The qualifications and professional competencies of architects on the energy efficiency of buildings. Are they prepared to embrace the 2020 targets ?

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ABSTRACT: The recast Energy Performance of Buildings Directive requires that from 2020 onwards, all new buildings are nearly zero-energy buildings. This new concept requires a strong implementation of sustainable construction methods and techniques as well as the integration of renewable energy technologies in building architecture. Among the stakeholders, architects intervene at an early stage of any building construction process. A survey and expert interviews were conducted, and a review of literature was carried out, followed by a comparative analysis of the structures and degree syllabuses of Portuguese architecture degree courses. The most common problems reported were the lack of dissemination of the EPBD requirements and the need to improve access to regulations, tools and methods, as well as best practices. The conclusion drawn from these results is that it is essential to raise architects awareness towards the important role that they can play in the implementation of these new requirements.

1 INTRODUTION

The new concept of buildings for the future involves a range of building materials and systems that place major emphasis on the issue of sustainability and energy efficiency. This requires for a deeper approach to these issues in order to help professionals to focus on the implementation of real solutions for the buildings.

Bearing in mind that an integrated design process has become the norm and that energy efficiency has become one of the priorities of a building project, design project teams must start looking at energy and performance issues early on and throughout the whole design and operation process. Architects belong to the group of professionals who will most likely make up the first design concept together with the client and other investors and consultants. As a building is designed, all the aspects of sustainability, bioclimatic solutions and buildings physics can be considered from the initial step, which will help engineers to achieve higher levels of optimization of the building energy performance. Additionally, the recast Energy Performance of Buildings Directive - EPBD - (European Parliament and Council of the EU 2010) requires that from 2020 onwards, all new buildings are nearly zero-energy buildings and, therefore, architects need to acquire, in a short/medium term, the sufficient knowledge to deal with these recent requirements. Thus, it is important to analyze whether sustainability and energy efficiency has been sufficiently discussed through the architecture degree courses and how prepared these professionals currently are, as well as how they are putting these subjects into practice in their design projects. The architects' role is undoubtedly important in the initial design phase of a building because they are the main responsible for defining many of the sustainable construction methods and techniques.

2 SCOPE AND METHODOLOGY

The focus of this paper is to give an evidence-based image of how deeply the subjects related to sustainability, energy efficiency and bioclimatic solutions are being learned by architecture degree courses undergraduates as well as of how these subjects are being put into practice in the design projects. As well as this, it reports on the barriers architects feel that they are facing nowadays and on their expectations about these matters for the near future.

In order to reach the aim of this study, a literature review was carried out, followed by a comparative analysis of different structures and degree syllabuses of architecture degree courses in Portugal. The analysis focused on the scientific areas and degree syllabuses of the course units in order to find out to what extent the subjects are part of the undergraduate learning outcomes. The statutes and regulations of Professional Orders and other Associations were also reviewed so as to understand the actual requirements and framework related to professional qualifications. In addition to this, a survey and expert interviews to architects were conducted. Based on the questionnaire structure and feedback, some additional interviews were held.

The inquiry and the interviews involved a total of 40 architects. The respondents work mainly in design project in Northern Portugal and their ages range from 26 to 55 years old. About 22 of the respondents have a Master's degree, 17 have a license degree and one has a license degree and a post-graduation. They all obtained their qualifications between 1986 and 2012, respectively. The majority of the respondents (70%) attended private higher education institutions and the other 30% attended state higher education institutions. About 50 architects were invited to answer the questionnaire, from recent graduate architects to more professional experienced architects.

The inquiry consisted of 30 questions, the majority being close answer questions. Some of the respondents recorded their answers directly on the questionnaire form whereas others were interviewed, in which cases the respondent followed the questionnaire as well as the normal procedures recommended for these cases by Yin (2002).

3 GOALS AND CHALLENGES OF THE RECAST EPBD

According to INE (2011), energy consumption in buildings in Portugal represents about 30% of the total consumption (17.7% in the domestic sector and 12% in services)**.** Furthermore, the energies used in buildings tend to be depleted, and Portugal, as well as the other European Union countries, greatly depend on energy when compared with other countries (79% of imported energy in 2011) (Conselho de Ministros 2013).

As far as climate change and energy are concerned, the European Parliament proposed a plan of action, the "Climate and Energy Package: Triple 20' targets until 2020", whose goals are as follows: a 20% reduction in greenhouse gas emissions from 1990 levels; raising the share of energy consumption produced from renewable sources to 20% and a 20% improvement in energy efficiency until 2020.

