# Africa-Europe BioClimatic buildings for XXI century

## POLICIES SUPPORTING PASSIVE AND BIOCLIMATIC APPROACHES AND THE DEVELOPMENT OF LOCAL MATERIALS IN NW-AFRICA & EU

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# ABC 21 project

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The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 894712.

# Document information

| | |
|---|---|
| **Name:** | Report on policies supporting passive and bioclimatic approach, and development of local materials and production chains in North-West Africa and EU |
| **Date:** | 31.08.2021 |
| **Work Package:** | WP2: Analysis of needs and potentialities in the building sector |
| **Task:** | Task 2.4 – Review of policies supporting passive and bioclimatic approach, and development of local materials and production chains in N-W Africa and EU |

# Authors



| Name | Email | Institution |
|---|---|---|
| **Lorenzo Pagliano** | lorenzo.pagliano@polimi.it | POLIMI |
| **Camilla Rampinelli** | camilla.rampinelli@e-sieben.at | e7 |



# Revision

| Version | Date | Author | Description of changes |
|---|---|---|---|
| 1.0 | 25.08.2021 | Lorenzo Pagliano - Camilla Rampinelli | |

# Executive Summary

We review in this report some successful or promising policies which might be effective in promoting highly comfortable buildings with minimal *energy need for heating and cooling, total primary energy use*, and *non-renewable energy use*, with a particular focus on summer comfort and cooling dominated climates. At the same time we consider also policies and institutional frameworks for the promotion of the use of local, low impact materials.
The focus of the analysis is methodological: the aim is to highlight some key points which might be useful in developing or assessing policies.

Some national implementations of the European Energy Performance of Buildings Directive (EPBD) are analyzed according to a set of criteria, e.g.

- uniformity in definition of overall building performance when expressed in terms of *energy needs, delivered energy, total* or *non-renewable primary energy* , as univocally defined in EN-ISO 52000 – 2017.
- explicit choice of a comfort model which might favor the use of the bioclimatic approach, with reference to the most recent standards e.g. ASHRAE 55-2020.
- use of physical energy balance rather than a nominal net zero balance over a year.

Europe (as the rest of Globl North) has developed standardised building archetypes relying heavily on materials of high embodied energy (concrete, steel, glass) and raw materials which are getting scarce. We review some experience and policies applied in Africa for qualifying and supporting bio and geo locally sourced materials.

For both continents, policies to support bioclimatic architecture under the XXI Century conditions will likely have to go beyond the building itself and involve district and city levels. Within the future climate, which will bring longer and longer periods of high temperature in summer, exacerbating the heat island effect in cities, efficient design and operation of buildings will be strongly connected with enabling/hindering conditions in cities. We present a matrix of interaction of policies aimed respectively at building and district level with a view of highlighting the necessary synergies.

As for financing economic incentives and support programmes, the report discusses:

- ways to finance: via debt or general taxation versus via a levy on energy carriers, with their respective implications on state budget and stability of industrial policy over time
- ways to establish a priority of investments with a focus on short term (indicators as Payback-time, marginal cost, interest rate form the private perspective…) or on reduction of risks and reduction of long term costs (full consideration of environmental and social externalities, internal rate of return, cost of conserved energy, interest rate form the society perspective…)

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# 1. INTRODUCTION

We review in this report some successful or promising policies which might be effective in promoting highly comfortable buildings with minimal *energy need for heating and cooling*, *total primary energy use*, and *non-renewable energy use*, with a particular focus on summer comfort and cooling dominated climates. At the same time we consider also policies and institutional frameworks for the promotion of the use of local, low impact materials.
The focus of the analysis is methodological: the aim is to highlight some key points which might be useful in developing or assessing policies.

EU has created via its Directives a legislative infrastructure (mandatory Building performance certificates, cost optimal methodology, mandatory nearly Zero Energy Buildings, National renovation plans) and support actions (e.g. Framework Research Program, H2020, fiscal and incentives to energy efficiency in many states, ...).
Voluntary labels like Minergie and Passivhaus, in certain cases used by local governments as *de facto* standards have favoured innovation and high-quality materials and components.

But also important limitations have been created by a nonuniformity of nomenclature across among Member States, and the parallel nonuniformity in definition of overall building performance when expressed in terms of *energy needs, delivered energy, total* or *non-renewable primary energy* , as univocally defined in EN-ISO 52000 – 2017. This creates a barrier to effective communication and comparability of performances of design approaches and techniques. Other approaches have taken more the road of giving the building sector precise guidance on the performance of single elements, with a clear focus on the envelope, as e.g the obligations on g-value of solar protections and on thermal mass in Switzerland.

We aim at analyzing whether some of the above policy tools may be relevant in a different context where there is high pressure from the need for affordable new housing e.g. in N-W Africa.

On the other side Europe has developed an architecture relying heavily on materials of high embodied energy (concrete, steel, glass) and raw materials which are getting scarce. It becomes urgent to explore how policy initiatives may promote geo and bio sourced materials in Europe, possibly taking inspiration of experiences in Africa, in particular in the NW.

For both continents, policies to support bioclimatic architecture under the XXI Century conditions will likely have to go beyond the building itself and involve district and city levels. Within the future climate, which will bring longer and longer periods of high temperature in summer, exacerbating the heat island effect in cities, efficient design

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and operation of buildings will be strongly connected with enabling/hindering conditions in cities. E.g. the use of night ventilation in summer to achieve comfort without using air-conditioning are dependent form the level of noise and air pollution, on the use of cool materials for urban surfaces, on shading and presence of vegetation at district level.

