Near Zero-Energy Housing

Subjects: Green & Sustainable Science & Technology | Environmental Studies | Environmental Sciences
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A context-specific approach to the investigation of barriers to Near Zero-Energy Housing could facilitate and accelerate the transition towards a zero-energy built environment.

Keywords: NZEB ; near zero-energy housing ; new build housing ; institutional barriers ; upscaling ; policy suggestions

1. Introduction

It has been more than 10 years since the European Parliament published the Energy Performance of Buildings Directive (EPBD) 2010/31/EU which included Article 9(1) stating that all new buildings are to be nearly zero-energy as of January 2021 [1]. In 2014, ZEBRA 2020's evaluation of the distribution of newly constructed dwellings showed that, out of 14 European Member States (MS), France was the only European country where the definition of NZEB matched the actual building regulations, thus making it the only country that has been actually building NZEBs since 2013 [2]. In 2016, the Directive published a synthesis report comprising the analysis of European MS national action plans which formed the basis of their recommendations and guidelines on the promotion of NZEB [3]. The report highlighted that, despite their noticeable efforts, all MS, with the exception of Slovenia and the Netherlands, did not include quantitative intermediate targets for the implementation of NZEBs by 2015 [3]. Instead, the targets mentioned were mostly qualitative and extremely variable from one MS to the other, making a progress assessment less tangible and a comparative analysis more difficult.

Consequently, the importance of setting quantitative intermediate targets was stressed again and repeated throughout the synthesis report, and one of the Directive's main summary recommendations was for European MS to accelerate their efforts in promoting the uptake of NZEBs and to ensure meeting these quantitative set target dates [4]. However, in 2018, the New Buildings and NZEBs central team under the Concerted Action EPBD reported that 24% of European MS still did not have a detailed definition of NZEB stated in legal documents [5]. The submission of National Action Plans in 2019 was another nudge for European MS [6]; however, it is fair to say that the transition towards the implementation and uptake of NZEB has been slow while the urgency and importance to achieve this transition is growing. Even more so now considering the European Green Deal that aims to make Europe the first climate-neutral continent by 2050 [7].

So, what are the factors obstructing or delaying this transition? Although innovation is key in achieving zero-energy designs, an effective transition to a zero-energy built environment requires a successful uptake and upscale of such designs [8]. In fact, one of the common running arguments around sustainability or energy transitions is that they are societal and cultural changes as much as they are technical. It is based on this fundamental argument that the Energy Cultures (EC) framework was conceptualized. The EC framework adopts an actor-centred approach where it recognizes the importance of technology through the study of an actor's material surrounding as one of its study entities. However, it also recognizes the societal and cultural aspects of change by broadening its scope to include as its other study entities the study of practices, norms and external transactional or contextual factors that could have a direct or indirect impact on the actor [9][10]. The foundational definition of institutions is any set of guidelines used to organize any form of human interaction. Any form of institution and combinations of institutions or guidelines will affect actions and outcomes [11].

The EC framework recognizes the complexity of these intra and interrelations and their significance or impact on achieving change by broadening its concept of culture to include external factors such as policies and regulations, in addition to habits and values, and materials and technology [9][10]. The identification of contextual factors and the determination of what is 'external' is dependent on the nature of the actor in the study [10]. When it comes to NZEB, whether the actor is the resident or the NZEB itself, external factors, in other words the institutional context, around the supply and uptake of NZEBs is the same. Thus, the question becomes: *What are the institutional barriers to the implementation and uptake of NZEBs?* Then more explicitly: *What insights can be gained from the investigation and identification of these institutional barriers and how can they inform policy?*

2. Barriers to the Implementation of Sustainability Measures Including NZEBs

One of the primary or foundational policy actions taken to evaluate the implementation of new measures is the investigation of barriers and drivers for an effective overall market response [12]. Consequently, be it explicitly or implicitly, the challenges to the implementation and uptake of new measures, designs or technologies within the built environment have been widely covered in sustainability and energy efficiency literature over the past years [13][14][15][16][17][18]. Considering the momentum gained by NZEBs since 2010, the barriers and opportunities to their implementation and uptake have also been thoroughly explored by academic literature [19][20][21][22][23][24][25][26].