According to Commission of the European Communities (2008) energy efficiency represents one of the goals of the climate and energy package, being one of the main means to reduce C02. The buildings sector represents one of the fields of action. The directive 2010/31/EU, of May 19 2010 (Energy Performance of Building Directive - EPBD) recast the directive 2002/91/CE, and consolidated that goal.

The biggest novelty about the recast EBPD (European Parliament and Council of the EU 2010) is that it makes it mandatory for buildings to be nearly zero-energy buildings after 2021 (NZEB "Nearly Zero Emissions Building"). Besides this, it also points towards the importance that retrofitting existing buildings assumes as an opportunity to take sustainable measures and improve their energy performance. Energy certification remains mandatory and the demands concerning energy efficiency will tend to increase. According to EPBD, a building with nearly zero energy needs is a building with a very high energy performance. The nearly zero or very low energy needs must be covered by energy from renewable sources produced locally or nearby. According to Aelenei (2012), the main issue is the annual energy balance between consump-

tion needs and production.

The International Energy Agency (IEA 2013) and through the Solar Heating & Cooling Programme, Task 40 and ECBCS Annex 52, is working on a definition of the net zero-energy buildings (nZEB) in order for the various member states to standardize the main guidelines to be followed based on experimental projects which relate different countries' realities as far as construction and building use are concerned.

According to Aelenei et al. (2011), zero energy balance buildings (NZEB) can be considered as an evolution of Low Energy Consumption Buildings or Passive Houses. Passive approaches play a crucial role in addressing NZEB design as they directly affect the heating, cooling, ventilation and lighting loads put on the buildings mechanical and electrical systems, and indirectly, the strive for renewable energy generation, in Aelenei et al. (2012). Thus, the optimization of architectural design is pointed out by several experts as one of the key measures to reduce energy needs.

In a recent European study elaborated by the Architects Council of Europe (2012) about the practice of architecture, the respondents agreed that energy efficiency is a key driver in the design of buildings today. The results show that 50% "strongly agree" and 40% "slightly agree", approximately 10% disagree, among which 2% "strongly disagree". The same study assessed how architects feel towards the competence to design a NZEB (Nearly Zero Energy Building). The percentage of architects who feel "very competent" and "competent" depends on the country, but it varies from 32% in Sweden to 80% in Austria. Portuguese architects' answers reveal a percentage of 60%. The study shows that there is no improvement from 2010 until now concerning how competent architects feel to design a Nearly Zero Energy Building in Europe. On the other hand, the answers to the question about how often respondents are currently asked by clients to design with NZEB standards or through regulation showed that a little more than half of the respondents are asked less than 10% of the time, and only 13% of the respondents are asked more than 50% of the time. These and other studies lead to the conclusion that architects are relatively aware of the advantages of these matters but the implementation in buildings is still far from being a current practice.

4 THE ARCHITECTURE PROJECT DESIGN AND ARCHITECTS' QUALIFICATIONS

4.1 *The evolution of the architecture requirements and its contribution to sustainability*

The adaptation of construction to climate as well as the use of local and natural resources gave rise to vernacular architecture. The industrial revolution marked the appearance and spread of new materials and technologies, thus marking the rupture with the traditional solutions. As a result of the dazzle of technological development, together with the low cost of fossil fuels, the balance between climate, culture and local materials was disturbed. The answer consisted of applying artificial solutions which consume energy in order to meet comfort needs. The oil crisis as well as the environmental disturbances and the great energy dependency on non-renewable resources are all concerns resulting from the society's contemporary lifestyle. In Portugal, these concerns have been felt and expressed in various ways. Besides the international and European energy and environment policies which result in national directives and requirements increasingly more specific, some buildings assessment and certification methodologies have also appeared. Some of these methodologies, such as energy certification, are mandatory, but others are voluntary, such as sustainability assessment methods. Meanwhile, new concepts have been appearing and architecture has been constantly described as "Green", "Eco-friendly", "Bioclimatic", "Passive", "Sustainable", etc. Moura (2007) disagrees with these adjectives used to describe architecture, claiming that "There is no eco-friendly, intelligent or sustainable architecture. There is only good architecture." The same author refers that "*architecture does not have to be sustainable. In order to be good, architecture is implicitly sustainable.*" Unfortunately, this is not always the case, and Simon & Graham (2006) said "*debates about sustainable architecture are shaped by different social interests, based on different interpretations of the problem, and characterized by quite different pathways towards a range of sustainable futures*". Anyway, these tools and new concepts promote sustainability.

