrated approach and the knowledge of the exigencies of designing a nZEB is not common for architects and engineers in Portugal which will lead in many cases to inefficient solutions, non-optimized buildings and higher costs due to extra measures for integration of energy efficiency measures and renewable energy systems (Silva et al., 2015).

6. **What should be (your own recommendation) the minimum EE and RET in your country?** (EE energy efficiency, RET Renewable Energy Threshold onsite):

Here are presented the different minimum performance thresholds for nZEB (Table 3.5.1) and the climate zone in Portugal during winter and summer seasons (Figure 3.5.4).

Table 3.5.1: Different Minimum Performance Thresholds for nZEB

Category	EE Threshold		RES Threshold	Country
	Heating demand	Cooling demand		
Energy Efficient	Climate zone I1 - 30kWh/m².a Climate zone I2 - 40kWh/m².a Climate zone I3 - 70kWh/m².a	Climate zone V1 - 0kWh/m².a Climate zone V2 - 15kWh/m².a Climate zone V3 - 30kWh/m².a	50%	Portugal

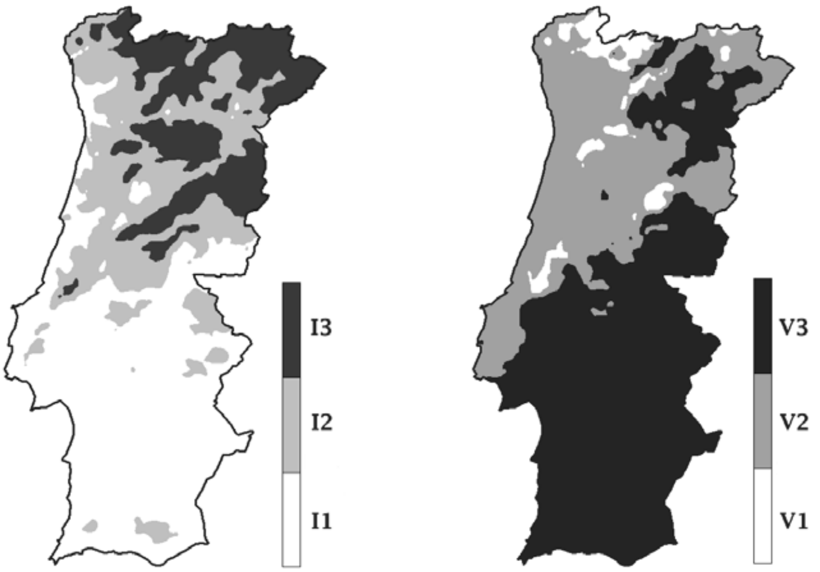

Figure 3.5.4: (a) Winter climate zones in Portugal and (b) Summer climate zones in Portugal (Portugal, 2015)

7. **Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.**

Most of population in Portugal is concentrated in a narrow area close to the Atlantic Ocean, between the metropolitan areas of Lisbon and Porto. This area, by the influence of the Atlantic has a mild climate, both in summer as in winter, being mainly included in summer climate zone V2 (climate intensity rising from V1 to V3) and winter climate zones I1 and I2 (climate intensity rising from I1 to I3) (see for winter and summer climate zones Figure 3.5.4).

Largest cities representing winter climate zones (Portugal 2015; FFMS 2016):

I1: Lisbon
I2: Braga
I3: Covilhã

Largest cities representing summer climate zones (Portugal 2015; FFMS 2016):

V1: -

V2: Lisbon
V3: Faro

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3.6 ROMANIA

Passive houses are spread on the entire territory of Romania with a fervent scientific interest manifested in four university centers beginning since 2007: Bucharest, Cluj-Napoca, Timisoara, Brasov, Iasi and Constanta. Among the favourite topics inside the science of the buildings, these centers orient towards distinct directions as for example in Bucharest exists the predilection for thermal design and optimization, in Cluj-Napoca for control strategies & intelligent building design while in Timisoara the measurement techniques occupy a special interest.

The technical universities from Bucharest, Cluj-Napoca, Timisoara, Brasov and Iasi assimilated rapidly the principles of design of nZEB's and passive houses and moved off a series of projects under the auspices of the European and national research grants.

Two projects (Figure 3.6.1) follow the frame of a governmental initiative focalized on renewable energy and sustainability in consensus with European legislation and its financial facilities: passive house AMVIC and the passive house Politehnica from Bucharest.

a)


b)

Figure 3.6.1: Two representative passive houses from Romania: a) PH AMVIC (Badescu et al., 2010, 2012 and 2016); b) PH Politehnica (Ionescu et al., 2015; Badea et al., 2014; Baracu et al., 2017)

The technical details of the passive houses are given in Tab. 3.6.1 and 3.6.2. A synergy of the design technics is remarked as in the future it is aimed the completion of a new standard.

Table 3.6.1 : Geometrical characteristics of the passive houses

Parameter	**Metrics of the buildings**		**Requirement / Recommend.**
	AMVIC (2009)	Politehnica (2011)	
Orientation of facade	South-South East	South	South
Position (Lat., Long., Alt.)	(44.388N, 26.011E,81A)	(44.438N, 26.047E,76.6A)	-
Overall dimensions LxBxH [m]	34.06 x 14.56 x 16	16 x 11.8 x 7.5	-
Configuration	Single-cluster; 1DG+1B+4S	Double-cluster, 1B+1S	-
Net floor area [m^2]	496	2x140=280	-
Envelope area [m^2]	2086	797.2	-
Indoor air volume [m^3]	9481	870.6	-
Compactness C=V/S [m^3/m^2]	3.11	1.78	Cubic= ideal
Legend: DG- Demi-Ground; B- Basement; S- Storey			

Table 3.6.2 : Energy performances of the passive houses

Parameter	**Metrics of the buildings**		**Requirement / Recommend.**
	Amvic (2009)	Politehnica (2011)	
Heating	EAHEx + HRU+EH	EAHEx + HRU // GHP + PHEx	-
Cooling	EAHEx + HRU+EH	EAHEx + HRU // GHP + PHEx	-
Ventilation	AV	AV; PC	-
DHW	2xSC	2xSC	-
Electricity	PV+Public Grid	PV+Public Grid	-
Pressure test- Air changes per hour [h^{-1}]	0.5	≤0.586	≤0.6
Specif. Space Heat Dem, [kWh/m^2/y]	9.56	12.5	≤15
Specif. Space DHW Dem., [kWh/m^2/y]	11.86	18	-
Specif. Space EEC, [kWh/m^2/y]	18.63	38.1	-
Total Specific PED, [kWh/m^2/y]	40.06	99	≤120
Legend: EAHex- Earth-to-Air Heat Exchanger; HRU- Heat Recovery Unit; GHP- Ground Heat Pump; PHex- Plate Heat Exchanger; SC- Solar Collector; PV- Photovoltaic; DHW- Domestic Hot Water; EH- Electric Heater; AV- active ventilation; PC- passive cooling; EEC- Electric Energy Consumption; PED- Primary Energy Demand.			

The controlled ventilation system with heat recovery (Fig. 3.6.2) afferent to PH AMVIC provides all days, regardless of season, fresh air at a comfortable temperature.

Figure 3.6.2: Ventilation system and the Heat recovery unit (HRU) of PH AMVIC

1. What is the minimum energy efficiency threshold for nZEB in your country?

The international and European policies on environment, GHG emissions, energy efficiency and renewable energy are assimilated by the Romanian standards and practices of design and along with them are proposed innovative solutions. Tab. 3.6.3 shows information for Romania.

Table 3.6.3: Statistics related to energy and GHG emissions in Romania (Metodologie de calcul a performantei energetice a cladirilor. Part. I and II)

Sector	**Primary energy factors PEF [kWh_{prim} / kWh_e]**	**CO_2 Emission Factors [kg CO2 / kWh]**
Oil	1.1	0.270
Natural gas	1.1	0.205
Firewood / Biomass	1.1	0.036
Coal	1.3	0.341
Municipal wastes	1.05	0.240…0.243
Hydro	1.10…1.50	0.024
Wind	1…1.14	0.007
Solar	1…1.14	0.02…0.05
Nuclear	2.80…3.45	0.016
Geothermal energy	2.5	0
District heating (CHP)	0.90…1.1	0.141…0.240
Electricity (mix)	2.8	0.252

From the point of view of the primary energy factors, Romania shows a performance which is around the average value across the Europe. The CO2 emission factors for some sectors, such as biomass utilization, shows Romania among the most advanced countries in Europe. The official Romanian documents avoid making reference to specific targets for minimum energy efficiency thresholds regarding end use and primary energy use intensity and carbon emissions. However, Tab. 3.6.3 suggests that improvements are necessary in other sectors, such as district heating.
The classes of energy efficiency used in Romania for the energy certification of the buildings (Metodologie de calcul a performantei energetice a cladirilor. Part. I) are represented in Fig. 3.6.3. As an example, if the heating demand ranges between 117 and 173 kWh/m^2/y, or if the total energy demand ranges between 201 and 291 kWh/m^2/y, the building is classified as type C. There is no minimum threshold specified for the heating demand, cooling demand or total energy demand.

