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Article

Institutional Barriers to Near Zero-Energy Housing: A Context Specific Approach

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Abstract: After more than ten years since the introduction of Near Zero-Energy Buildings (NZEBS), the transition towards a zero-energy new built environment can still be considered slow despite European Member States' various efforts to facilitate, promote and accelerate their implementation and uptake. The barriers to sustainability measures in general and NZEBs in particular have been extensively explored by academic literature and despite different research scopes, perspectives, locations and times, previous studies have reached similar outcomes. Similar barriers were perceived by different housing professionals in different geographic contexts and these same barriers also persisted through time. This study argues that while this could be interpreted as a validation of outcomes, it also underlines a limitation resulting from a general level of analysis. Thus, this study contributes to the discussion by adopting a context-specific approach in its investigation of barriers to near zero-energy housing in small towns in Flanders, Ireland and the Netherlands. The data was collected from a series of focus groups with housing professionals in Leuven, Kilkenny and Almere. Through descriptive coding, this study's outcomes echoed previous research findings. However, a closer look through inferential coding resulted in the identification of 21 new contextual barriers leading to the formulation of more specific policy suggestions with a different allocation of precedence that depends on every context.

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



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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?*

Section 2 of this paper explores the literature on barriers to the implementation and uptake of sustainability or energy efficiency measures, technologies or designs including NZEBs. Considering this is an explorative study focusing on (near) zero-energy, low-carbon, small and affordable housing, the literature reviewed involves a combination of the concepts of sustainability, housing, policy, and energy performance. This review establishes the basis for this study's methodological approach consisting of a series of focus groups, which is described in Section 3. Section 4 presents the results by differentiating between barriers that persisted in 2019 and new contextual barriers. Section 5 presents the discussion of findings where the importance of a context-specific investigation is highlighted and potential policy suggestions are formulated accordingly. Finally, Section 6 concludes the paper by highlighting its contribution and limitations leading to direction for future research.

2. Literature Review

2.1. 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 [13–18]. 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 [19–26].

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	[13,14,16–18]	[20,22–26]	11	1
LRB02	Lenient building regulations	[14,16–18]	[19,22–26]	10	2
LRB03	Shortage of skills	[13–15,18]	[20–24,26]	10	2
LRB04	Lack of awareness	[14–16,18]	[21–26]	10	2
LRB05	Unclear or conflicting policies	[13,14,17]	[19,21–25]	9	3
LRB06	Uncertainty and risks of innovation	[14–18]	[20,23–25]	9	3
LRB07	Lack of adequate financial incentives	[13–16]	[19,24–26]	8	4
LRB08	Lack of expertise and experience	[15,16,18]	[21,23,24,26]	7	5
LRB09	Cultural preferences	[16,17]	[20,23–26]	7	5
LRB10	Lack of knowledge	[14,16,18]	[20,23–25]	7	5
LRB11	Payback period and return on investment	[14,16,17]	[22–25]	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	[14–16,18]	[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
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

2.2. Definitions of Most Recurrent Barriers

This subsection elaborates on the definitions of the barriers that reoccurred in at least six previous studies. In other words, it defines the barriers, ranking from 1 to 6.

The first most recurrent barrier was revealed to be higher costs. Higher costs comprise any additional costs associated with the implementation of sustainability measures, technologies and/or materials compared to standard construction and/or the typical measures imposed by current policy and regulations. However, higher costs are not restricted to

the initial stage of construction. They also apply to the maintenance and conservation of innovative sustainability measures.

The second most recurrent barriers are lenient building regulations, the shortage of skills and the lack of awareness. Lenient building regulations are perceived as a barrier mainly when current or established regulations are less stringent than the sustainability measures or designs in question. The shortage of skills mostly applies to the implementation of sustainability measures within the construction sector and includes the lack of training for it. The definition of the lack of awareness is quite broad but it can be manifested through market demand. When purchasers or end-users do not realize the magnitude of climate change consequences and the urgency of action, they do not demand sustainability measures or designs.

The third most recurrent barriers are the unclear or conflicting policies and the uncertainty and risks of innovations. Under unclear and conflicting policies, conflicts can occur between different policy areas as well as between the policies of local authorities and those of the central government. Uncertainty and risks of innovations describe the general reluctance to use new materials and technologies or adopt new methods and designs. These are usually perceived as unreliable due to the insufficient testing and the lack of experience when it comes to their implementation, maintenance and management.

The lack of financial incentives is the fourth most recurrent barrier. After the economic crisis in Europe, financial institutions were more reluctant to loan, which results in the absence of adequate and supporting schemes. The barrier of the lack of financial incentives is interrelated with the barrier of uncertainty and risk of innovations as the latter accentuates the former.