Hence legislation and policies able to guide land planning procedures in a direction favorable to bioclimatic architecture are relevant for the future. Policies for mobility in a situation of rapid urbanization as in many African countries might profit of EU experience and jump forward with creativity by avoiding the car-centric design which many EU cities are now working hard to reverse, in certain cases with rapid results (e.g. Paris, Bruxelles,…).

## 1.1 Scope and objectives

Based on the analysis performed in the parallel work for preparation of D.3.1., (energy) D.3.2. (comfort), which has shown the recent progress in the definition of low and zero energy buildings and the development of comfort models, a series of criteria are derived for the analysis of current policies and the formulation of forward looking ones. For a summary of D.3.1., (energy) D.3.2. (comfort), see the deliverables themselves and the presentation of the keypoints in the webinar (Energy and comfort assessment in buildings: important new advances introduced in international standards. Which implications arise for EU and African policies?) held at eceee conference.

Those criteria might be summarized, for clarity of presentation and communication in form of a list of questions:

- do policies EXPLICITLY mandate reductions of "*energy needs for heating and cooling*"?
- Do policies promote reduction of *total primary energy* use and not only of *non-renewable primary energy* use, do they promote low and zero energy balance with a physical or fictional accounting approach?
- do policies explicitly refer to the *Adaptive comfort* model?
- do policies allow and promote use of air velocity as key factor for summer comfort?
- Do policies correctly consider both stationary parameters (e.g. *stationary thermal transmittance*) and dynamic parameters (e.g. *periodic thermal*

*transmittance*, phase shift and attenuation of heat wave through walls and roofs)?

- Do policies promote physical and regulatory frameworks that enable low-energy life-styles?
- do policies promote clean, silent, low temperature districts where to build?
- do policies support a "societal point of view" in investment analysis? e.g. using "cost of conserved energy" or Internal rate of return rather than (short time oriented) payback time as indicator? Societal discount rates (e.g. 1-2%) rather than private discount rates (e.g. 5-10%)?
- do policies include external costs (pollution, health damage) in calculating the optimal level of *energy needs* or energy performance of buildings to be enforced?
- Do policies support the conscious and skilled use of local materials and their integration in the design and construction workflow?
- In general, do policies support the adoption of bio-climatic approach and passive tecniques in general terms or via precise, verifiable approaches and parameters as e.g. the above mentioned ones?

## 2. BACKGROUND AND OBJECTIVES

The recent IPCC's Sixth Assessment Report (AR6)1 on the physical science basis of climate
change concludes that "It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. …
Since 2011 (measurements reported in AR5), concentrations have continued to increase in the atmosphere, reaching annual averages of 410 ppm for carbon dioxide ($CO_2$), 1866 ppb for methane ($CH_4$), and 332 ppb for nitrous oxide ($N_2O$) in 2019….
The scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years. … In 2019, atmospheric $CO_2$ concentrations were higher than at any time in at least 2 million years (high confidence), and concentrations of $CH_4$ and $N_2O$ were higher than at any time in at least 800,000 years (very high confidence).
Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since AR5. "

Under such dramatically shifting boundary conditions, policies should evolve creatively and as quickly as possible. In particular, countries under strong and rapid devolution might profit of previous experience (positive and negative) to leapfrog towards new policies able to strongly participate to mitigation at global level and to embed from the start adaptation to future climate needed at local level.

Currently energy efficiency and, more recently, energy flexibility drive the policy practices to achieve high sustainability goals, e.g., in a heating dominated period a clever utilization of thermal mass may allow one to manage the building as a thermal battery over a time frame of a few days rather than hours, if the building fabric is highly insulated and high efficiency heat recovery on ventilation is applied. Therefore, in the case of existing buildings, the path of deep renovation focused first at improving the building fabric can be a prerequisite enabler. This flexibility (in new or retrofitted building fabrics) allows dealing with the challenges linked to the intermittent nature of many renewable energy sources and their exploitation at the level of a cluster of buildings. Given the need of a means of storage from the daily to the interseasonal scale, a strong reduction of *energy needs for heating and cooling* via efficiency techniques and physical and regulatory frameworks that enable low-energy life-styles might prove decisive. This would reduce the size of the required storage and the connected embedded energy and energy losses.
At the same time, a strong reduction of *energy needs* and hence of the physical infrastructures required to serve those needs, appears as a fundamental step for achieving the international goals related to halting land consumption. The United Nations

Sustainable Development Goal (SDG) indicator 11.3.1: "Ratio of land consumption rate to population growth rate" postulates that when this ratio is high, such a "growth turns out to violate every premise of sustainability that an urban area could be judged by". In Europe, where population is projected to remain stable or even slightly declining throughout this century [21], the EU institutions have taken a commitment to be "a frontrunner in implementing [ . . . ] the SDGs" and to aim at "no net land take by 2050" [22,23]. On 29 April 2021 the European Parliament approved with a majority of 605/660 a resolution asking the EU Commission to draft a new directive for the protection of soil with the objectives of "no land degradation" by 2030 and "no net land take" by 2050 at the latest. The inclusion of land protection objectives might be quite important also for Africa, to face climate instabilities affecting food production and the doubling of population foreseen in the next few decades.