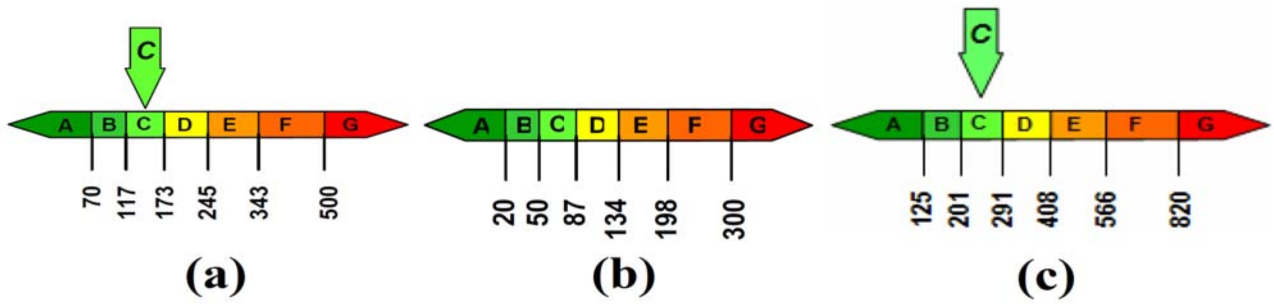

Figure 3.6.3: Scale of the certificate of energy performance in Romania (Metodologie de calcul a performantei energetice a cladirilor. Part. I):
a) Heating demand [kWh/m^2/y]; b) cooling demand [kWh/m^2/y]; b) total energy demand [kWh/m^2/y]

The classes of the Romanian standard (Metodologie de calcul a performantei energetice a cladirilor. Part. I) are expressed considering a direct summation between the end-use types of energy. The A-G scale of Fig. 3.6.3 is widely adopted by the EU countries but only few of them cover the performances of the passive houses. For such situation some countries extended A-G scales of the certificate of energy performance to A+, A++ and even A+++. This is not yet the case of Romania.

To our knowledge, presently, there is no nearly zero energy building renovation in Romania.

The minimum threshold of 15 kWh/m2/a for heating demand as well as for cooling demand is realistic for new public buildings. When new residential buildings are considered, a realistic but still ambitious minimum threshold to be obeyed by most of the population in the next ten years might be 70 kWh/m2/a for the heating demand.
The number of Romanian PassivHaus-es certified by Passive House Institute of Darmstadt is small: there is just one such PH, built in Burlusi village, Valcea county. The number of (not-certified) PHs increased in the last years but they are still below ten. However, the number of buildings thermally insulated at the level of a PH (but without forced circulation air ventilation) is larger, of the order of tens.
There is already some accumulated experience in Romania concerning the implementation of the PassivHaus Standard (Rotar et al., 2011), with three passive houses well documented and whose performance has been monitored for several years. The best documented PassivHaus in Romania is the office building AMVIC PH (Badescu et al., 2010). This makes credible the adoption of this standard in Romania.
There are several issues related with PH usage in the warm season, mainly related with overheating, which have been shortly presented in (Badescu et al., 2010). Simple solutions such as windows opening during the night may solve most of these problems.

2. **What is the Heating-Cooling balance for nZEB in your country?**

The heating and cooling demand balance is very important for high performance buildings. In cooling or heating dominated climates, building designer seek through bioclimatic and passive strategies to deal with only one acclimatization system to reduce cost and achieve maximum possible comfort. However, in warm South European climate this balance is sometime symmetric. The implications of a symmetric or quasi symmetric balance lead to dual acclimatization systems with thermal and electric demand and can have a large on the energy supply networks. In warm South European warm climates, reaching low energy efficiency thresholds, eg. 15 or 30 kWh/m².a, can be met more easily than in cold ones. It is then possible to reduce heating needs even though various design parameters are not optimal (shapes, orientations, window sizes, performance of components, etc.). It may be interesting to aim at "zero energy heating" targets to achieve the savings optimum. This could then make it possible to reach low heating demand values around 5 kWh/m².a in the case of Mediterranean climates. However. 15 or 30 kWh/m².a for cooling can be more difficult due to high solar radiation, building envelope airtightness, high thermal mass and high outdoor ambient temperature in warm cities. Moreover, increasing infiltration level, in contrast to heating demand, reduces cooling demand. In contrast to central and north European countries, which require maximum air tightness levels, NZEBs in warm climates should not be fully airtight.

Romania is placed in South-Eastern Europe; many southern regions of the territory can be associated to the Southern climate of the Europe and others to the Northern Europe (Fig. 3.6.4). The temperate-continental climate of Romania consists in hot summers and relatively cold winters and the seasons manifest with distinctiveness (Ionac et al., 2014; Manea et al., 2016). Annual average temperature is 8 ^{0}C in the north and 11^{0}C in south, 2.6 ^{0}C in the mountains and 12 ^{0}C in the plains (WeatherOnline-Romania, 2016 and Lustenberger, 2012). In the Köeppen -Geiger classification Romania has **Cfa** Climate (Group C-Temperate hot-summer climate) on most regions while in the Carpathian Mountains **Dfb** Climate (Group D-Warm summer continental) (Chen et al., 2013).

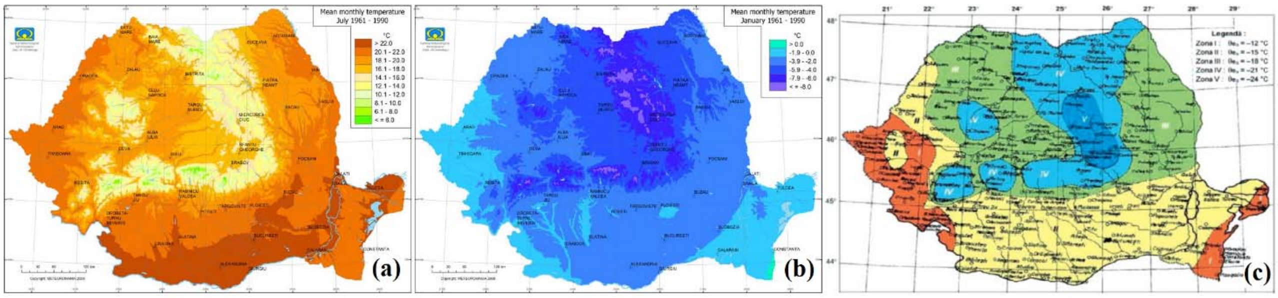

Figure 3.6.4: Averaged temperature distribution on the territory of Romania: a) summer season (National Meteorologic Administration, 2016); b) winter season (National Meteorologic Administration, 2016); c) standard climatic zoning (I-V) (Ordinul nr. 386/2016).

Several properly designed Romanian passive houses have heating demands of about 6-12 kWh/m²/y. Passive House AMVIC (Bucharest), for instance, reached a heating demand of 9.56 kWh/m²/y. Nearly zero heating demand is difficult to reach except by using Renewable Energy Systems.

The airtightness should be high because buildings may have heat losses of 15-50% due to the non-conformal airtightness. While ASHRAE proposes the minimal ACH_{lim} of $0.35h^{-1}$ for a building from reasons of indoor air quality then a conservative value ACH_{lim}=2* ACH_{lim}=0.7 h^{-1} looks suitable, implementable and ecological for the buildings of highest class of efficiency like NZEBs. This is in rather good agreement with the value required by PassivHaus Institute ACH_{lim}=0.6 h^{-1} is a bit too much artificial as in the most cases requires the introduction of plaster in the structure of the envelope. A reference airtightness of 0.7-0.8 h-1 is still high and is easier reachable. The advantage of this threshold of airtightness is that will not require mandatory mechanical ventilation to maintain the indoor air quality. This level of air exchange guarantees a natural maintaining of the indoor air quality. In general, the solutions that provide airtightness does not rise up the cost at the same level as the Renewable Energy Systems as it is required mainly to install at least double-glazed windows with relatively high sealing and the use of plaster.

Most of the PHs in Romania is not connected to district heating network but to the electric grid. The primary energy consumed by a PH is defined as the sum of all primary demands for heating, domestic hot water, auxiliary and household electricity. It is computed in two steps. First, the electrical energy (EE) provided to the PH by the electric grid is evaluated. Second, the electrical energy, multiplied by the "primary energy factor" (PEF), gives the primary energy. The "primary energy factor" depends on country. For example, the Romanian standard (Metodologie de calcul a performantei energetice a cladirilor. Part. I) states a primary energy factor of 2.8. Note, however, that in practice, a Romanian self-assumed national primary energy factor could be smaller than 2.7. In 2008, statistical data indicated for Romania an electricity production mix of 42.5 % coal, 26.4 % hydro, 13.7 % oil, and 17.3 % nuclear, which gives a theoretical primary energy factor of 2.47.

