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Triggering Deep Renovation of Buildings in Portugal

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Abstract. EU and national buildings related regulations are moving towards policies that improve indoor thermal comfort, reduce energy consumption and its environmental impact by establishing very ambitious targets in the emissions reduction in the decades to come. In this context, improving energy efficiency through deep energy renovations is a key action line because of its potential to meet long-term climate and energy targets. However, deep renovations need to become more environmentally friendly, more reliable in terms of performance and more attractive to all concerned stakeholders, in addition of enabling the implementation of the Near Zero-Energy Building (nZEB) assumed by the Energy Performance of Building Directive in 2010. This paper highlights the key aspects related to the strategic pillars of deep renovation and explore ongoing related funding schemes to meet Portugal´s carbon neutrality and related sustainability goals.

1. Introduction

1.1. Context

According to recent statistics, buildings (residential and commercial) are responsible for 40% of energy consumption and 36 % of gas emissions in the EU [1]. As the main used energy sources are wood (30%), electricity (28%), natural gas (22%) and oil (11%), they are equally an important source of carbon dioxide (CO2) emissions [2].
For this reason, the EU adopted a European Climate Law, establishing the aim of reaching net zero greenhouse gas emissions (GHG) in the EU by 2050, with an intermediate target of reducing GHG by at least 55% by 2030 compared to 1990 levels [3]. To reflect developments in the framework of this new EU regulation, as well as to ensure the accurate accounting under this Regulation, Portugal has adopted in 2019 the national energy and climate plan 2021-2030 (NECP 2030) [4].
Accordingly, achieving a big emissions reduction within the buildings sector is a key action beside transport sector, with reductions amounting to 35% and 40% by 2030 compared to 2005. At the same time, ambitious targets were set in respect of the renewable energy uptake of Portugal in the gross final consumption of energy, with a 47% uptake in place in 2030.
With appropriate actions taking place to ensure the effective implementation of these targets and given the fact that most of the existing residential buildings are in need of deep renovation, it is clear at this point that nearly zero energy buildings (nZEB) will assume a key role in the following decade [5, 6]. In fact, NECP 2030 states that renovation alongside energy efficiency measures allows achieving multiple objectives, such as lower energy bills and improved thermal comfort, and therefore, renovation is

particularly important, and it should be regarded as a priority. In addition, it also states that nZEBs are also important since the energy demand of renovated buildings are lowered close to zero.

1.2. Challenges

Some of the technologies needed to renovate the buildings sector are already commercially available and cost effective. Others are costly and may require government support to attain wide market uptake [7]. However, many could benefit from a mix of further R&D and economies to scale back prices, enhance performance and improve their affordability. Thus, the future challenges on buildings technology are not a technological development issue, but rather a concerted effort to facilitate enabling policy design and stakeholder engagement to support the implementation of strategic and effective mechanisms in accordance with national priorities.

One of the most important strategic tools designed to answer the future challenges has been promoted by the European Commission in 2010 and is related with the implementation of Nearly Zero Energy Buildings – nZEB in EU countries [8]. Despite of the compulsory character of EPBD recast, which required all buildings to become “nearly zero energy” by 2020, they represent a very small percentage of the market today in Portugal.

Market barriers within the buildings sector are extremely complex, however the delay in the implementation of the EU directives in Portugal is partly explained by the recent financial condition that considerably affected the building sector. At this moment, however, when the Construction Output in Portugal averaged 4.7% from 2001 until 2022 and the construction orders is expected to increase [9], the economic barriers are no longer Portugal´s the biggest problem. Today, there is a necessity for integrated and comprehensive ways to assist overcome the remaining barriers associated with higher initial prices, lack of client awareness of technologies and their potential, and the split of incentives between clients and utilities [10]. This concerted effort around an integrated strategy which uses the best available technology in combination with the adequate strategies, ensuring that all available options are employed in an optimized fashion, can overcome these market barriers. This requires exceptional effort and coordination among an oversized set of stakeholders, from policy makers to builders, technology developers, manufacturers, equipment installers, financial institutions, businesses and building users.