## 2.1 Supporting policies for Bioclimatic and passive approach

### Building level

Bioclimatic approach with its reliance on passive technologies is by definition a solution to the goal of mitigation (by minimizing use of active systems requiring an external – mostly fossil in last century – source of energy) and the need for some adaptation (by creating indoor and outdoor spaces which provide comfort just with passive interaction with the surrounding environment).
Recently the concept of "passive survivability" by the LEED certification framework rephrases what has been the objective of vernacular architecture for centuries and was made explicit and conscious by the work of bio-climatic researchers and pioneers of XX century (Baruch Givoni, Victor Olgyay, Laurie Bake, Assan Fathy…)

Use of local materials with low embedded energy and little environmental impact has also been a necessity for centuries and after being abandoned is making a come back at meany levels, including high quality, conscious architecture as e.g. Anupama Kundoo, Francis Kere, Mass group are practicing. Those approaches have the potential to overcome the aura of modernity constructed around standardized and architecturally poor construction typologies which became prevalent in the OECD countries during the last decades of XX century and are now often used as models in developing and emerging countries.

### District/urban level

The cultural shift needs to be appreciated and incorporated in policies not only at building level, but also at district/urban level. This is part of the philosophy and physics of bio-climatic architecture and was made explicit since the beginning e.g. in the seminal work of Baruch Givoni [1] [2], Hassan Fathy [3], Louis Soulier [4],…
The challenge of sustainable development of urban areas is of key importance for both Africa and EU. The European Union has defined an ambitious strategy and

implementation plans to make cities inclusive, safe, resilient and sustainable, in accordance with the 2030 Agenda for Sustainable Development of the United Nations [5]. Ongoing and foreseen accelerated urbanization in many areas of the world, including Africa, interacts with other challenges, including rapid population growth, age structure of population , climate change, environmental quality and access to energy [6]. Urban and regional planning is called to reassess how to sustainably supply the population with the needed services at an affordable cost. Reflecting this, urban actors and scholars have created a number of city labels, such as “sustainable city”, “smart city”, “green city” and “resilient city”, to represent cities’ responses to various challenges of urban transformation. Among them, the ‘smart city’ has prevailed as the most researched concept in the recent period [3], even if it is sometimes presented as being focused only on the application of information and communication technologies (ICTs) and leaving in the background a number of issues related to building physics and space and social organization. Most recently a “15 min City” concept has been presented that proposes fundamental changes in urban planning aimed at redesigning neighborhoods so that individuals can reach the school, workplace, groceries, sport and recreational sites, etc., within a 15 min travel distance, either by bike or on foot [4,5].

| **Sufficiency Actions in Buildings→** | **Summer Night Ventilation and Ceiling Fans Rather Than Air Conditioning** | **Summer Night Ventilation Rather Than Air Conditioning** | **Adequate m$^2$ per Capita Floor Space** | **Adopt “Sufficient” Mobility Modes: Bicycle, Walk, Public Transport** | **Line Drying and Water/Hot Water Saving** |
|---|---|---|---|---|---|
| In order to perform sufficiency actions, inhabitants would need→ | Silence at night, clean air | External air temperature < 20 °C at night | Pleasant common indoor/outdoor spaces (shared guest rooms, music rooms, office space, playing spaces for children, etc.) to reduce the need for individual volumes | Easy access to services, schools, work and coworking spaces, equally distributed in the city; independence of movement for children and elders | Well-designed spaces for line-drying, installed water saving devices. Comfortable showers in place of bathtubs |
| Presently cities create constraints→ | Noise, mainly from cars and motorcycles. PM10, PM2.5 pollution and other air contaminants | Asphalt, city canyons | Inhospitable districts, obligation for car parking spaces at buildings and free car parking on streets | Distance between functions, unacceptable risks for cyclists, pedestrians and persons with disabilities | Dust in air |
| Cities should offer enabling conditions→ | Car-free residential districts and zones at 20 or 30 km/h | White/cool surfaces. Geometries facilitating air movement. Water surfaces and urban vegetation | Walkable, cyclable districts, green spaces, spaces for playing and spaces in the building for common activities | Equitable access to street space and equal access to various transportation modes | Information campaigns on water saving devices and on the high quality of drinking water from the tap |
| Legislation and Regulation shouldaddress→ | Objective and adequate temperature and humidity set-points in regulation. Limitations to car number and to speed limits to 20–30 km/h | Mandatory white/cool surfaces, mandatory external solar protections (as, e.g., in Switzerland) | Minimum requirements of green spaces and of common spaces for meetings | EPBD (and national build codes): mandatory protected spaces inside buildings for bicycles, wheelchairs and strollers | Mandatory spaces for line drying, mandatory labeling of low-flow water devices, mandatory showers rather or in addition to bathtubs (with access at the same level of the floor for easy access by aging population) |

**Table 1. Interactions between policies to support reductions in energy use at building and district/city level. Both types of policies might concur to support the uptake of the bio-climatic approach Source: [7]**

# 3. POLICY FRAMEWORK IN THE EU AS EXAMPLE OF POLICIES FOR LOW ENERGY USE IN OPERATIONAL PHASE

In the Commission work programme for 2021, the revisions and initiatives linked to the European Green Deal climate actions and in particular the climate target plan's 55 % net reduction target are presented under the Fit for 55 package.