We can quantify the influence of the heating demand on the electric grid by defining the ratio R between the specific heating demand (HD) and the primary energy (PE) needed. The value of the indicator R for the three documented PHs in Romania is as follows:

- Politehnica PH (Bucharest):

$$R = \frac{HD}{PE} = \frac{HD}{EE \cdot PEF} = \frac{12.5}{99 \cdot 2.8} = 0.045$$

- AMVIC PH (Bucharest):

$$R = \frac{HD}{PE} == \frac{9.56}{40 \cdot 2.8} = 0.085$$

- Dumbravita PH (Timisoara):

$$R = \frac{HD}{PE} == \frac{13.59}{40 \cdot 2.8} = 0.121$$

These values may be used as first guess for the heating/cooling balance on the energy supply network capacity for heating.

3. What is the Thermal comfort limits for nZEB in your country?

In 2007, the European Committee for Standardization (CEN) introduced the European standards EN 15251, which suggests the adoption of the Fanger's PMV/PPD model for mechanically heated and/or cooled buildings and Humphreys and Nicol's adaptive model for buildings without mechanical cooling systems. In 2008, the PassivHaus standard required comfort levels complying with the EN 15251 respecting the following rule:

> The number of hours in excess of 25°C may not exceed 5% of the time working. This criterion is verified by using a dynamic simulation.

In Southern Europe, there are no studies that investigated to correlation between the variations of minimum performance threshold and suitable or fit to purpose comfort models in warm climates.

In the past, national standards covered the issues related with comfort in buildings. During the process of joining the European Union, these standards has been removed and replaced by European standards, implemented ad litteram or with some adaptation. The standard ISO 7730-2005 is presently adopted in Romania (ASRO, 2006). It contains the Fanger model PMV-PPD. Supplementary to ISO 7730, EN 15251 describes shortly the concept of adaptive control (for HVAC system) and also establish the equations of checking the indoor temperature in conditions of natural air exchange (without mechanical ventilation). Preliminary studies on the adaptive comfort model have been already performed in Romania (Udrea et al., 2016).

Romania is a country where the resources of oil and gas cover 30%-50% from the total consumption. This is a reasonably large percentage. The country has good coal and biomass resources, consisting mainly of wood. Percentages of energy consumption in 2008 have been provided above. Generally, the country does not have fuel poverty problems. Is not believed that the nZEB objectives, once defined in this country, will be connected with fuel poverty but with the general, global, tendency towards increasing energy efficiency in all sectors.

In Romania, the overheating risk for passive houses is over 5% in free-running conditions of summer in Bucharest area (Badescu et al., 2010). This happens during time intervals with tropical-like nights, when the potential of decreasing the indoor temperature by opening the windows and natural ventilation during the nights is low. Note that Bucharest belongs to climate region II in Fig. 3.6.4c. It is likely that overheating risk is nearly zero in climate regions III to V. Similarly, the overheating risk exists for NZEBs in climate regions I and II, since the building is highly insulated and with high airtightness.

Passive cooling techniques, such as opening the windows during the night after hot days, may be a reasonably good solution most of the time in climate regions III to V in Fig. 3.6.4c. In those regions the overheating risk is practically zero. Usage of active cooling may be taken into consideration in climate regions I and II in Fig. 3.6.4c. However, the overheating risk is still low (less than 5%) in those regions and implementation of active cooling systems is not economically justified. Overall, passive cooling may be considered a reliable solution all over the country.

4. What is the minimum renewables threshold for nZEB in your country?

Energy efficiency and renewable energy technologies provide important opportunities to reduce greenhouse gas emissions. Efficiency is a policymaking principle that recognizes the central role that cost-effective energy savings can play in meeting energy, climate, and economic goals. However, many new constructions in the Southern European countries fail to take up many clean energy investments that are cost-effective. While investments in building renewable energy, technologies seem easier and profitable.

a) Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

The normal approach is first to invest in energy efficiency (superinsulation, high airtightness, etc.) and in a later stage to invest in Renewable Energy Systems (RES). The reason is that the super insulations, installing high quality windows or assuring the airtightness of the envelope appear more common for any customer. However, the personal preference of the Romanian investors often does not agree with the priority of energy efficiency over the RES. In many cases it is

preferred a basic level of thermal insulation combined with early investment in solar collectors, PV panel systems, etc. This is the case when constraints exist for the budget. If such constraints do not exist then the entire package associated to NZEBs is adopted: superinsulation, airtightness, RES.
Only under certain circumstances. When discussing about certification, a building should obtain a certificate of clean energy if it is able to produce from renewable sources at least 33% of the demand. This kind of certificate would encourage further the user to go further for effective benefits. S/he may install PV units towards producing 110% of the demand, obtaining in this case a Green Certificate of energy producer for the exported energy to the grid.
Green Certificates are available In Romania that brings benefits for energy producers. Subsidies exist for clean energy, which are distributed through green certificates (3 certificates per MWh of photovoltaic and 1.5 certificates per MWh of wind turbine). This governmental action proved to be quite successful but it is waited further to encourage and proliferate the Plus Energy Buildings. Authentic Plus Energy Buildings (PEB) still do not exist in Romania.

5. What is the construction quality for nZEB in your country?

NZEBs require high construction quality through new construction technologies, high-tech components, specialized competencies and high-level expertise. To achieve NZEBs, the use of energy efficient technologies and materials is necessary. These technologies and materials must respond to the exigencies of the NZEBs and satisfy the NZEB market demand. In most Southern European countries there are barriers regarding the know-how of professionals and the number of architects and engineers that are able to deal with new technologies and standards).
A market with segmentation of products is defined as follows. For the same product (for instance, heat recovery unit), different categories (or segments) are defined: heat recovery units with efficiency between 80% and 100% are one segment (say A); another segment (say B) consists of heat recovery units with efficiency between 60% and 80%, and so on. NZEbs may be built by combining products belonging to different segments (for instance, heat recovery unity of segment A, windows of segment B, etc). Different such combinations are possible, all of them being able to yield a proper NZEB. A market with segmentation of products should be clearly defined for NZEBs. The technology involved in NZEBs should be covered in all segments of the market, including "High-End", "Middle-Level", "Low-End" and "Compatible" products and the differentiation should be concretized at the level of efficiency and compactness but at comparable quality, reliability and life-cycle. Today there are issues with the segmentation of the products as the equipment of renewable energy are provided almost exclusively as high-end without standard rules of differentiation. The consequence is that the houses with passive properties are less numerous than they should be. A diversification of the producers would disaggregate some monopolistic practices and the access to high quality products at reasonable price would help the customers.
Additional categories of energy efficiency for buildings should be defined, through a distinguished segmentation of efficiency levels of sold equipment/products. Using only two levels of description like "high-tech" and "low-tech" is not enough for the complexity of the market. That is why a more detailed segmentation is more appropriate.
An important barrier is the lack of a mature market for the products. NZEBs are high quality buildings; some levels should be defined in terms of efficiency. Example: a heat recovery unit (HRU) with efficiency of 75% is acceptable and may be categorized as a "low-end" product while a HRU with efficiency of 90% is definitely a "High-End" product. Another barrier is the fact that products with basic efficiency are sold at premium prices (i.e. at the level of the high-end products). In this way it is affected the market of high-end products itself. (Rotmans et al., 2001) distinguished four transition phases of a development process that in our case is the market of NZEBs: predevelopment, take-off, acceleration and stabilization. The market of NZEBs in Romania is in the phase of take-off since the basic premises are already created for a significant expansion in the future.

6. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

We suggest the usage of Tab. 3.6.4, which extend the existing system of buildings labelling.
This table facilitates a correlation between the energy efficiency and the market segmentation

associated with products quality. Double letter building represents buildings that have installed systems for renewable energy sources.

Table 3.6.4: Categories of buildings.

Label	Category	EE Threshold (%)			RES Threshold (%)	Emissions Category	Market segment		Country
		Heating	Cooling	Total Energy			Market label	Price level	
AA+	PlusEB	15…30	15…30	120…150	+110	Negative Emissions	High-End Products	Highest	Romania
AA0	NetZEB	15…30	15…30	120…150	+100	Zero Emissions			
AA-	Low Energy	60	60	180	+30	Low Emissions			
A+++	Passive	15	15	120	N/A	Extreme-Low Emiss.			
A++	Ultra-Low Energy	30	30	150	N/A	Ultra-Low Emissions			
A+	Low Energy	50	50	180	N/A	Low Emissions	Middle-End Products	Middle	
A		60	60	180	N/A				
B	Basic Energy	80	80	200	N/A	Basic Emissions	Low-End Products	Low	
C		120	120	200	N/A				
D	Tolerable Energy	180	180	250	N/A	Tolerable Emissions	Tolerable Products	Discount	
E	Intolerable Energy	240	240	300	N/A	Intolerable Emiss.	Intolerable Products	Recycling	
F		500	500	300	N/A				
G		>500	>500	>300	N/A				

7. Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.