1.3. Opportunities

NECP 2030 has identified for Portugal deep renovation of existing buildings as one of the priority actions to achieve energy efficiency targets. The long-term strategy for the renovation of the national building stock includes a commitment to save 34 % of building-related primary energy consumption by 2050, relative to 2018 levels, targets which were qualified by the Commission to be of modest ambition both its primary and final energy consumption [11].

As part of the recovery and resilience plan (PRR) as a response to the COVID-19 crisis, Portugal has decided to devote 38% of its total allocation to measures that support climate objectives. Among different investments, financing of a large-scale renovation programme to increase the energy efficiency of buildings is included, the Sustainable Buildings Programme (SBP), which consists of a wide range of initiatives and (sub-)programmes. The pillar of PRR under the initiative C13 - Energy Efficiency in Buildings, includes investments in three categories, residential buildings (TC-C13-i01), central government buildings (TC-C13-i02) and service buildings (TC-C13-i013), each funded with 300M€, 240M€ and 70M€, respectively. Implemented by the Environmental Fund of the Ministry of the Environment and Climate Action, the SBP programme is currently under implementation [12].

1.4. Project RePublic_ZEB

The RePublic_ZEB project [13] is a project funded between 2014 and 2016 under Intelligent Energy for Europe – Programme of European Commission program, which centred on the energy and carbom dioxide emissions related to existing public buildings in South-East of Europe and their improvement towards nZEB. The main objective of the project was to support the participant countries to develop and promote on the market a collection of concrete technical solutions and guidelines for the retrofitting of the public building stock towards the nearly zero-energy target [14]. Based on the assessment of the of best practices for the retrofitting of public buildings in partner countries, a standard framework and a methodology for the definition of a nZEB target for public buildings was developed during the timespan of the project.

This paper highlights the key aspects related to the strategic pillars of deep renovation and identifies energy efficiency measures and guidance with a specific focus on the public buildings using the available data from RePublic_ZEB project [15, 16].

2. Method

2.1. Definition of reference buildings

Based on an inventory of the National Energy Certification System (SCE) regarding existing building stock developed by the National Energy Agency (ADENE) covering every type of buildings (public and private) with regard of construction year, utility, geometry, share of fuel type per building category, thermal characteristics of the building envelope and energy performance indicators, a strategy for outlining reference buildings was developed based on a statistical analysis.

The statistical analysis was performed using a sample provided by ADENE consisting of a number of 339 public buildings divided by categories as presented in Figure 1.

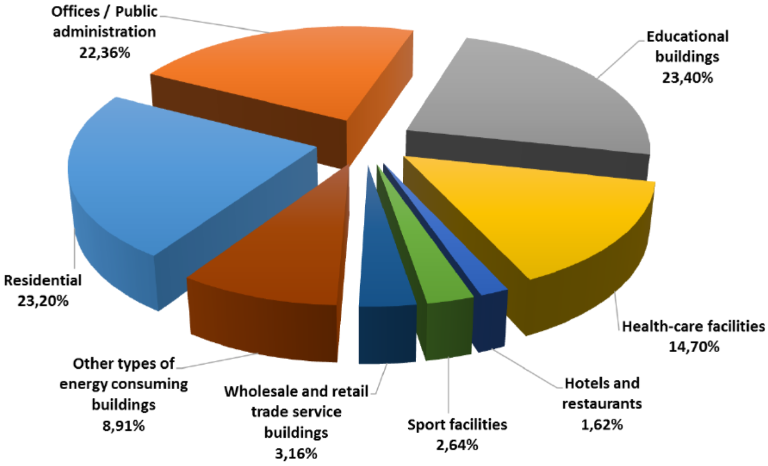

Figure 1. Category of buildings of the public building stock (339 buildings) [15].