The European Green Deal, presented in the communication (COM(2019)640) of 11 December 2019, sets out a detailed vision to make Europe a climate-neutral continent by 2050, safeguard biodiversity, establish a circular economy and eliminate pollution.

In her 17 September 2020 State of the Union address, the Commission President Ursula von der Leyen proposed the emissions reduction target for 2030 to be set at 55 %, alongside a revision of the EU's climate and energy legislation by June 2021, a target of spending 37 % of the €750 billion NextGenerationEU recovery fund on Green Deal objectives, and the intention to raise 30 % of the NextGenerationEU budget through green bonds.

The Commission adopted the communication 'Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people' (commonly known as the 2030 EU Climate target plan), on the same day. It also includes an updated 2030 emissions reduction target of net 55 % compared to 1990 levels, from the current 40 % emissions reduction target.

Revisions of all the main Directives addressing energy (Energy Performance of Building Directive, Energy Efficiency Directive, Renewables Directive) are underway and foreseen to be completed during 2021 or beginning 2022.

Connections between buildings and mobility (hence districts/cities) have appeared for the first time in the latest version of the EPBD , where art 8 and recital 28 ask for holist urban planning, creation of spaces for bikes in buildings,… and might be clarified/reinforced in the upcoming revision, also under pressure by environmental groups (e.g European Cycling Federation)

At the same time at EU level work is ongoing to develop a framework definition of Positive Energy District (PED) and Key Performance Indicators for measurable PED comparison, that can support the development of 100 PEDs by 2025 and beyond; a plan for 100 climate-neutral EU cities by 2030 is also being developed.

## 3.1 Standards on comfort and energy performance

Thermal comfort analyses have inspired the development of several models in the last fifty years [1,2]. The most adopted thermal comfort models are the so-called rational comfort model developed by Fanger [3], the ASHRAE adaptive comfort model developed by de Dear and Brager [4,5] and the European adaptive comfort model developed by Nicol and Humphreys [6]. Fanger's thermal comfort model, often referred to as the PMV/PPD model, was built on experiments involving exposure of subjects to steady-state conditions in climate chambers and considered the occupants to be passive receptors detecting the surrounding envi- ronmental conditions. On the other hand, the adaptive comfort theory has been developed from field studies and considers the building occupants as active agents interacting with their built environment [7].

These models have already been integrated into several standards, such as ASHRAE 55 [10] and EN 15251 [11] (now EN 16798-1 [12]), which have also undergone several revisions [13].

The thermal comfort standards offer information for using their respective models in the design phase of new building projects or in the renovation of existing constructions, as well as when assess- ing the performance of existing buildings.

The interpretation and application of the comfort standards have important practical implications [14]. In particular, there is an urgent challenge to strengthen policy actions in the context of summertime conditions under increasingly extreme temperatures: energy use for space cooling is rapidly growing [15], and the sum- mer comfort issues are increasingly difficult to tackle due to cli- mate change and exacerbation of urban heat island [16–18].

The publication of the second ASHRAE Global Comfort database has made available in a coherent way and in one single database the wealth of data collected in real buildings in the last decades and has been one of the basis for the recent update of ASHRAE 55, which incorporates some recent findings on comfort very relevant for the bioclimatic design.

In particular  the role of air velocity in providing comfort in summer also at relatively high temperature and humidity levels is clearly shown in analytical and graphical format.

Similarly, the publication of EN- ISO 52000 part -1 and part -2 has made available clearer definitions of energy levels and examples of ways of defining overall performance and nearly zero energy buildings.

It is important to analyze how much of these advances are captured in policies, legislation and regulation as a prerequisite for their widespread adoption in design and construction practices.

### 3.2 Energy performance of buildings (EPBD) and a distinction between : nearly Zero Energy Building (nZEB ) and Net Zero Energy Buildings (NZEB)

The definition of low or zero energy buildings has been discussed in literature and introduced in legislation in various forms. It is important to analyze which type of definition might better match objective, measurable, physical targets and serve the promotion of bio-climatic architecture. A rational definition for buildings might also be a basis for a rational definition for districts.

In order to allow for a clear analysis , discussion and communication, we propose to keep a distinction between the definition of *nearly Zero Energy Building* (**nZEB**) given in EPBD and the *Net Zero Energy Building* (**NZEB**) terminology used in some other literature with many different definitions [Attia et al, 2017].

E.g. Italy has chosen not to use compensation for exported energy to the grid, apart from what unavoidable due to the fact that the calculation method is based on a monthly time step. In the wording of EN-ISO the situation might be described by saying that the parameter kexp is set zero in principle, but slightly higher than zero in practice due to the monthly calculation method.

In order to describe the extent to which Member States might choose to consider the accounting of exported energy as a compensation of energy use, the standard EN-ISO 52000 introduces a $k_{exp}$ factor, variable between 0 and 1. A value $k_{exp} = 0$ describes the absence of compensation, a value $k_{exp} = 1$ describes the situation where each unit of energy exported compensates for one unit of energy used. Intermediary situations are possible.

The opposite situation, where all energy exported over a year can be used to compensate (offset) energy taken from the grid over a year coincides with some of the definitions of **Net Zero Energy Building (NZEB),** where "net" is intended as difference between energy use and energy generation or , equivalently between delivered energy and exported energy, all quantities being considered **over a period of a year**. In this case the parameter kexp is set to 1.