Largest cities in Romania which are representative through their climate are presented in Tab. 3.6.5.

Table 3.6.5: Major cities of Romania and specific climate zones (WeatherOnline-Romania, 2016)

City	**Population [Habit. no.]**	**H&C criterion**	**Coordinates [Lat. (°N) ; Long. (°E); Alt (m)]**	**Climate zone**		**Heating Degree-days**
				Zone (see Fig. 4c)	**Average yearly temperature / Heating Design Temperature (°C)**	
Constanta	283872	H&C zone	44.18; 28.7; 40	I	13.1 / -12	2703
Bucharest	1883425	H&C zone	44.43; 26.10; 77	II	12.1 / -15	3055
Timisoara	319279	H&C zone	45.74; 21.22; 87	I	12.6 / -12	2924
Brasov	253200	H zone	45.64; 25.59; 610	IV	10.8 / -21	4262
Cluj-Napoca	324576	H zone	46.76; 23.60; 380	III	10.7 / -18	3618

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3.7 SPAIN

1. What is the minimum energy efficiency threshold for nZEB in your country?

The present situation in Spain regarding the nZEB definition is uncertain. Despite the existence of diverse minimum energy efficiency requirements for buildings, and the publication of a draft of the nZEB indicators in 2016, the nZEB level is not properly defined yet. This late definition was underlined in previous reports, such as the review conducted by JRC (D'Agostino et al., 2016) or the study made within the RePublic_ZEB project (Aelenei et al., 2015). In relation to the delay of many MS towards Nzeb regulation, in August 2016 the European Commission established some common guidelines to define nZEB (EU commission, 2016).

Later on, in December 2016 the Spanish Ministry of Development published the first draft of the nZEB indicators. It included a new set of building energy performance indicators (see Table 3.7.1 below) and an EPBD visualization tool (Ministry of Development, 2016). However, this set of indicators hasn't defined the thresholds or reference values yet. The full draft of this new regulation is expected to be published in late 2017 and become applicable in summer 2018, only a few months before the nZEB deadline of 31st of December of 2018 for new public buildings. Before this final regulation comes into force, a Royal Decree of June 2017 has set the threshold of nZEB as the current requirements of the building energy code, to solve temporarily the regulation gap.

Table 3.7.1: Draft of building energy performance indicators for the update of building energy code of Spain, DB-HE 2018 (Ministry of Development, 2016)

Requirement	**Indicator**
Energy use	Non-renewable Primary Energy use ($C_{ep,nren}$)
	Total Primary Energy use ($C_{ep,tot}$)
	Renewable energies: - Minimum contribution of global energy use - Swimming pool heating - Outdoor open space heating/cooling
Thermal envelope	Global thermal transmittance (K)
	Solar gain limitation in summer ($Q_{sol,jul}/A_{util}$)
	Minimum thermal insulation of partitions
	Condensation verification of thermal envelope
Building energy systems	Thermal systems
	Lighting systems

Before suggesting the nZEB thresholds, it is necessary to review briefly which indicators and limits were used by the Spanish regulation in the last decade. The first EPBD was transposed into the Technical Building Code (CTE, 17th March 2006) and the Regulation on Building Heating Installations (RITE, 20th June 2007); the requirements included a minimum thermal insulation in all the elements of the thermal envelope according to each climate zone and also a minimum energy performance of services as heating, cooling, DHW generation with some thermal solar panels and illumination of tertiary buildings. Later, the EPBD recast was adopted by newer versions of the Technical Building Code (CTE DB-HE, 12th September 2013) and the Regulation on Building Heating Installations (RITE, 5th April 2013); which increased most of the preceding requirements of energy efficiency and incorporated two new indicators: non-renewable Primary Energy (PE) use and energy needs. In residential buildings, the energy demand or needs are calculated on a building scale and limit the heating and cooling needs up to a certain amount in correspondence with each climate zone and building size. The permitted heating energy needs nowadays range considerably from 15 kWh/m²/y in south coast regions to 40 kWh/m²/y in the coldest locations. Additionally, these limits are higher for small constructions, for instance, a small single-family house placed in the coldest region may be up to 70 kWh/m²/y. The allowed cooling needs are quantified separately and have to be below 15 kWh/m²/y or 20 kWh/m²/y depending on the location again. In a similar way, the limits of non-renewable PE consumption vary from 40 kWh/m²/y to 70 kWh/m²/y according to location and building size; and incorporates all the PE needed for heating, cooling and DHW and discounts the positive effect of the renewable sources on-site. In fact, the flexibility of these indicators demonstrates the wide differences between Spanish climate zones.

In general, it is important to keep the focus on the main challenges. The big differences between Spanish climate zones require a set of indicators that permit evaluating different approaches to achieve the nZEB level. Moreover, the combination of heating and cooling needs increased considerably the overheating risk in most regions. Besides, the economic circumstances in the country reduce dramatically the private and public investments in new constructions and energy retrofits. And last but not the least, the lack of knowledge and tradition on highly insulated buildings may create a usage and maintenance problem; this is patent in most stakeholders, starting from architects, engineers, builders, maintenance operators to end users, etc. Recent studies show that the majority of residential buildings built on the last decade in Spain present a low energy-performance, as explained in (Fernández-Agüera et al., 2016) and more deeply in (Gangollels et al., 2016).

Considering the aforementioned situation in Spain, the draft of energy performance indicators of Spain is based on previous indicators but it also implements some new ones. On the one side, one indicator was used under previous regulations: the non-renewable PE consumption. On the other side, three new indicators are incorporated: total primary energy use, global thermal transmittance and solar gain limitation in summer. The total PE use limits the total amount of energy used in the building, without considering the renewable energy production on-site. The global thermal transmittance substitutes the current indicator of heating and cooling energy demand, aiming to prioritize the building systems with better primary energy factors. The solar gain limitation in summer sets a maximum average of solar gains per square meter in a typical hot month, July. This indicator could be extremely useful to prevent any overheating problems. Besides, there are many other secondary indicators, such as the obligation of additional renewable energies for certain uses, the minimum thermal insulation of internal partitions and the condensation verifications. These indicators are mainly based on the harmonized methodologies developed by the Draft prEN ISO 52000-1 Energy performance of buildings - Overarching EPB assessment. In any case, these indicators belong to a draft version and the Spanish Ministry of Development is working on the cost-optimal assessment to set the thresholds.

Therefore, the nZEB threshold proposed should be conservative and not too ambitious for now. A strict threshold like Passive House would not probably help with the recommended climate adaptation in distinct regions at a reasonable cost. Instead, a combination of heating and cooling energy needs may offer wider possibilities to future nZEB design is recommended, especially in buildings uses with moderate internal gains. So, the limit in residential buildings for the sum of heating and cooling energy needs may be 20 kWh/m²/y; whereas in office buildings the heating and cooling needs may be higher, up to 20 kWh/m²/y each one. This should permit a feasible adaptation to each climate zone with a reasonable cost. This value is similar to the Passive House limit but incorporates the cooling need which is important in Spanish climate. In an average case with proper ventilation, the U values of the envelope may be between 0.20 W/m²K and 0.30 W/m²K and the windows U-value range from 1.00 W/m²K to 1.60 W/m²K. Starting from these values, the total energy use indicator which embraces heating, cooling, Domestic Hot Water (DHW), ventilation and lighting, as explained in the EU recommendations (EU commission, 2016). A safe value for residential sector may be 60 kWh/m²/y to guarantee de energy efficiency of all the systems. If the DHW need is covered to great extent by solar panels and heat storage, an adequate RES contribution should not be a problem considering the solar potential of Iberian Peninsula. Table 3.7.2 below summarizes the proposed values.