For each category and sub-category, the statistical analysis was performed using the subsequent indicators:

- Total floor area (built-up area), m².
- Total useful conditioned floor area, m².
- Area occupied by the building(s), m².
- Compactness ratio (area of the exterior walls/building gross volume).
- Number of floors.
- Building construction typology (as defined at national level).
- Building age.
- Energy services (heating, cooling, ventilation, DHW, artificial lighting).
- Type of heating and/or cooling system.
- Climatic zone.
- Energy performance (split by energy carrier).

Table 1 shows the main thermal characteristics likewise as normal specific consumption per building category. Figure 2 shows the share of the various energy uses within the final energy consumption for every public building category. The data shown in Table 1 and Figure 2 was obtained through calculation of the statistical function mode which return the foremost representative value found within the sample studied for every typology and sub-typology from the database of the 339 certified buildings.

Table 1. Thermal characteristics per building category [15]

	Building category	Wall [W/m²K]	Roof [W/m²K]	Floor [W/m²K]	Windows [W/m²K]	Final Energy Use [kWh/m².yr]
1	Residential					
	< 1990	1,70	2,60	3,10	4,80	
	1991 - 2006	0,96	2,60	2,50	4,10	129,02
	2007 - 2013	0,96	0,39	0,37	3,90	
2	Offices and Public administration					
	<1990	1,76/1,3	1,25	2,21	3,90	
	1991 - 2006	2,3	1,25	N/A	3,14	48,60
	2007 - 2013	1,60/0,32	0,43	0,58	4,06	
3	Educational					
	<1990	1,3	2,25	2,21	3,90	
	1991 - 2006	0,47	0,53	N/A	3,14	195,76
	2007 - 2013	0,66	0,40	0,58	4,06	
4	Healthcare facilities					
	<1990	2,4	2,8	N/A	5,10	81,12
	1991 - 2006	0,96	2,25	N/A	4,05	
	2007 - 2013	0,62	0,72	0,56	3,30	
5	Hotels & Restaurants					
	<1990	0,96	2,60	3,1	5,1	109,11
	1991 - 2006	1,10	2,60	2,21	6,0	
	2007 - 2013	N/A	N/A	N/A	N/A	
6	Sport facilities					
	<1990					
	1991 - 2006	N/A	N/A	N/A	N/A	118,7
	2007 - 2013	N/A	N/A	N/A	N/A	
		0,6	0,59	N/A	1,41	
7	Commercial					
	<1990	0,96	2,60	2,25	6,2	70,91
	1991 - 2006	0,96	N/A	3,1	6,0	
	2007 - 2013	0,54	0,42	N/A	2,3	
8	Other types					
	<1990	0,43	2,60	0,75	5,12	48,3
	1991 - 2006	N/A	N/A	N/A	N/A	
	2007 - 2013	0,46	0,44	0,45	1,6	

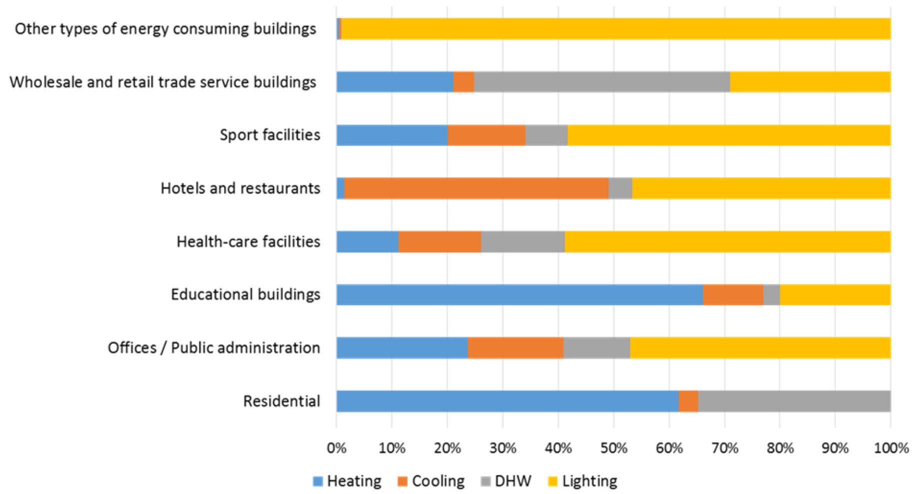

Figure 2. Estimated share of the various energy uses in the final energy consumption for every public building category (339 buildings) [15].