The design of a new building involves the drafting of a range of projects, namely the architecture project and partial specialties projects. Portuguese Law n. 31/2009 of July 3 describes the design project as "the coordinated set of written and drafted documents, integrating the main project and the other projects, which define and characterize the functional, aesthetic and constructive conception of a construction work (…)" The same law describes the main project as "the one which defines the features imposed by the function of the construction work and represents the matrix for the other projects which condition it and are conditioned by it." Therefore, the architecture project of a building represents the main project, which means that the other projects must respect it as a matrix.

In Portugal, the transposition of the first EPBD (European Parliament and Council of the EU 2002) gave rise to a new regulation for buildings thermal behavior – RCCTE (2006), whose application is mandatory in a new building design project, as well as it is the building energy certification. The RCCTE changed significantly the calculation methodology and introduced new requirements regarding the buildings surrounding environment as well as the mandatory installation of solar collectors. It is possible to say that the demands regarding the quality of the thermal project increased significantly with the introduction of the Buildings Energy Certification System (SCE) as a consequence of the project's validation by a qualified expert and the issuing of the respective certificate. These new requirements and demands also condition the architecture project in various respects, namely: the increase of the thermal insulation and walls thickness; the treatment of thermal bridges and the integration of solar collectors.

These were some of the novelties resulting from the current legal requirements which implied a change in the buildings architectural design. These new requirements gave rise to the development of new constructive solutions, such as: ventilated façades, prefabricated insulation systems, heat pumps, and photovoltaic systems, among others.

The recast EPBD brought about an even bigger challenge as it is necessary to implement practices which are allied to the current technology and which are sustainable throughout the building life cycle. It is important to highlight that the new national law which transposes this directive was passed by the Council of Ministers in June 2013, in which a review of the existing national law was carried out and several scattered laws were assembled into a single law.

4.2 *The architect's role in the context of sustainability and EPBD*

The recast EPBD refers that "*Member States should enable and encourage architects and planners to properly consider the optimal combination of improvements in energy efficiency, use of energy from renewable sources and use of district heating and cooling when planning, designing, building and renovating industrial or residential areas*". The recognition of the importance of the architects' role in the implementation of this directive is unanimous.

In the Directive n. 2008/C319/05 of December 13 on the Council's Conclusions regarding Architecture, it is assumed that "*architecture, a subject of cultural creation and innovation, namely technological, represents a notable illustration of what culture can give to sustainable development due to its impact on the cultural dimension of cities as well as on the economy, on the social cohesion and on the environment."*

In turn, in the 12th Congress of Architects promoted by the Portuguese Order of Architects (2009), the need for the creation and implementation of an Architecture public policy was expressed, in the light of what happens in most countries in the European Union. Such policy should imply, among other goals, the promotion of sustainable construction best practices, energy efficiency and the fight against climate change with regard to buildings, cities and landscapes. In addition to this, such policy should also value culture and citizenship, as well as architects' professional practice.

4.3 *Qualifications for the practice of architecture*

According to Portuguese Law 31/2009 of July 3, from October 31 2014 onwards, architecture design projects will be drafted and signed by architects who are members of the Order of Architects only. The duties of the design project's authors include the compliance with the norms and law in force and the application and justification of the solutions which comply with the required demands; the guaranty of aesthetic, functional and feasibility levels of the project and

construction work; the guaranty of a joint work with the project's coordinator in the harmonization of the written and the designed elements in order to ensure integrity and coherence. In the construction phase, designers must provide technical assistance.

The design of a building involves the drafting of the architecture project (matrix project) by an architect or by a team of architects, as well as the drafting of specialties projects by engineers of various specialties. Ideally, this group of technicians would work in the same physical space and as a team. According to The Architects Council of Europe (2012), technicians' work is often done in an individual and isolated way, without any team spirit. However, one of the technicians involved in the project has to take the role of the project coordinator. In the construction of buildings, the architect or one of the architects in the team often takes that role. The project coordinator has to ensure the articulation among the project team with regard to the construction work features, the compatibility between the various projects and the compliance with law and regulations concerning each specialty, so that the interpretation of the project by the various stakeholders of the construction execution is unequivocal. Therefore, the project coordinator must have technical knowledge in several areas.

According to the same Law n. 31/2009 of July 3, architects can also play the role of construction manager and of "engineer". These figure must ensure the execution of the construction work and the compliance with the execution project, and the "engineer" must check the execution of the construction work. Both must ensure the compliance with law and regulations. However, in order to be able to play these roles, architects, as well as other technicians, are subject to a set of minimum requirements and exceptions related to work experience and others.