Table 3.7.2: nZEB threshold proposal for Spain

Building use	Energy needs for heating and cooling	Total Primary Energy Use (heating, cooling, DHW, ventilation and lighting)	% renewable sources	Overheating verification
Residential	< 20 kWh/m²/y	60	60	X
Office	20+20 kWh/m²/y	90	50	X

Regarding the building energy renovations, large socio-economic barriers are limiting the progress of deep renovations in residential sector. Many European projects have demonstrated that deep renovations are feasible and even nZEB levels may be achieved on urban scale renovations, like FARO REMOURBAN in Valladolid (de Torre Minguela et al, 2016), Re_PublicZEB in Catalonia (Aelenei et al, 2015) and ECOCITY in Vitoria-Gasteiz (Ruíz-Cuevas et al., 2016). However, they also have proven that cost optimal interventions are still far from deep renovation levels, and so the impact of nZEB renovations is for now unaffordable. Besides, the tenure condition of Spain indicates that 78.2% of dwellings are owner occupied and flats are the most common typology, while only the 13.2 % are detached houses (EUROSTAT, 2014). This complicates the renovation processes in multifamily buildings because the decision making with multiple ownerships and economic issues is too slow. It is urgent that public administration stimulates the renovation applying the best practices from Spanish tested cases.

2. What is the Heating-Cooling balance for nZEB in your country?

Spain is a large country that includes many different climatic zones. The Köppen-Geiger classification (Kottek et al., 2006) indicates that the country is warm temperate, separated in three main areas: the south and eastern areas closer to Mediterranean Sea present low precipitations and hot summer (Csa), the western and northwestern areas present low precipitations and warm summer (Csb) and the remaining areas on the north and northeast are fully humid with warm summer (Cfb). These differences are patent in Spanish Building Code (CTE) (CTE, 2013) which identifies 5 levels of winter, from the most temperate A to the coldest E; and 3 levels of summer, from the mildest 1 to the warmest 3. Figure 3.7.1 represents the climate zones of the capitals, towns may differ according to altitude.

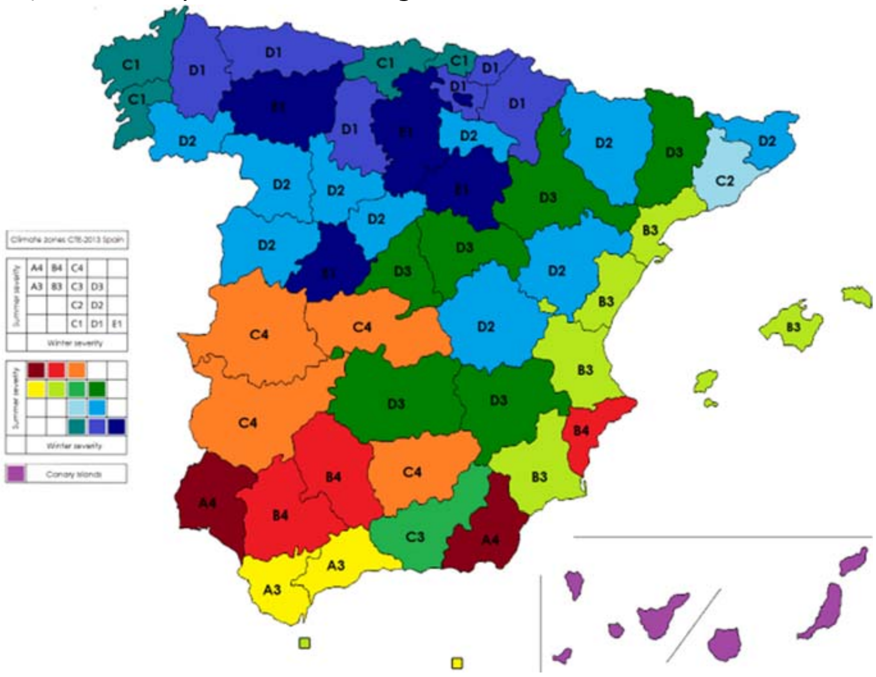

Figure 3.7.1: Spanish climate zones (made by authors based on data obtained from CTE DB-HE of 2013)

So, this weather variety can be represented for the nZEB purposes as 4 main types: temperate zones with low energy needs, heating dominated zones, cooling dominated zones and also heating and cooling dominated zones. The Canary Islands have specific climates which are not considered in this study. Table 3.7.3 combines the aforementioned Köppen-Geiger climate zones and CTE zones, in a global nZEB classification according to each ones Heating Degree Days (daily calculation on base 18.33) and Cooling Degree Days (daily calculation on base 18.33) from the Typical Meteorological Year (TMY) of CTE.

Table 3.7.3: Spanish main climate zones identified by driving heating-cooling needs

Main energy needs	Heating dominated	Heating and cooling dominated	Cooling dominated		Temperate zones		
Representative city	Burgos	Madrid	Huelva	Valencia	Barcelona	Bilbao	A coruña
Population	177.100	3.141.991	146.318	786.189	1.604.555	345.141	243.870
Köppen Geiger	Cfb	Csa	Csa	Bsk	Csa	Cfb	Csb
Spanish climate	E1	D3	A4	B3	C2	C1	C1
HDD 18.33	3028	2313	847	1154	1772	1882	182
CDD 25	0	78	171	81	11	0	0

The impact of climate on nZEBs is crucial. A proper design should provide low heating needs but also an overheating prevention. The air tightness level in conventional residential Spanish buildings is medium: a recent study in high rise dwellings measured an air renovation ratio at 50 Pa of 5.72 h^{-1} on average (Fernández-Agüera et al., 2016). It is probably going to be difficult to change this trend in a short term, thus, it is expected that future nZEB present airtightness values ranging from 2 to 6 h^{-1}. In any case, there are some residential cases already built which may be considered as very low energy buildings. For instance, a recently built Social Housing ZEB implemented active facades to reduce ventilation heat losses (Hidalgo-Betanzos et al., 2016) and estimates that the renewable energy generation may reach to a zero-energy use for annual heating and DHW, at least in simulations. Moreover, there are 56 certified Passive Houses in Spain (Spanish PH database, 2017), spread along Cataluña, Madrid, Navarra, País Vasco, Andalucía, Castilla y León, Canarias, etc. which demonstrates that an ultra-low energy need is possible in all Spanish climates.

The risk of overheating was solved with thermal mass and ventilation strategies in vernacular architecture. At present, high insulation levels and modern airtight construction, which are in general oriented to winter season, have uncovered many failures in summer comfort. In any case, air tightness and high insulation itself are not the origin of the failure and the causes are more likely related with other general aspects of the design. Studies conducted by the European Federation of HVAC associations (REHVA) point to shading design and incorrect programming of ventilation (Nielsen, 2011). Many of these problems may be solved by ventilative cooling strategies (Kapsalaki & Carrié, 2015) but many others cannot; mainly because the night temperatures during most part of summer are not cold enough to permit free cooling (Rodriguez-Vidal, 2015) (Hidalgo-Betanzos et al., 2015). In regions with long periods of warm outdoor temperatures, the strategy requires mechanical cooling, insulation and air tightness. The draft of indicators includes a limitation of the solar gains in July, which obliges to implement design solutions which could help mitigate the overheating risk under daylight conditions. On the other hand, it is not clear whether the Spanish nZEB requirements will include any airtightness limit or not, but it could affect negatively the overheating prevention if not addressed well.

Regarding energy security and grid condition in Spain, the impact of nZEB buildings is not clear for now. The heating/cooling balance of these buildings should be greatly covered by on-site renewable energies, but any increase on the electricity demand at peak hours may be risky. The Spanish grid situation according to the electricity system operation and transport, Red Eléctrica, requires a reduction on the peak and valley hours' difference (RED21, 2016). The Iberian Peninsula is often considered an electrical island which requires a detailed management to avoid any supply failures (RED21, 2016). Additionally, it warns about the limited interconnection capacity remains in a weak 2.8 % with France and about the considerable difficulties to manage a higher renewable share than the present 36.9 % of annual energy demand (RED21, 2016). Besides, as a positive side-effect of the economic crisis, the grid and the power generation plants are not at full usage at present (Spain, 2017), and so the installed capacity seemed to be ready for upcoming nZEB buildings. Actually, the barriers for nZEB development are more related with administrative fees and limits for on-site power generation and the uncertainty of energy regulation frame for renewables. In any case, there is room for optimism because most of these issues are included in the objectives agreed in 2014 by the European Council about "2030 climate and energy policy framework" (European Council, 2014).

3. What is the Thermal comfort limits for nZEB in your country?

At present the thermal comfort in Spanish buildings is controlled by a regulation based on Fanger's model (RITE, 2013) and it doesn't consider for now the adaptive methodologies of EN15251. In the case of residential buildings, they don't need to provide any cooling as long as they demonstrate a low cooling need (below 15 kWh/m²/y). In the future nZEB regulation of Spain, it is expected to implement the thermal comfort in more detail. In European southern countries the limit of PH design on 25 ºC during less than the 10% of the time is not enough, because the combination of hot temperatures and high radiation create a high risk of overheating in the majority of southern countries. So, the overheating prevention has to be faced in a wider perspective. Many studies focused in overheating were summarized into the recent CIBSE TM52 publication about overheating risk (CIBSE, 2013) and established a three steps methodology to detect overheating risk in design. Concerning the maximum temperatures, it proposes a rounded limit for inside operative temperature in 28 ºC for no more than the 1% of the occupied hours.