Since details are what mattrers and makes the difference in effectiveness and impact of the various formulations, in order to illustrate in a clear way what are the issues, potentialities and risks connected to the choice of a specific definition, we analyse here a case of legislation from a European country, namely Italy, based on data and analysis from the H2020 project AZEB [8].

## 3.3 An example of national implementation of EPBD, with potentialities and limits

### Italian implementation of EPBD an nZEB definition

In Italy, a nZEB is defined according to DM 26/06/2015 (minimum requirements) as a building which has a better performance than a "reference (virtual) building", which is characterized by the same shape, location, orientation, function, window/wall ratio as the actual real one and has physical properties (e.g. U values) as fixed by law in the definition of the reference building (Figure 10). Consequently, there is no explicit fixed energy thresholds in kWh/($m^2$y) for being classified as an nZEB but it depends on a series of requirements (Table 3) which must be verified with respect to the reference building.

In addition, the annex 3 of the current Italian legislation about the promotion of renewable energy (Dlgs 28/11), coherent with the Directive 2009/28/CE, describes the minimum mandatory amount of energy provided via the exploitation of renewable sources for nZEBs. In particular: the systems producing thermal energy must be sized and realized to guarantee the contemporary fulfillement of two requests: a) to cover 50 % of the expected primary energy for domestic hot water (DHW) and b) to cover 50 % of the sum of the expected primary energy for DHW, heating and cooling, using energy produced from Renewable Energy Sources (RES).

Moreover, c) the power of the electrical renewable energy systems installed has to be greater o equal to P= (1/K)*S, where S is the footprint surface of the building at ground level (in m2) and K = 50 m2/kW. For public buildings, these obligations are increased by 10 %.

**Figure 1*: Project and reference building (ref. ANIT 2017).***

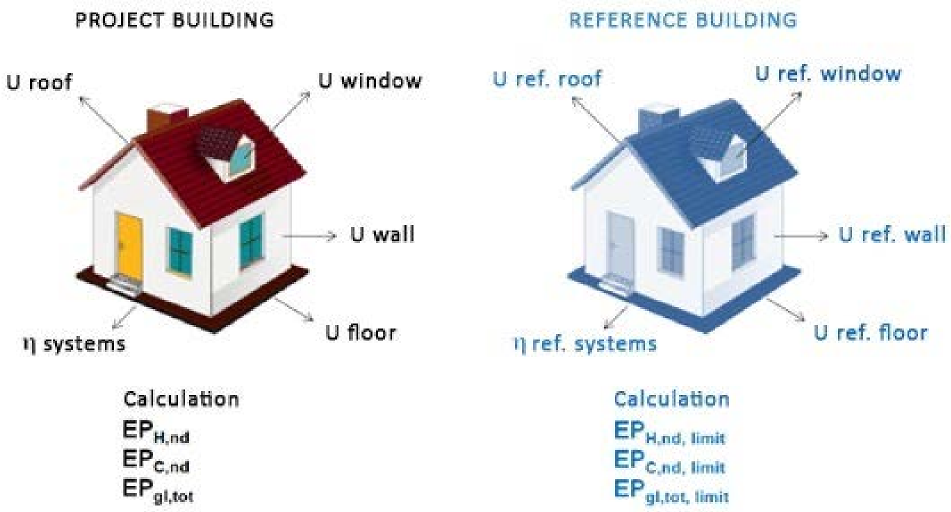

**Table 2:** ***Requirements for nZEB buildings according to Italian legislation (DM 26/06/2015 and DLgs 03/03/2011).***

| DM 26 June 2015 - annex 1 | | | |
|---|---|---|---|
| **Number** | **Indicator** | **Unit** | **Description** |
| i | $H'_T < H'_{T,max}$ | [W/m²K] | Transmission heat transfer coefficient per unit of *thermal envelope area* |
| ii | $A_{sol,est}/A_{sup,utile} < (A_{sol,est}/A_{sup,utile})_{max}$ | [-] | Equivalent summer solar area per unit of *useful floor area* |
| iii | $EP_{H,nd} < EP_{H,nd,limit}$<br>$EP_{C,nd} < EP_{C,nd,limit}$<br>$EP_{gl,tot} < EP_{gl,tot,limit}$ | kWh/(m²y) | *Energy need for heating*<br>*Energy need for cooling*<br>*Total global primary energy** (includes non-renewable energy and renewable energy) |
| iv | $\eta_H > \eta_{H,limit}$<br>$\eta_W > \eta_{w,limit}$<br>$\eta_C > \eta_{C,limit}$ | [-] | Average seasonal efficiency of the winter air conditioning system<br>Average seasonal efficiency of the DHW system<br>Average seasonal efficiency of the summer air conditioning system (includes moisture control) |

*includes the following *services/end-uses*: winter air conditioning, DHW, ventilation, summer air conditioning, artificial lighting, transportation of people and things

| Legislative Decree 3 March 2011 - annex 3 | |
|---|---|
| **Number** | **Description** |
| i | cover 50% of *primary energy* for DHW through energy produced by RES (*on-site*) |
| ii | cover 50% of *primary energy* for DHW, summer and winter air conditioning through energy produced by RES (*on–site*) |
| iii | P = (1 / K) * S |

(i) The **transmission heat transfer coefficient per unit of *thermal envelope area*** is a parameter to control the quality of the building envelope in terms of transmission losses. It is calculated as:

$$H'_T = H_{tr,adj} / \sum_k A_k \qquad [\frac{W}{m^2 K}]$$

Where

- $H_{tr,adj}$ [W/K] is the transmission heat transfer coefficient of the envelope calculated based on ISO 14683:2007(E) and UNI/TS 11300-1;
- $A_k$= the area of the k-th component (opaque or transparent) of the envelope [m²].