These studies were conducted at different times and expanded over different locations. They varied in scope ranging from general such as the barriers to sustainable building to specific such as the barriers to zero-carbon homes or NZEBs in particular. The barriers were explored from different angles of stakeholders be it policy makers, housing experts or professionals in the construction industry and the subjects of investigations were also different since they included energy efficient housing, low-carbon housing or prefabricated affordable housing apart from NZEBs. The distinction between the studies evaluating barriers to sustainability measures in general and studies evaluating barriers to NZEBs in particular is important as it underlines the development of barriers through a change of scope. Even within NZEB focused studies, although the scope of the research is now narrower, the studies reviewed still differed in their points in time, the methods implemented, the perspectives taken and their geographic contexts. Yet, despite these differences, the outcomes with regards to the barriers to sustainability measures and NZEBs revealed significant similarities and overlaps. **Table 1** summarizes these outcomes and highlights the similarities by listing them in a descending order starting with the most common barriers with the highest number of references. It also highlights the overlaps in its listing by making a distinction between mentions that occurred in studies around sustainability measures in general and mentions that occurred in studies around NZEBs in particular.

Table 1. List of overall barriers to the implementation and uptake of sustainability measures including NZEBs.

Code	Barrier	Sustainability	NZEB	Overall Mentions	Rank
LRB01	Higher costs	[13][14][16][17][18]	[20][22][23][24][25][26]	11	1
LRB02	Lenient building regulations	[14][16][17][18]	[19][22][23][24][25][26]	10	2
LRB03	Shortage of skills	[13][14][15][18]	[20][21][22][23][24][26]	10	2
LRB04	Lack of awareness	[14][15][16][18]	[21][22][23][24][25][26]	10	2
LRB05	Unclear or conflicting policies	[13][14][17]	[19][21][22][23][24][25]	9	3
LRB06	Uncertainty and risks of innovation	[14][15][16][17][18]	[20][23][24][25]	9	3
LRB07	Lack of adequate financial incentives	[13][14][15][16]	[19][24][25][26]	8	4
LRB08	Lack of expertise and experience	[15][16][18]	[21][23][24][26]	7	5
LRB09	Cultural preferences	[16][17]	[20][23][24][25][26]	7	5
LRB10	Lack of knowledge	[14][16][18]	[20][23][24][25]	7	5
LRB11	Payback period and return on investment	[14][16][17]	[22][23][24][25]	7	5
LRB12	Limited authority	[13][14][16][18]	[24][25]	6	6
LRB13	Lack of communication and coordination	[13][14][16]	[20][21][23]	6	6
LRB14	Access to technology	[14][18]	[20][23][24]	5	7
LRB15	Inadequate policy	[13][14][18]	[20][25]	5	7
LRB16	Business as usual approach	[18]	[22][23][25][26]	5	7
LRB17	Lack of priority and trade-offs	[14][15][16][18]	[22]	5	7
LRB18	Access to land	[13][14]	[23]	3	8
LRB19	Insufficient investment	[13][15]	[22]	3	8
LRB20	Poor management and maintenance	[13][16]	-	2	9
LRB21	Information asymmetry (supply/demand)	[13][16]	-	2	9

Code	Barrier	Sustainability	NZEB	Overall Mentions	Rank
LRB22	Lack of involvement	[18]	[26]	2	9
LRB23	Split incentive	[16]	[24]	2	9
LRB24	Community opposition	[13]	-	1	10
LRB25	Lengthy governmental approval process	[13]	-	1	10
LRB26	Climate and geography	-	[21]	1	10
LRB27	Design methodology	-	[21]	1	10