The challenges related to thermal comfort in residential buildings are different from the ones present in tertiary buildings. Whereas offices and tertiary buildings can be cooled inside the ranges provided by the PMV/PPD method of Fanger, the residential buildings usually don't have any cooling systems and the upper limits are easily exceeded. In these cases, the buildings are free-running during the warm season and so the adaptive model of EN 15251 may be applied in theory. It is worth remembering the boundaries of EN 15251, 2007 for Annex 2 method: "*The operative temperatures (room temperatures) […] are valid for office buildings and other buildings of similar type used mainly for human occupancy with mainly sedentary activities and dwelling, where there is easy access to operable windows and occupants may freely adapt their clothing to the indoor and/or outdoor thermal conditions.*". Regarding these conditions in detail, there are two main problems for a real scale application: the long hot periods are very frequent in southern Europe and increase the upper limit up to barely acceptable 30 ºC easily (CIBSE, 2013); and also, the expected window opening is limited by problems like the noise in urban areas and the long unoccupied hours in residential buildings.

To face the first problem, usually designers implement ventilative cooling strategies (Kapsalaki & Carrié, 2015) but this is not always possible in southern European regions. For instance, Sevilla presents several months' average temperatures over 25 ºC, which led to an impossible night time ventilation for weeks and so require the installation of a cooling system. To some degree, this should be complemented by ventilative cooling strategies during the transition months of spring and fall, when possible.

To face the second problem, designers must prevent overheating risk with a realistic passive design, which faces the truth of inexpert users' behaviour and counts with consequent lower natural ventilation rates. In the end, every tenant or owner expect to keep their inside temperatures below a reasonable value during nights; this too hot limit may vary from one region to another by culture and tradition. The present building regulation (CIBSE TM52, 2013) did not require any bioclimatic measures like Window to Wall Ratio (WWR), g-values or shading coefficients. However as mentioned before, the future nZEB definition might also implement a parameter to quantify the envelope design, which may embrace some of these aspects as a way of boosting the passive design against other alternatives.

4. What is the minimum renewables threshold for nZEB in your country?

The present situation of renewable energies in Spain is uncertain. For now, the current regulation (Spain, 2012) limited the benefit of the electric production since 2012 and since then installation of new PV panels and CHP plans stopped. A further analysis of the economic impact of PV on Spanish grid shows an initial fast growth between 2007 and 2008 and a full stop afterwards (Azofra et al., 2016). They demonstrate how the PV production has a positive effect and opens future scenarios which may be applicable to nZEB PV context. Apart from his regulation restraint, the PV potential in Spain is great and so a great amount of the energy use of nZEB should be provided by PV panels or other renewable sources. It is still too early to set the minimum threshold without knowing the cost-optimal systems, but according to the guidelines of EU commission for Mediterranean countries (EU, 2016) the net production of renewable energies may be around 60 kWh/m²/y.

5. **What is the construction quality for nZEB in your country?**

The present method and regulation concerning Energy Performance Certificates (EPC) in Spain is explained and analysed in a recent report of Qualicheck project (QUALICHeCK, 2015), which indicates that the EPC often includes several critical errors in input data and final verifications which may became considerable barriers for future nZEB design. Among others, it is lacking reliable as-built data, on-site air tightness test, solar shading verification, etc. Thus, measurements and tests should be mandatory at least for certain cases where the non-compliance risk is higher until the construction sector adapts to the nZEB concept in upcoming years.

Regarding the quality control in buildings, some regions are improving the protocols to control the construction process, for example the Basque region. A thermal control guide has been recently published with a methodology to improve the quality control on-site. This work is the result of a collaboration between the Laboratory of Quality Control of Buildings of the Basque Government and the University of the Basque Country UPV/EHU (Hidalgo-Betanzos et al., 2016). This guide provides a method with a set of checklists to help improving the construction processes of the main building elements. To a great extent, this affects the final thermal performance, as explained in the reports of QUALICHeCK project. It comprises several crucial aspects such as thermal bridging, thermal insulation properties, window installations, ventilation systems, component testing and so on.

For now, the nZEB design should be aware about the real gap present in the theoretical development and the market situation. Probably a wise solution will tend to adopt mainly low-tech and well-known solutions as much as possible and keep the high-tech solutions only for extraordinary cases. For instance, residential buildings may not need any high-tech system, whereas many tertiary buildings may most likely demand high-tech solutions to be able to face the high internal gains or the strict thermal comfort control, like the required by hospitals and so on.

6. **What should be (your own recommendation) the minimum EE and RET in your country?** (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.7.4 presents the minimum threshold for nZEB:

Table 3.7.4: Different Minimum Performance Thresholds for nZEB

Categories	EE Threshold		RES Threshold*	Country
	Heating	Cooling		
Spain, residential	20kWh/m².a		60 %	**Spain**
Spain, offices	30 kWh/m².a	30 kWh/m².a	50 %	**Spain**

* Percentage of the total PE use, including heating, cooling, DHW, ventilation and lighting.

7. **Please list the three largest cities in your country representing the highest population numbers and representing different climatic zones in your country.**

Table 3.7.5 is a summary of the three biggest cities presented in Table 3.7.3.

Table 3.7.5: Climate data of Spanish three biggest cities

Biggest cities	Madrid	Barcelona	Valencia
Population	3.141.991	1.604.555	786.189
Main energy needs	Heating and cooling dominated	Temperate zone	Cooling dominated
Köppen Geiger	Csa	Csa	Bsk
Spanish climate	D3	C2	B3
HDD	2394	1902	1276
CDD	677	498	811

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4 BARRIERS OF NZEB IMPLEMENTATION IN SOUTHERN EUROPE

The 2016 European Energy Efficiency Directive requires that MS draw up national plans for increasing the number of nZEB and develop policies and take measures to stimulate the transformation of buildings that are refurbished into nZEB. According to the review results these are perceived as challenging targets and many MS are finding it difficult to match them. Southern European countries have their own technical and societal barriers, beside the economic barriers including fuel poverty that lead to a low implementation rate of nZEB and the status of high performance renovation is poorly documented (Attia, 2017; Boardman, 2013; Kontonasiou et al., 2016 and Santamouris, 2016). There are strong barriers for nZEB in the residential sector that play a significant role in the housing sector. We highlight below the most arduous barriers identified from the study.

- The first common barrier that appeared from the study is related to the particularity of geography and climate in Southern Europe. The climate in Southern European cities presents hot summer, intense solar radiation, recurrent heat waves and exacerbation of urban heat island effect due to climate change. The apparent temperature thresholds and solar radiation in the Mediterranean cities are high. Design and construction practice has generally failed in the last decades to merge the new construction materials and components with the consolidated bioclimatic concepts of solar shading, thermal mass and night ventilation. Design and construction skills of bioclimatic design have been mostly lost and summer comfort is objectively difficult to evaluate quantitatively and to grasp intuitively due to its intrinsically dynamic features (Attia, Hamdy et al., 2013). The potential and limits of passive strategies are often either overlooked or overestimated, with a general lack of objective assessment and optimised design. Poor design, construction, documentation and management are widespread in the standard construction practices of last decades and are not frequent still today. As a result, many residential and service sector buildings are frequently experiencing summer conditions, which are out of the comfort ranges, whatever comfort model is chosen (Attia & De Herde, 2011 and Pagliano & Zangheri, 2010), and /or suffer of other discomfort issues (glare from unprotected transparent surfaces, noise form air conditioning equipment, …). This situation decreases the overall wellbeing and productivity of building occupants and increases their vulnerability to health problems (Robine et al., 2008; Ciais et al., 2005 and Baccini et al., 2008). nZEB in Southern Europe need to be adaptive buildings addressing both heating and cooling seasons more properly. The lack of finding geographically and climatic (geoclimatic) adapted and performance proofed concepts for nZEB in Southern Europe makes it very difficult to define primary energy thresholds for nZEB and minimum comfort performance requirements. The correlation between climate change and overheating risk should be further investigated (Mcloed et al., 2013 and Pagliano et al., 2016). Well-being and comfort should be the primary goals of building design but quite often, contrary to energy performances, are not explicitly and objectively specified in the design scope and hence fail to be correctly addressed in the design and construction phases. Without clarifying the above issues, performance of new construction and deep renovation will remain vague and ineffective.