(ii) The **equivalent summer solar area per unit of *useful floor area*** is calculated as:

$$\frac{A_{sol,est}}{A_{sup,utile}}$$

Where:

$$A_{sol,est} = \sum_k F_{sh,ob} * g_{gl+sh} * (1 - F_F) * A_{w,p} * F_{sol,est} \quad [m^2]$$

and:

- $F_{sh,ob}$= is the shading reduction factor for external elements for the area of actual solar capture of the k-th glass surface, reported in July;

- $G_{gl+sh}$= is the total solar energy transmittance of the window calculated in July when the solar shading system is used;
- $F_F$ = is the fraction of the area relative to the frame, the ratio between the projected area of the frame and the projected total area of the window component;
- $A_{w,p}$ = is the total projected area of the glazing component (window transparent area);
- $F_{sol,est}$ = is the correction factor for the incident irradiation, obtained as a ratio between the average irradiance in July, location and exposure considered, and the average annual irradiance of Rome on a horizontal scale.

(iii) ***Total***[1] ***global primary energy*** **$EP_{gl,tot}$** is calculated as:

$$\frac{E_{Pgl,tot}}{A}$$

Where:

$E_{Pgl,tot} = E_{PH,tot} + E_{PW,tot} + E_{PV,tot} + E_{PC,tot} + E_{PL,tot} + E_{PT,tot}$

- $E_{PH}$ is the *total primary energy* for winter air conditioning [kWh]
- $E_{PW}$ is the *total primary energy* for DHW [kWh]
- $E_{PV}$ is the *total primary energy* for ventilation [kWh]
- $E_{PC}$ is the *total primary energy* for summer air conditioning [kWh]
- $E_{PL}$ is the *total primary energy* for artificial lighting [kWh]
- $E_{PT}$ is the *total primary energy* for transportation of people and things [kWh]

A: is the *useful floor area* of the building [$m^2$].

(iv) The **average efficiencies** $\eta_u$ of the utilization subsystems (emission / supply, regulation, distribution and, if provided accumulation) and $\eta_{gn}$ of generation are defined in Tables 7 and 8 of the Appendix A and include the effect of the consumption of auxiliary electricity.

The DM 26 june 2015 (annex 1) defines exactly how renewable energy produced *on-site* and used by the building can be counted in the calculation of the yearly *primary energy* use,

- Only to contribute to the same energy carrier (e.g. electricity with electricity)

- Only as long as the monthly energy use of that carrier is covered. The excess production in one month (produced *on-site* and exported) cannot be used to compensate for overproduction in another month.

[1] The pedix "gl" stands for "globale" meaning that *primary energy* is referred to ALL end-uses considered in Italian legislation e.g. heating, cooling, hot water, ventilation, lighting in the case of non-domestic buildings, transport of people and things.

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Hence in fact what is called primary energy in the Italian legislation corresponds to the *numerical indicator of non renewable energy use with compensation* of ISO 52000, with a $k_{exp}$ factor much lower than 1.

## Comments and potential improvements

The Italian National implementation of EPBD, which adopts in the definition of nZEB the indicators *energy needs, total primary energy*, fraction of t*otal primary energy* covered by renewables, and the *non renewable primary energy* as indicator for the Energy Performance Certificate, is in overall line with the EN ISO 52000 and consistent in the use of nomenclature. There is a shortcoming in the uncomplete alignment between the indicators for the definition of nZEB and for the general Energy Performance Certificate which may create confusion in the building market.

The use of the reference building procedure introduces a series of shortcomings:

- in the design phase it removes the signal to optimize building shape and orientation
- in the design phase it highly attenuates the signal to optimize the window/wall ratio
- in the real estate market it makes very difficult to compare the building under analysis to other buildings since there is no absolut threshold; the comparison on which the energy label is awarded is with the reference building model, which is specific to the building under analysis, rather than with all the other buildings

The choice of calculating the *non renewable primary energy* use essentially with *no compensation* (the excess production in one month - produced on site and exported - cannot be used to compensate for energy taken from the grid in another month for exported energy (a part from what is unavoidable due to the fact that a monthly calculation method is used) has the advantage of:

- focusing on the building and its success in fulfilling the definition of nZEB of EPBD art.2;
- avoiding incentives to use the energy grid as an inter-seasonal energy storage which would transfer cost from the building to the grid and generate new environmental pressure (e.g for construction of large storage facilities).

ABC21 is funded by the
EU's H2020 programme

# 4. REGULATION FOR PROMOTION OF LOCAL BIO AND GEO SOURCED MATERIALS WITH LOW EMBEDDED ENERGY

We discuss in this chapter examples of regulation and standards for the promotion of local bio and geo sourced materials with low embedded energy

## 4.1 Earth standards

After examining 40 different standards of 20 different countries, it was observed that adopted standard documents can be classified into three categories.

- Soil classification.
- Earth building materials.
- Earth construction systems.

In general, there are three types of documents governing the implemented building codes and standards.