It is also closely linked to one of the fifth most recurrent barriers: the long payback periods and return on investments. The barriers of lack of experience and expertise, lack of knowledge, and cultural preferences are the other fifth most recurrent barriers. The definition of the lack of expertise and experience is closely related to the shortage of skills as it implies a lack of information to implement sustainability measures and designs. However, it also applies to other professionals such as designers and engineers. The lack of knowledge is associated to a lack of interest in sustainability leading to the non-consideration of sustainability measures that go beyond existing policies and regulations. Cultural preferences of traditional methods can be linked to both supply and demand through the business as usual barrier and the community opposition barrier especially when it comes to affordable housing developments since their foundational essence is one: the reluctance or resistance to change one's habits.

The limited authority and the lack of communication and coordination are the sixth most common barriers. In the absence of governmental support, the barrier of limited authority is raised. It can occur when the stakeholders involved do not have the authority or adequate leadership and support to implement sustainability measures. It can also apply to local authorities in the case of high interference from the central government. Last but not least, the lack of communication and coordination applies to the channels between local authorities and central governments as much as those between different policy areas and departments or different design and construction disciplines.

2.3. 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).

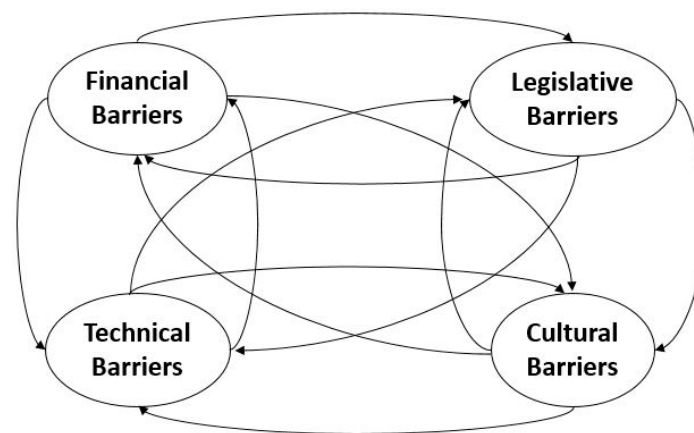


Figure 1. Common categories of institutional barriers.

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.

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.