Architects assume a crucial role in the constructive process, either as designers or as coordinators, project managers, engineers or construction managers. Also, architects are usually the ones who establish communication with the project client. Therefore, they must be able to identify the client's comfort and habitability needs, and they must have the knowledge required to ensure that those needs are met, implementing optimized solutions as far as energy performance and environmental and economic sustainability are concerned, and giving priority to passive solutions.

5 COMPETENCIES ACQUIRED IN ARCHITECTURE DEGREE COURSES

According to Portuguese Law 74/2006 of March 24, the Architecture curricular training confers the Master's degree with 300 ECTS (European Credit Transfer System). The degree course is proposed by the higher education institution and is then assessed and accredited by the Portuguese Higher Education Evaluation and Accreditation Agency by Regulation n.º 504/2009 of December 18. The first 180 ECTS confer the license degree. The Order of Architects confers the title of architect to the graduates who "*are in possession of certificates stating the academic qualifications foreseen by the Application Regulation, n.1 article 2, (license degree in Architecture in a course certified before March 24 2006, or integrated master's degree in Architecture with a course syllabus certified after March 24 2006)"*, or alternatively, who are in possession of a training certificate in architecture registered in the European Directive 2005/36/CE of September 7 (European Commission 2005). The candidates to the title of Architect must also attend a traineeship and are subject to mandatory training sessions as well as to passing an exam of "Knowledge Verification in Status and Deontology."

According to the research done on the structure of the Architecture degree courses taught in Portugal, the weight of the subjects related to energy efficiency and energy technologies represents between 5 and 6 ECTS among the total 300 ECTS for each cycle of studies, and such subjects can also be approached in the Project curricular units, although only as autodidactic research in most cases. In the face of the importance of the topic, the low incidence of these subjects throughout the courses seems insufficient to the adequate preparation of the future graduates. According to Byrne (2013), some areas, such as resource management and energy efficiency, have been absent from architecture degree courses and retrofitting has always been a disregarded area in architecture.

However, the market has increasingly been providing an offer of extracurricular courses and training sessions. Currently, there is an offer of courses addressing energy efficiency and sustainable construction, namely some master's degrees and post-graduations as well as more spe-

cific courses such as the Passive House Norm. Also, there are seminars, conferences, and workshops promoted by various entities. Most, if not all the training offer is held on the coastal area and at times which make it difficult for professionals from the inland area to take part. The time to implement and put the new requirements of the recast EPBD into practice is short. It is important that the architects' curricular training addresses buildings energy efficiency and renewable energies.

6 CURRENT POSISTION OF ARCHITECTS TOWARDS SUSTAINABILITY AND ENERGY EFFICIENCY

6.1 *State of knowledge, barriers and drivers*

The results of the study enable us to make some considerations on the state of knowledge, the barriers, and the drivers of architects regarding this issue. With regard to the architects' motivations and positive considerations, we highlight the ones in Table 1. With regard to the barriers felt by architects, we highlight the ones in Table 2.

Table 1: Main positive considerations and drivers

1	Working in team and in the same physical space makes decision making easier and increases the Project quality, as problems and doubts are sorted out more easily.
2	SCE brought more transparency into the information to provide to the client, increased the Project quality as well as the stakeholders' accountability.
3	There is an environmental awareness and architects are open to the adoption of sustainable solutions
4	Professionals are already adopting strategies such as: solar exposal of façades and insulated fenestration; shading; natural lighting; insulation equipment incorporation; and thermal bridges treatment.

Table 2 – Main barriers

1	Law regarding the buildings energy certification system (SCE) is considered quite specific and bureaucratic, thus difficult to implement, especially in retrofitting cases. (The law in force demanded changes in the construction habits, namely: the integration of solar collectors; the increase of insulation thickness; the increase in number and quality of constructive details; and the increase of the project drafting time.)
2	SCE increased the costs to the client.
3	Architects consider the adoption of some sustainable and passive solutions and technologies difficult to put into practice, especially due to: lack of knowledge, even regarding energy benefits; lack of the client's awareness; low expression in the market; and increase of costs.
4	There is still a very low implementation in buildings of passive bioclimatic strategies, such as: Trombe walls; annex greenhouse; green roofs and walls; evaporative cooling;
5	The idea prevails that the implementation of active solutions such as acclimatization systems, hot water preparation, and renewable energy incorporation leads easily to the energy class increase and, therefore, the implementation of other passive solutions is neglected.
6	Some architects consider there is still a lack of expert engineers to support architects in the design of these building sustainable solutions.
7	There is the perception that the Portuguese Order of Architects does not provide an accessible and sufficient promotion of knowledge updating.