- A second common barrier that appeared from the study is methodological. The methodology used to implement nZEB in Southern Europe is partly related to **inappropriate use of rules of thumb or calculation-based design approaches** with little feedback from performance monitoring. Most building professionals and researchers in Southern Europe overly rely on steady state simulation tools to address the design and construction of nZEB and have no links to laboratory or field measurements or real performance monitoring. Based on the interviews feedback, there is a perception among professionals and building owners/occupants in Southern countries that static or semi-static calculations based on EN standards (e.g. those generally used for drafting EPCs) represent the real consumption of buildings. In fact, EPC levels granted to buildings are just made for benchmarking purposes and quality assurance; however, they do not represent the real expected building performance and EUI. At the same time, there are very little monitored case studies for nZEB in Southern Europe that assess the dynamic behaviour of buildings in relation to energy use for active space heating and cooling and passive cooling. The EN15603:2008 and the other EN standards allow for the calculation of energy needs for heating, cooling and hot water and energy use for lighting and ventilation of new building and retrofits. The relatively simple use of stationary or semi stationary calculation tools makes it seem possible to achieve nZEB in Southern European cities. However, those calculation tools are often used as design tools with high confidence of the building performance after construction (Attia, Hamdy et al., 2013 and Attia & De Herde, 2011) without an estimate about the degree of uncertainty deriving from uncertainties in the input values (outdoor weather file often outdated or not pertaining the exact location under study, building material properties, effectiveness of controls, effect of occupants behaviour, approximation of the software algorithms and of the geometrical description of the building,...). Comparison of the monitoring results shows that some nZEB do not perform adequately in terms of summer comfort (Mcloed et al., 2013) similarly to many of the conventionally designed buildings. Interpretation offered for the discomfort experienced in part of the nZEB were pointing at different ventilation and shading control patterns by the occupants (Mlakar & Strancar, 2011; McLeod et al., 2013 and Sameni et al., 2015). Even though Schnieders (Schnieders, 2009) found that in PH buildings "*the peak heating and cooling loads where also less pronounced and internal temperature fluctuations were lower regardless of whether active cooling was applied" he also warned that* "it is important to note that the differences in climates and the effects of individual building parameters are so large that a dedicated energy balance must be set up for every PH. The use of standard values for different buildings is not appropriate" (Schnieders, 2009). This supports the hypothesis that the energy gap and overheating risk are possibly related to **theoretical design approaches** that are based on an improper use of calculation methods with an overreliance on the numerical results without a critical view which includes an estimate of uncertainties. A better communication on the role of EPBD calculations and EPCs is further needed.

- Lastly, national and local authorities in Southern European countries often **lack local governance and a national strategy to create an infrastructure for nZEB implementation**. One of the main barriers to nZEB market uptake is the weak human infrastructure. By human infrastructure we mean:
  i) local authority officials dealing with buildings permits and energy performance certification,
  ii) building professionals/researchers dealing with the design and constructions process,
  iii) and industrial stakeholders dealing with products manufacturing and supply.

- In many cases, local authorities are not in contact with local research centres to deepen their understanding of nZEB and their implementation requirements. As a consequence, little effort has been done to provide local guidelines for nZEB procurement. The strong climate variation in some countries requires flexible and regional climate performance requirements for nZEB. For example, the heating and cooling balance in Northern Spain is not the same as in Southern Spain. For the nZEB definition, descriptive parameters should be clearly identified, but their mandatory target values should be carefully tuned to the individual climates. In this context, many local authorities are not prepared to lead this transition. Also, many building professionals cannot lead the nZEB implementation process from design to construction to meet the expected market demand (Garthley et al., 2017 and Sameni et al., 2015). Even architects and engineers who opt to comply with the PH standard face serious challenges with implementation due to the lack of vocational training and capacity building for nZEB. There are several multidisciplinary actors that should be involved in nZEB implementation and not only engineers, adding to the complexity of the process. In many investigated cases, there are no national or regional strategies to empower consultation, builder's skills and construction services for new and renovated nZEB. Most contractors in the South are far away from nZEB best practices and technical construction accuracy. Finally, the construction industry is not prepared with experience and products to deliver and supply the expected market demand. The sustainability business is fundamentally based on local industrial infrastructure of systems, products and national energy mix. In relation to the first barrier, most national industries in Southern European countries, are, on average, not well positioned to cater for high-tech buildings requiring innovative products, systems and solutions aligned with the national energy mix and carbon emission reduction targets. So, overall, the top down legislation framework and targets set by the European Directives were insufficient to stimulate the development of a national and local bottom up environment of human and industrial infrastructure to carry out the transformation of building practices. The above difficulties and barriers should be successfully addressed as a prerequisite condition for allowing the construction of a successful set of new nZEBs and for achieving the deep renovation of the existing buildings stock in Southern European Countries, which form more than one third of the EU total building stock, (BPIE, 2017).

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5 DISCUSSION AND CONCLUSION

After presenting the results of our meta-analysis above, we would proceed to discuss the outcomes of our research. In this section, we identify the key study findings and developed a series of recommendations towards a higher market uptake of nZEB in Southern European Countries for new construction and retrofits. The market of nZEB in Southern Europe is in the predevelopment phase. The next step of the market development process would be the take-off phase before the acceleration phase and finally reaching the stabilization phase. In order to balance the presented overview on the current state of implementation of nZEB and their technical and societal barriers, we present a group of recommendations. The recommendations can provide future perspective for policymakers, funding agencies (including the national banks and the European Investment Bank) and building stakeholders, with regard to the transition phases and development of nZEB. The following discussion highlights the key study findings and elaborates on the study strength, limitations and future work.

5.1 Study Findings

Our assessment indicates that three main technical and societal barriers impede the market uptake of nZEB in Southern Europe. We think that the introduction of the EPBD, EPCs and the nZEB performance target and regulations happened fast for most Southern countries which did not manage to keep the pace to build up local knowledge and infrastructure, given the parallel budget restrictions under the Maastricht rules. This is an alarming conclusion, because if we add up to those barriers the financial barriers related to the cost-optimality, which are out of this study scope, we can confirm that the Southern European countries are likely not to be ready for an effective successful implementation of the nZEB target. Obviously, there is a lack of understanding of nZEB's performance in Southern Europe, disparity in the use of performance indicators, and the dependence on a virtual calculation approach that is not based on an experimental approach of building monitoring. As a consequence, there are no clear functional concepts of nZEB that can help to set up a definition and implementation strategy. The use of static calculation-based design approach is insufficient in a cooling and heating dominated region. However, we believe that the root cause of those barriers is the lack of sufficient funding of human infrastructure which is namely the:

i) procurement officials and technical staff in local authorities,
ii) building professionals/researchers and
iii) research and technical staff in industrial stakeholders in most Southern European countries.

Ironically, the European Union, the European Investment Bank and national governments in Southern Europe focus on supporting and financing the implementation of nZEB without focusing on the enforcing and enabling human infrastructure (problem root cause) that should understand and define nZEB's performance before carrying them out.

5.2 Study Recommendations

In Southern Europe, the challenge of embracing the nZEB concept is technical, societal, and organizational before being economical. The nearly-zero energy target is a good idea to improve the IEQ and EE of new buildings and the existing building stock. According to our interviewed experts, Southern European MS are looking to embrace this target. However, the challenge remains on how to reach it. As part of this paper's scientific contribution, we classified and grouped a series of recommendations under five major topics. This includes suggestions for nZEB performance threshold in Southern Europe's MS.

Technical Development

A prerequisite for any technical should be based on a common regional framework and terminology. We recommend a systematic use of EN/ISO definitions of energy levels in both technical and policy documents in order to facilitate the work and reduce costs of design and construction firms. MS should make clear and explicit requirements for low energy needs for heating and cooling in their national implementation of the nZEB concept. Reaching nZEB requires that we change our rules of thumb and design assumptions of the real potential of bioclimatic architecture and passive design in mixed-mode and cooling dominated climates. We need new and different concepts that are geoclimatically developed respecting climate sensitivity and avoiding overheating risks. This includes developing the definitions and performance requirements for nZEB in Southern Europe. As part of our research, we present in Table 5.1 some performance threshold suggestions for nZEB in Southern Europe's Member states. We suggest the minimum EE and RET production across the investigated countries. Table 5.1 lists the suggested performance thresholds based on the input provided by national experts. In complementarity with Table 5.1, we recommend using the adaptive comfort model EN 16798-1, formerly known as EN 15251, in all Southern Countries. We need to develop nZEBs that are energy efficient and also healthy, comfortable and that meet relevant IEQ requirements. We advise MS to continue developing national adaptive comfort requirements backed by field measurement and surveys in relation to fuel poverty. It is substantial to reach a consensus on the definition of nZEB for new and retrofit of existing buildings among Southern European member states.