2.2. Refurbishment towards nZEB

After a careful analysis of best observe examples in energy retrofit in Portugal, various energy efficiency measures available for deep renovation of public buildings were identified [16]. The measures for office buildings, representing one of the largest shares of public buildings (Figure 1), are summarised in Table 2, grouped according to investment categories of the SBP Investment Fund currently under implementation under the recovery and resilience plan in Portugal.

Table 2. Thermal characteristics per building category (adapted from [16])

SBP Investment Fund - initiative C13 - Energy Efficiency in Buildings		Refurbishment solutions - RePublic_ZEB						
		Building category	Value type	Units	Before refurbishment	Refurbishment level		
Category	Investment					1	2	3
Opaque and transparent envelope	Application of thermal insulation	Wall	U_w	W/m^2K	1.4	0.7	0.4	-
		Roof	U_w	W/m^2K	1.65	0.5	0.3	-
		Floor	U_w	W/m^2K	3.1	0.5	0.3	-
	Replacement of windows	Windows	U_w	W/m^2K	5.1	3.8	3.0	2.7
Technical systems	Interior and exterior lighting	Interior Lighting	Installed power	W/m^2	10-12	LED		
	DHW installation	DHW			Conventional gas boiler	Not considered		
	HVAC installation	HVAC	EER COP		Traditional heat pump	2.9 3.3	3.10 3.41	3.8 4.2
Renewable Energy Systems	Installation of photovoltaic for self-consumption	PV	Installed power	kWp	-	45		

It is worth mentioning, however, that the SBP Investment Fund programmes are not specific in terms of the requirements to be meet by each category of investment as shown in Table 2, as the investment programmes are carried out in conformity with national and Community legislation in force. Nevertheless, by grouping the refurbishment solutions according to investment categories of the SBP Investment Fund, emphasises the importance of the findings of the Republic_ZEB project in the light of actual challenges.
As Table 2 shows, the main interventions are related to the building envelope, heating ventilation and air conditioning (HVAC) and domestic heating water (DHW) systems, lighting and power generation systems, and include several levels of refurbishment.
Regarding the performance levels, different levels of thermal insulation were proposed for the retrofitting of opaque envelope building components (e.g. different thicknesses of thermal insulation materials applied on the external face). In the case of the windows and doors, different assembly of double and triple glazing were proposed as well, leading to different U-values.
Regarding the renovation of the heating and cooling systems, they include the updating the energy systems (e.g. by condensing boilers, geothermal heat pumps, air source heat pumps, variable refrigerant flow systems, the emission systems (radiators, fan-coils, radiant heating and cooling, variable refrigerant flow systems, etc.) and the control systems.
For the retrofit of the lighting system, it was considered updating the illuminators by LED, with the possibility of installing control systems for occupancy and daylight control.
For the renewable energy systems, for the nZEB performance in Portugal, the photovoltaic system is the most adequate.
It is also worth mentioning that, in addition of the categories shown in Table 2, the technical systems of the SBP Investment Fund include: optimization of fluorinated gas related emissions, heat exchangers installation or replacement, building management systems and sensors, efficient water use and rainwater harvesting systems, and incorporation of natural-based solutions and materials, recycled materials and bioclimatic architecture solutions.

3. Conclusions

This work provides an overview of the key aspects related to the refurbishment solutions for deep renovation of buildings in Portugal. It provides a revised perspective of effective refurbishment solutions for nZEB office buildings in the light of ongoing related funding schemes currently in form which aim to meet Portugal´s carbon neutrality and related sustainability goals.
The importance of this work is to produce valuable input to the building construction sector and support all concerned stakeholders for the development and implementation of the recent EU and national energy efficiency strategic plans.