- Standards and regulations issued by NSBs (national standards bodies).
- Normative documents issued by local/national organizations.
- Technical documents.

Table 3 shows countries with already established building standards and codes for earth and ecological buildings with their respective standard type.

**Table 3: Countries with already established building standards and codes for earth and ecological buildings with their respective standard type.**

| Type of standard | Countries |
|---|---|
| NSB | Brazil, Colombia, Germany, France, India, Kenya, Kyrgyzstan, Nepal, New Zealand, Nigeria, Peru, Spain, Sri Lanka, Tunisia, Turkey, USA (New Mexico, California), Zimbabwe |
| Normative documents | Australia, Spain, Switzerland, Germany, France is under development |

In order to design and implement earth or ecological building codes into national or international standards, the following process of approval should be passed with the National Standards Bodies (NSB). First, the preparation of a draft development by a group of specialists ("the technical committee") with proven competence in building with earth. Second, the prepared draft is presented to a broad range of specialists with a view to reaching a consensus between them. Third, presentation of the "consensus draft" to the NSB for final approval. In Europe, the draft must pass the EC Bureau for Standards for certification. Finally, the publishing of the finalized standard draft in a state decree.

Generally, the parameters covered in earth building standards are:

- Building materials/techniques: adobe, CEBs (compressed earth blocks), rammed earth, timber-framed structures with earth infill.
- Material properties: texture, plasticity/binding strength, natural constituents (organic, lime, salt content), shrinkage, compatibility, classification, test results, safety performance.
- Local conditions: earthquake damage.

Germany were one of the first countries to develop standards for earth and ecological building materials, known as DIN testing standards for different earth-based building materials.

- DIN 18942-1: 2018-12: Building materials in earth – part 1
- DIN 18945, DIN 18946, DIN 18947, DIN 18948 - Specifies the terms for applying clay building materials
- DIN 18942-100: 2018-12: Building materials in earth - Part 100 Conformity tests
- DIN 18945: Earth blocks—terms, requirements, test methods.
- DIN 18946: Earth masonry mortars—terms, requirements, test methods.
- DIN 18947: Earth plaster mortar—terms, requirements, test methods.
- DIN 18948: 2018-12: Clay plates – Requirements and test methods

The following tables display the different classes and strength properties of earth blocks, earth masonry mortars and earth plaster mortar building materials following DIN testing standards.

**Table 4: Brick classes for earth blocks (EB) following DIN EN ISO 7500-1:2004-11.**

| EB Class | Compressive strength interval value (MPa) |
|---|---|
| EB2 | 2.0 - 2.5 |
| EB3 | 3.0 - 3.8 |
| EB4 | 4.0 - 5.0 |
| EB5 | 5.0 - 6.3 |
| EB6 | 6.0 - 7.5 |
| Test procedure | DIN EN ISO 7500-1:2004-11 |

**Table 5: Brick classes for earth masonry mortar (EMM) following DIN EN 1015-11: 2007-05.**

| EMM Class | Compressive strength interval value (MPa) |
|---|---|
| M2 | ≥ 2.0 |
| M3 | ≥ 3.0 |
| M4 | ≥ 4.0 |

| | |
|---|---|
| Test procedure | DIN EN 1015-11: 2007-05 |

**Table 6: Brick classes for earth plaster mortar (EPM) following DIN EN 1015-11: 2007-05.**

| EPM Class | Compressive strength interval value (MPa) | Tensile strength interval value (MPa) | Adhesive strength interval value (MPa) |
|---|---|---|---|
| S I | ≥ 1.0 | ≥ 0.3 | ≥ 0.05 |
| S II | ≥ 1.5 | ≥ 0.7 | ≥ 0.10 |
| Test procedure | DIN EN 1015-11: 2007-05 | | |

Table 7 illustrates the area of applications of earth building materials depending on their mechanical strength according to DIN 18945-48 standards.

**Table 7: Area of applications of earth building materials as a function of their strength following DIN 18945-48.**

| Brick Class | Area of application |
|---|---|
| Ia | Rendered, exposed external masonry in fare-faced timber-framed walls |
| Ib | Continuously rendered, exposed external masonry |
| II | Clad or otherwise constructed weather-protected external and internal masonry |
| III | Dry applications (e.g. deck infill, stacked walls) |

## 4.2 Straw Bales standards

There are several regulations and standards in the context of straw bale construction. Some of them are given below [9]:

- BSF-112: Building Science for Strawbale Buildings (USA)
- ICC- International Code Council, 2018 International Residential Code for One- and Two-Family Dwellings- Appendix S: Strawbale Construction.
- 2011- Oregon Residential Specialty Code- Appendix R: Straw-Bale Structures (USA).
- IBC- International Building Code.
- BS 4046: 1991 Specification for Compressed Straw Building Slabs (British Standard).

## 4.3 Research activities and promotion

Some countries and universities are running research and detailed testing on the properties of the raw materials and of the manufactured building components [10]. Support to those type of research activities might be an important policy option.

Also some institutions have been created to promote the use of local materials once they are tested.