Table 5.1: Suggestion for nZEB performance threshold in Southern Europe's Member States

Country	Climate Zone	Min. Energy Efficiency: Energy need for Cooling kWh/m².a	Energy need for Heating kWh/m².a	Primary Energy kWh/m2.a	RES share	Summer Climate Cities	2010-2015 CDD 25°C	HDD 20°C	Latitude	Altitude
	1					Larnaca	125.7	1051	34.5°N	26m
	2					Nicosia	304.2	1253	35.1°N	220m
Cyprus	1	100-120	15	100	30%	Paphos	29.3	1039	34.8°N	72m
	4					Prodromos	8.5	2831	34.6°N	1380m
	H1a					Paris	75	2294	48.8°N	35m
	H1b					Strasbourg	123	2843	48.5°N	150m
	H1c					Lyon	155	2142	45.7°N	200m
France*	H2b	5-20	5-20	50	50%	Nantes	57	2063	47.2°N	26m
	H2c					Toulouse	158	1777	43.6°N	150m
	H3					Marsilia	257	1381	43.2°N	42m
	D					Kozani	51	2844	40.3°N	710m
	C					Thessaloniki	135	2110	40.6°N	7m
Greece	B	80	80	100	25%	Athens	228	1321	38°N	194m
	A					Iraklion	115	1064	35.3°N	35m
	A					Lampedusa	368	1060	35.3°N	20m
	B					Palermo	362	1570	38.1°N	14m
Italy	C	15	15	120	50%	Napoli	336	1803	40.5°N	72m
	D					Rome	234	1405	41.9°N	13m
	E					Milan	168	2439	45.2°N	121m
	F					Bolzano	245	3552	46.5°N	262m
	1	0	30			Porto	27	1250	41.9°Nx	94
Portugal	2	15	40	33	50%	Lisbon	61	1093	38.8°N	114m
	3	30	70			Faro	77	606	37°N	72m
	1					Constanta	151	2363	44.2°N	40m
	1					Timisoara	223	2595	43.2°N	87m
Romania	2	15	15	120	10%	Bucharest	261	2633	44.4°N	77m
	3					Cluj-Napoca	134	2974	46.7°N	380m
	4					Brasov	0	6876	45.6°N	610m
	D3	10	10			Madrid	106	2306	40.4°N	667m
Spain	C2	10	10	60	60%	Barcelona	53	1597	41.3°N	12m
	E1	5	15			Burgos	1	3407	42.2°N	859m
	A4	15	5			Huelva	141	1205	37.2°N	24m

According to Table 5.1, there is a disparity between the different suggested energy need thresholds mainly for cooling ranging from 5 to 100 kWh/m^2.a. This means that the energy needs for cooling remain significant in Southern Europe. Therefore, we recommend predisposition elements for passive cooling systems or efficient active cooling systems and integrate them in the design as backup systems for extreme heat periods. With climate change, Southern Europe will be exposed to intense and longer heat waves. After having reduced solar and internal gains, integrating passive cooling systems, such as ground exchangers, evaporative cooling, night sky radiation or correctly sized efficient active cooling, in the current nZEB definition and design is better than avoiding it and leaving users to do it themselves. Potential and limits of passive cooling strategies should not be either overlooked or overestimated, but rather be subject to careful and uncertainty-conscious design and monitoring-based assessment, in order to objectively face the challenges created by climate change, dense urbanisation, noise pollution, air pollution and population ageing.

Organizational – Harmonizing and Sharing

We need to harmonise actions between Southern Countries. The advantage of Southern European countries is that they consider the knowledge transfer between the MS as a mean to cross many barriers associated with nZEB implementation. The creation of an nZEB observatory for Southern Countries will help to create a database of monitored nZEB. EPCs and monitored data on real case studies needs to be collected, quantified and better shared. This can help in generating and consolidating regional knowledge and expertise taking stock from the Northern strongly influenced concept of nZEB, but enriching and adapting it to the variety of southern climates. Also, we should take into account European building related standards and norms, in order to address indoor environmental quality and the environmental impact assessment of materials. Private rating systems and standards, such as the PH, LEED, DGNB and BREEAM or others, can also encourage the holistic design/build/operate approach through integrated project delivery processes, which is very important to foresee the future regulations related to well-being and environmental product declaration. We should consider the knowledge transfer between Southern MS as a good starting point to increase the knowledge uptake and accelerate the implementation of nZEB.

Organizational – Infrastructure

On the organisation level, we recommend to take strong action for developing the needed human and industrial infrastructure for nZEB implementation. The empowerment of scientists, professionals, industrial stakeholders, policy makers and local authorities in Southern Europe makes them able to embrace the new transition. For example, we recommend empowering building researchers and allowing them to develop monitoring based concepts and definitions of nZEB and long-term case study analysis and reasoning (Garthley et al., 2017). This includes the generation of new weather files (using recent hourly climate series and simulations of future climate with regional models (Pagliano et al., 2016)), climate comparisons, guidelines for passive cooling and efficient active cooling systems, grid interaction models and prepare for the following deep renovation challenge. This step involves creating an industrial strategy to empower the local industry to produce and supply buildings with ultra-efficient products and materials. We need new and different building design concepts that are geoclimatically developed respecting climate sensitivity and technological state of progress. Locally or regionally manufactured building components, products and materials should lead the market transformation.

Legislation and Enforcement

Legislation should be based on an evidence-based policy strategy. Legislation must require permits and certification for renovation as well as new constructions which are capable to trace the renovation status, which is presently subject to extreme uncertainty, and building stock energy performance. This includes ensuring quality of construction works through quality checks, compliance procedures and proper commissioning. A project like QUALICHECK is a very good start to achieve the reliability of EPC declarations and the quality of the works (QUALICHeCK, 2017). The project ensures better enforcement and refurbishment in the frame of the revised EPBD, to create regulatory conditions to ensure better IEQ. This can also be achieved by ensuring regular inspections and continuous commissioning of passive systems and technical building systems of nZEB to maintain the envisaged IEQ parameters, EE, and RES production. This work should be tackled on a Pan-European level to unlock the relation between tenants and owners and support the acceleration of renovation rates.

Educational – Awareness

More attempts are needed to raise the awareness about energy neutral buildings and to discuss the strategic approach of SMEs to develop a suitable conceptual model for nZEB in Southern Europe. Professional education can bring advanced concepts and technologies to SMEs. We recommend better preparing the building professionals and providing vocational trainings while simplifying the design and construction process of nZEB. This includes educating professionals and one shop service providers and builders. Networking and awareness rising can bring various forms of strategic alliances, in addition, a strategic framework for improving nZEB quality and profitability for SMEs.

Regarding citizens, the rate and depth of renovation will increase when the added value (ecological and economical) will seem obvious to tenants and owners. In parallel, we suggest creating cooperatives with a focus on renovation service to members to provide strong direction towards deep renovation and to bring capital and investments for middle and large nZEB renovation projects. Evidence suggest that a part of the solution to speed up the uptake of nZEB and renovation process is to make energy neutrality of buildings desirable, and to use it as a self-esteem and social status perspective (Garthley et al., 2017 and ZEBRA 2020, 2017).

5.3 Study strengths, limitations and future research

The methodology used in this paper was based on interviewing national experts from seven South European countries. We tried our best to find representative experts, however we focused mainly on researchers coming from national research institutions such as universities and research centres. In this case, the statistical representation cannot be claimed. The overview provided by experts is therefore prospective and our analysis and recommendations are experience based working hypothesis but need to be enriched and confirmed with further analysis. However, this study aims at covering a lack of cross comparison on the current trends and state of nZEB implementation in Southern Europe. This is very important because Southern Europe's buildings stock represent more than 33% of the European total residential building stock. Our identification of the main barriers of nZEB implementation and market uptake status identifies a common pattern in Southern Europe, which is in line with other studies including the ZEBRA2020 project (Hauge et al., 2013). We believe that we are in a transitional phase and facing new phenomena of building transformation and creation in Southern Europe. Therefore, we created an overview and adopted a critical approach to better understand nZEB and their implementation and more importantly, encourage the development and set up of local and climate adaptive models and concepts of nZEB. The strength of the study relies on its findings that reveal a misunderstanding of nZEB, regarding their energy and comfort performance in Southern Europe, and the lack of essential analysis of the nature of nZEB in Southern Europe. At the same time, the study suggests new recommendation and performance requirements that can help in supporting the decision making on a European and national level. Policy makers and funding agencies should respond accordingly and recognize that a full infrastructure needs to be deployed in Southern Europe, adequate to the urgency of the 2020 deadline. At present, nZEB in Southern Europe are to a certain extent more a research object than an actual implementation issue, which imposes new obligations on policy makers and funding agencies.

The next step for this research will be the cross comparison of representative low-tech and high tech nZEB case studies in Southern Europe. We aim also at including other countries in Southern Europe. We hope that the future work will start with the development of nZEB proofed concepts and definition to derive recommendations and strategies for the building industry in order to move to the large-scale implementation and accelerate the market uptake of nZEB.

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Figures' Index

Tables' Index