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References

[1] European Commission. 2022. Energy performance of buildings directive [online] Available at: <https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings> [Accessed 30 August 2022].
[2] Almeida, M., Ferreira, M., Rodrigues, A. and Baptista, N., 2017. Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation (Annex 56) - Guidebook for Policy Makers. International Energy Agency.
[3] European Commission. 2022. 2030 Climate Target Plan [online] Available at: <https://ec.europa.eu/clima/eu-action/european-green-deal/2030-climate-target-plan_en> [Accessed 30 August 2022].
[4] European Commission. 2019. Portugal national energy and climate plan 2021-2030 (NECP 2030) [online] Available at:

<https://ec.europa.eu/energy/sites/default/files/documents/pt_final_necp_main_en.pdf> [Accessed 30 August 2022].
[5] Lopes, R.A., Magalhães, P., Gouveia, J.P., Aelenei, D., Lima, C., Martins, J. 2018. A case study on the impact of nearly Zero-Energy Buildings on distribution transformer aging. Energy, 157, pp. 669-678.
[6] Majdalani, N., Aelenei, D. Lopes, R. A., Santos Silva. C. A., 2020. The potential of energy flexibility of space heating and cooling in Portugal, Utilities Policy, 66, 101086
[7] 2013. IEA Technology Roadmap - Energy efficient building envelopes. [online] International Energy Agency (IEA). Available at: <https://iea.blob.core.windows.net/assets/2be63379-1185-42e7-9608-94e5d3682956/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.pdf> [Accessed 30 August 2022].
[8] European Commission. 2018. Energy performance of buildings directive [online] Available at: <https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en> [Accessed 30 August 2022].
[9] Trading Economics. 2018. Portugal New Construction Orders [online] Available at: <https://tradingeconomics.com/portugal/construction-orders> [Accessed 30 August 2022].
[10] BPIE - Europe's buildings under the microscope. 2011. A country-by-country review of the energy performance of buildings. Buildings Performance Institute Europe (BPIE).
[11] COMMISSION STAFF WORKING DOCUMENT - Assessment of the final national energy and climate plan of Portugal. [online] European Commission. Available at: <https://ec.europa.eu/energy/sites/default/files/documents/staff_working_document_assessment_necp_portugal_en.pdf#page=3> [Accessed 30 August 2022].
[12] European Commission. 2021. NextGenerationEU: European Commission endorses Portugal's €16.6 billion recovery and resilience plan [online] Available at: <https://ec.europa.eu/commission/presscorner/detail/es/ip_21_2985> [Accessed 30 August 2022].
[13] Aelenei, L., Petran, H., Tarrés, J., Riva, G., Ferreira, A., Camelo, S., Corrado, V., Šijanec-Zavrl, M., Stegnar, G., Gonçalves, H., Magyar, Z., Salom, J., Polychroni, E., Sfakianaki, K., (2015). New Challenge of the Public Buildings: nZEB Findings from IEE RePublic_ZEB Projec., Energy Procedia, 78: 2016-2021. DOI: 10.1016/j.egypro.2015.11.195.
[14] Gomes, R., Ferreira, A., Azevedo, L., Costa Neto, R., Laura, A., & Silva, C. 2021. Retrofit measures evaluation considering thermal comfort using building energy simulation: two Lisbon households, Advances in Building Energy Research, 15:3, 291-314, DOI: 10.1080/17512549.2018.1520646
[15] Petran, H, Radulov, L et al. 2014. D2.1-Report on the Preliminary Assessment of Public Building Stock - RePublic_ZEB Project. [online]: Available at: < https://www.researchgate.net/publication/318541531_Report_on_the_Preliminary_Assessment_of_Public_Building_Stock > [Accessed 30 August 2022].
[16] Magyar, Z, Nemeth, G, Kontra, J. 2015. D3.3- Report on best practices and lists of technologies useful for the refurbishment of buildings with detailed national sections & D3.4 Report on proposed packages of measures - RePublic_ZEB Project.