With regard to the knowledge concerning bioclimatic/low energy consumption projects/solutions, 62.5% of the respondents find it insufficient. In turn, most of the knowledge they have was acquired through training sessions and self-initiative research. About 36 of the 40 respondents intend to attend courses in this area in a short time. Some specialists believe that training for engineers and architects in this area should be differentiated and that architects should be informed and advised about the best solutions by specialized engineers.

Over 60% of the respondents have knowledge regarding passive/bioclimatic strategies such as: Trombe walls; green roofs; geothermal acclimatization; annex greenhouse and evaporative cooling.

Little more than half of the respondents take the design project economic feasibility into account when adopting passive strategies. However, only 37.5% of the respondents get clients' feedback on economic savings and comfort levels through the solutions adopted.

About 75% of the respondents do not take the law in force into account in the architectural design of low energy consumption buildings. As well as this, 87.5% of the sample does not have

knowledge regarding 2010 EPBD. Also, 70% do not have knowledge of the requirements after 2020 regarding nearly zero-energy consumption buildings (NZEB), or consider the regulation on energy efficiency well-adapted to the building retrofitting specificities.

In general terms, the implementation of an architecture policy is inexistent, and so are methodologies which favor the implementation of bioclimatic solutions and the quantification of their economic and environmental benefits. The inexistence of practical examples adapted to the different regions of the country is also transversal and causes contempt towards the principles which support the solutions implemented in vernacular architecture, which is also visible as far as the law in force is concerned. This contributes to the conditioning of wider retrofitting practices.

6.2 *Recommendations and improvement actions*

Based on the results of this study, it is possible to put forward some recommendations and improvement actions, presented as follows:

- The existence of an architecture policy focused on sustainable development and energy efficiency, with a more practical implementation feasibility and containing examples;
- The adaptation of the learning outcomes and syllabuses of the architecture degree courses curricular units, placing emphasis on subjects regarding sustainable building, energy efficiency, renewable energy systems and energy retrofitting.
- The promotion of courses/training sessions focusing on NZEB, bioclimatic solutions, energy efficiency, renewable energy and sustainable construction;
- A higher focus of the law in force on building retrofitting;
- The provision of technical Thematic Guides/Catalogues containing successful building practices and examples adapted to each region, among other elements;
- A higher level of freedom of action regarding building retrofitting;
- The promotion of research on methodologies adequate to the incorporation of various bioclimatic solutions and mechanisms to accelerate their integration process in the SCE. Town Councils can promote their implementation by reducing the Property Taxes on NZEB.

7 DISCUSSION AND CONCLUSION

The aim of this study was to understand the level of preparation and knowledge that Portuguese architecture experts have regarding sustainability and energy efficiency issues.

The new directive brings about more changes regarding construction requirements and methods. The conclusion drawn from the study was that architects play a crucial role as decision-makers, coordinators and communicators with the client, since not only do they integrate the project from the very beginning, but they are also given the qualification to perform these tasks. However, the study shows that most of the architects inquired recognize that their degree course did not provide them with sufficient skills or tools to implement sustainable and bioclimatic solutions in buildings. As well as this, the degree course syllabuses register a low number of ECTS, and consequently few learning outcomes concerning these issues throughout the learning process.

The respondents generally agree that the SCE contributes to improve the project and the construction work quality as well as the stakeholders' accountability. However, it also requires for a higher level of knowledge concerning the implementation of constructive and system solutions. Thus, team work improves the quality of the work, but is hardly put into practice. The results also show that the respondents consider that legislation, bureaucracy and costs related to SCE influence many of the technical options, especially as far as older buildings retrofitting is concerned. Many architects have been demanding more training and more tools for decision support, as well as further clarification of the regulations. Thus, it is necessary to develop and publish clear and specific information on the implementation of practical examples of passive and energy efficiency solutions adapted to each region.

In conclusion, the achievement of NZEB in the end of 2020 attending sustainability does not appear to be an easy process, as it requires the effort and cooperation of various stakeholders as well as the mobilization of various resources. Furthermore, it seems clear that there is still some

way to go towards raising the architecture professionals' awareness of the important role they play in this domain. Thus, it is necessary to accelerate the creation of mechanisms which help them feel and actually be better prepared to embrace the challenges set by the new regulation and the goals for 2020.

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