The World Bank states in a report [11] the potential large importance of “materials that may be “temporary” or “traditional” or “semi-permanent. … While these materials are not preferred by many governments, experience shows that they can be durable in addition to being inexpensive and locally sourced. For example, the ubiquitous termite hills on Zambia’s Copperbelt are now being quarried for their fine clay to be burnt into bricks in an informal-sector industry.” Recognizing the importance of these materials to the affordable housing sector, Cameroon established a Local Materials Promotion Authority (MIPROMALO) to promote the use of locally manufactured materials that reduce the cost of housing. “

## 5. FINANCING: VIA DEBT AND GENERAL TAXATION OR VIA LEVIES ON ENERGY

Considering the case of State policies based on economic incentives and support to design, construction and components for low or zero energy buildings the choice of the ways for financing has very relevant implications:

- Through general taxation
- Through a levy on energy prices (similar to a taxation on energy) e.g. according to art 7 of EED in Europe
- Through Public debt (payment by the State probably to be paid back via taxation in the future)

A financing route which may limit the reliance on public debt and avoid the risk of this debt falling on medium and low income population in the future, would have to rely on typologies of financing mechanisms that do not draw on the state budget. In Europe these mechanisms already exist and should possibly be strengthened and better targeted.

They derive from Articles 7 and 7-bis of the European Energy Efficiency Directive (2018, recast of the 2012 Directive) and apply the obligation to promote energy savings that this Directive assigns to energy companies (electricity and gas). This obligation has been included in the European Directive also thanks to the fact that, since 2004, this obligation has been in operation in Italy through the mechanism of the Titoli di Efficienza Energetica (TEE, also called White Certificates), designed by the Ministries of the Environment and Industry with the technical advice of the end-use Efficiency Research Group. In essence, the Italian legislator assigns energy distribution companies - i.e. those that own and maintain medium voltage electricity or gas distribution networks - an annual energy saving target to be achieved by promoting saving actions among their users, actions that are certified through the issuing of TEE.

Distributors are reimbursed for their costs (incurred directly or through Energy Service Companies, ESCOs) through a fund created with a small component of the energy price to end users. In more recent years, the Conto Termico was introduced in Italy; this mechanism also promotes energy savings (particularly thermal energy) and is financed by a small component of the energy price. The resulting fund is managed by the state and allocates funds through tenders, in which the public administration can also participate.

Both mechanisms can therefore finance in particular deep renovations of buildings, drawing funds from specific components of energy tariffs. This way of financing underpins a number of positive features common to TEE and the Conto Termico: as they are not financed by tax levies, they are totally external to the state budget and therefore do not have a negative impact on the debt/GDP and deficit/GDP parameters. By promoting economic activity, on the contrary, they can produce an increase in the State's tax revenues without disbursement from the budget, and therefore an improvement in these ratios. They can therefore be used intensively to reduce the *energy needs* of buildings, with measurable and certified results: certification of savings is in fact a basic feature of all these types of programmes worldwide, particularly in the United States. Finally, since they do not affect the state budget, they do not have to be voted each year in the financial law and are therefore an intrinsically stable mechanism. In Italy, they have had 5-year cycles between reviews, have been in operation for 16 years, and have constituted the bulk of Italian energy-saving efforts agreed with Europe.

They are used also in other countries in EU. , the April 2020 report by the French Ministry of the Environment on the use of Energy Savings Certificates shows that they are largely used in France to combat energy poverty by tackling in priority buildings with a high "*energy need for heating or cooling*".

It should be noted that, if spent effectively, the investments in end-use reduction charged in the tariff would slightly increase the price of the unit of energy, but would reduce energy use and thus the bill for households, businesses and the nation, as well as permanently reducing emissions and pollution.

In order to ensure that the bills of the poorer sections of the population are not burdened during the transitional period in which the efficiency actions are implemented, there are two alternatives: making the levy on the price of a single unit of energy (kWh or m3 of gas) increase with consumption, according to the "polluter pays" principle, or guaranteeing economic aid to households in difficulty, in general, not linked to energy expenditure, but which would help them to bear the cost of the bill until, for example, their house is insulated and the bill falls. Similar mechanisms already exist, and can be calibrated to the situation.

The funds collected through the energy price levy can be managed by an independent administrator, which can be selected through a special call for tenders (e.g. an energy efficiency expert firm, a university research group, an agency formed by municipalities and experts could participate). Examples are, at national level, entities such as The Energy Saving Trust in the UK, and, at local level, entities such as EnergiePositif, active in the Paris region. On the other hand, funds can be managed by energy distributors or sellers who are subject to the saving obligation of Art. 7 of the Energy Efficiency Directive (e.g. energy companies owned by municipalities in Germany, energy distributors in Italy, energy sellers in France).

As for criteria for the selection of where to allocate the incentives, it is important to include in the calculation external costs, costs connected to risks of extreme events, and costs connected to lock-in in situations of high consumption.

For example if new buildings are not constructed to state of the art standards, the resulting building stock would be locked in in a high consumption state and continue to unnecessarily take up a high amount of energy for decades thus generating high costs in the medium and long term.

On apparently counterintuitive prioritization of investments see a recent paper by researchers of World Bank “Climate policy: When starting with the most expensive option makes sense” [12]. From which we quote: “Traditional climate economics models recommend capturing the cheapest opportunities to reduce emissions first – the ‘low hanging fruits’ – and keeping the most difficult options for later. This approach sounds like common sense, and it is at the basis of the ‘marginal abatement cost curves’ (MACCs) approach (McKinsey and Company 2009). .. but “in many cases, delaying action is particularly expensive (and action particularly urgent) in sectors where decarbonization is difficult or expensive. Hence our title.”

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ABC21 is funded by the EU's H2020 programme