Categorization of Most Common Barriers

Whether studies focused on sustainability measures in general or NZEBs in particular, the identification of barriers always led to a certain categorization. In 2009, the feasibility of zero-carbon homes was investigated from the perspective of home builders in England [25]. Identified barriers were categorized into legislative, financial, technical and cultural barriers, thus covering all the potential aspects of constraints. In 2011, low-carbon housing refurbishments in England were evaluated this time from the perspective of architects and the same categorization was adopted [22]. Some research resulted in fewer groups such as a study evaluating the environmental legislation barriers and drivers to energy conservation and building design where legislative, financial and design barriers were identified [14]. Others opted for more groups as for example a study evaluating zero-carbon homes from the perspective of the construction industry in the UK that assigned skills and knowledge and industry their own categories of barriers in addition to economic, cultural and legislative barriers [23]. Overall, aside from the slight differences between these categorizations, the most recurrent distinctions made are between financial, cultural, technical and legislative barriers. The combination of all four can be considered to provide an institutional overview of barriers to NZEBs. However, it is important to highlight that the assignment of barriers to corresponding categories is not a straightforward process. One must recognize that they are all interrelated and that any change in one will most certainly affect another (**Figure 1**).

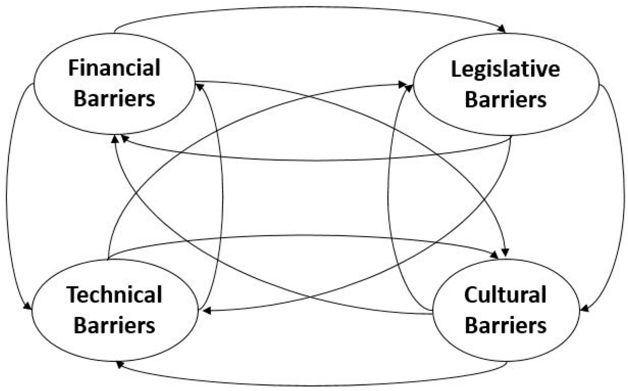

Figure 1. Common categories of institutional barriers.

Recalling the foundational definition of institutions being any set of guidelines used to organize any form of human interaction, each category is a form of institution and combinations of institutions or guidelines will affect actions and outcomes [11]. Moreover, some of the barriers identified such as the lack of communication and coordination could apply or fall under any of the four categories. Thus, to avoid repetition, a fifth category of ‘overarching barriers’ was created. In line with that reasoning, **Figure 2** illustrates the most common barriers to the implementation and uptake of NZEBs according to these five categories. The numbers accompanying the arrows indicate the number of mentions of these most common barriers in previous studies. The dashed arrows highlight the overlap of the lack of communication and coordination barrier that resulted in the creation of the fifth category of overarching barriers.

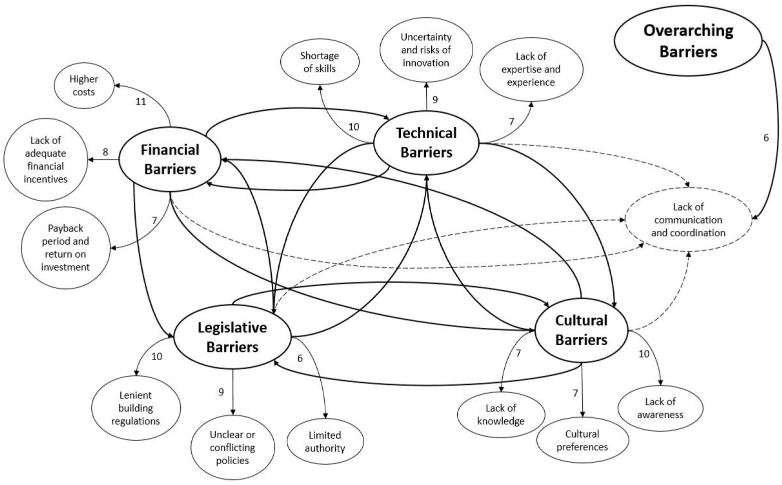

Figure 2. Categorization of most common barriers.

2.4. The Importance of Context and NZEB Related Policies

The review of studies on sustainability measures in general followed by a review of studies on barriers to NZEBs in particular, shed light on the fact that the barriers identified in these studies remained the same despite different research scopes, perspectives and geographic locations. This indicates that these stated constraints are applicable to any type of sustainability measure and that they are perceived by most professionals involved in the provision of these measures. Additionally, underlining the fact that the studies reviewed were conducted at different points in time singles out the persistence of these identified barriers through time. Academically, this can be interpreted as a validation of research outcomes and conclusions. However, in practice, this underlines a significant limitation. It raises the question of how these constraints have been addressed and why they have been recurring over time despite the formulation of recommendations and measures to overcome them.

A possible explanation to the persistence of similar results is the general level of analysis. While reaching generalizable outcomes and having a holistic view on challenges to the uptake of innovations is helpful, a more context-specific level of analysis could help identify more context relevant challenges leading to better and more precise recommendations. It is well known that energy commitments, legislative structures, traditions and practices, and building regulations all vary from one country (i.e., context) to another [16][19]. In fact, a closer look into a certain context often generates new and more specific outcomes, in this case, barriers. For instance, a study on future challenges to NZEBs in Southern Europe identified the different geography and climate of Southern European countries as one of the main barriers to the successful implementation of NZEBs (**Table 1**, LRB26). Hot summers and recurrent heat waves are a few of the climatic conditions leading to poor NZEB designs and a significant energy performance gap. This is also linked to the second context-specific barrier identified in this study, which is a poor design methodology (**Table 1**, LRB27). It is argued that due to these different geographic and climate conditions, rules of thumb and steady state simulation tools are not enough to achieve a successful design. Thus, in Southern European countries, there is a need for design requirements based on field measurements and real performance monitoring data [21]. In Northern European countries this approach has already been in place [5][19][24].

The recognition of changing conditions due to different climates and locations is exactly why the EPBD did not provide specific, harmonized minimum or maximum requirements to European MS in their definition of a near zero-energy building. In fact each MS was required to determine their own requirements tailored to the peculiarities of their contexts [3]. This also resulted in MS having individual action plans. First, the growing imperative of NZEBs entailed the submission of nearly zero-energy buildings national plans [27]. Then, following the Paris Agreement, each MS had to submit its own National Climate and Energy Plans [6]. European MS even have their own national action plans such as the Dutch Climate Agreement [28], the Irish Climate Action Plan [29] and the corresponding progress report [30]. That is to say the importance of contextual characteristics and their acknowledgment as influencing factors is manifested in policy and government reports. Yet, in academia, there is still a need for context-specific investigation and studies exploring in detail the challenges and opportunities to the implementation and uptake of NZEBs while taking into account local peculiarities.

As part of a larger project funded by Interreg North-West Europe entitled Housing 4.0 Energy: Affordable and Sustainable Housing through Digitization (H4.0E), this research aims to contribute to this discussion by conducting a more context-specific investigation of barriers to the successful implementation and uptake of near zero-energy housing in Belgium, Ireland and the Netherlands from the perspective of professionals involved in the commissioning, design, construction and regulation of housing. Through the H4.0E, a number of small and affordable (near) zero-energy dwellings will be designed and built in the three different northern European countries. In particular, the dwellings are divided into three pilot projects: one in Huldenberg in Belgium, another in Kilkenny, Wexford, and Carlow in Ireland, and a third in Almere in the Netherlands. The overarching project aim is not only to provide new and affordable housing solutions for small, low to middle-income households composed of one to two persons but also to explore and facilitate the uptake of these dwellings within Flanders, Ireland, and the Netherlands [31]. This paper is the initial stage of a larger study that will investigate, with reference to the EC framework, the norms, practices and materials surrounding H4.0E dwellings and their occupants.

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