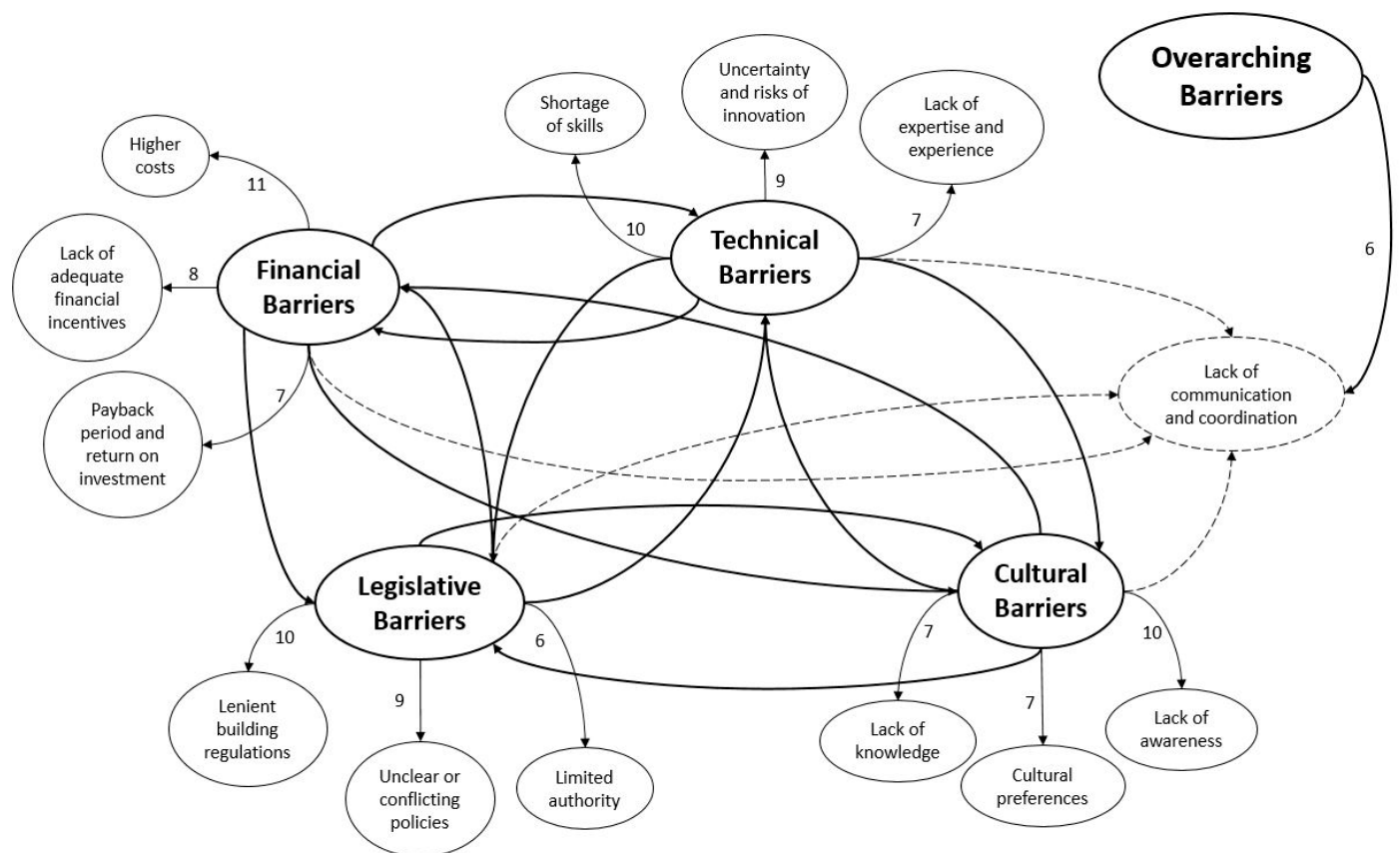


Figure 2. Categorization of most common barriers.

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.

3. Materials and Methods

This study followed an iterative approach in its implementation, alternating between desk research, qualitative data collection and qualitative data analysis as illustrated in Figure 3. The desk research mainly covered secondary sources such as academic articles, textbooks, government proceedings, government reports and websites. The qualitative data was collected through focus groups. The qualitative data analysis is described below.

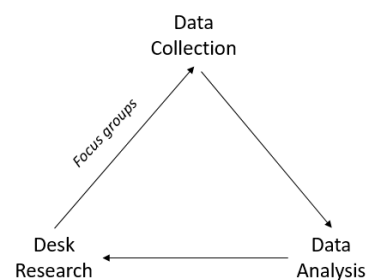


Figure 3. Iterative methodological approach.

3.1. Focus Group Content

The explorative review of studies on barriers to sustainability measures in general and to NZEBs in particular was foundational to the design of the focus group discussions in two ways. First, it allowed the identification of the main categories of barriers for an overall institutional overview: legislative, financial, technical, cultural and overarching barriers. Second, in most of the studies reviewed the categorization of barriers followed the data analysis. In this study, these categories were taken as a starting point to the focus group discussions. In other words, main keywords were determined under each category, which led to the formulation of the explorative and engaging questions that guided the focus group discussions. Keyword examples would be: housing policy, planning and land use policy, energy policy, building regulations, building standards, financial schemes, tax reductions, subsidies, and cultural habits and preferences. A distinction between implementation and uptake was ensured through the division of focus group discussions into two rounds. The first round focused on the current challenges to the actual

implementation of H4.0E dwellings and the second round focused on potential challenges to their uptake to a wider scale.

3.2. Focus Group Participants

One focus group was conducted per each pilot between the months of April and June 2019. The focus groups gathered housing designers, technical experts, housing providers and decision makers in the field as well as local and regional authorities for a balanced composition of people representing all parties involved in the field of housing. In fact, the focus group method was selected specifically to have an open discussion amongst the different parties involved in housing provision. The participants were recruited by nomination [32]. The number of participants per focus group did not exceed the recommended maximum of 15 as 9 housing professionals were present in Almere and Kilkenny and 12 in Leuven [33]. The discussions were guided by a moderator and an assistant-moderator and took place in English and in Dutch depending on the location. With the participants' consent, the discussions were recorded then transcribed into detailed reports. The reports were then shared with the H4.0E pilot representatives and the housing professionals who participated in the study for their comments and feedback. The input received was taken into account during the qualitative data analysis described in more detail below.

3.3. Pilot Characteristics

One of the ways the importance of context was included in this study was through the different pilot projects' characteristics. Each H4.0E pilot project had a different ownership, tenure type, target group, income range and housing sector as can be seen in Table 2. The Flemish and Irish pilots have similar project characteristics and they are significantly different from the Dutch pilot characteristics. While the first two focus on providing affordable NZEBs to low-income households on waiting lists through either social housing or partial subsidization, the Dutch pilot targets low to middle-income households within the private housing sector looking to become owners and willing to self-build their dwelling [31]. Thus, the importance of a context-specific investigation could be tested through the comparison of focus group outcomes between the Dutch, Flemish and Irish pilot projects considering all three have different geographic contexts but the latter two have similar project characteristics.

Table 2. H4.0E pilot project characteristics.

Country	Belgium	Ireland	Netherlands
Pilot location	Huldenberg	Wexford, Carlow, Kilkenny	Almere
Ownership	Private	Local Authority	Private
Tenure Type	Rental	Rental	Owner Occupied
Target Group	Waiting list	Social housing waiting list	Self-builders
Income Range	Low-income	Low-income	Low/Middle-income
Sector	Private, Partially subsidized	Social Housing	Private

3.4. Qualitative Data Analysis

The qualitative data collected was analyzed directly from the transcribed reports. An initial screening of focus group outcomes amongst the three pilots projects allowed the underlining of barriers that have been identified by previous studies yet reoccurred in this study. Having the pre-determined barrier categories and the pre-identified barriers serving as the main thematic groupings, the data was coded into these key categories and barriers—otherwise known as *descriptive coding*. Secondary and tertiary screenings allowed the highlighting of the importance of a context-specific investigation through the identification of new context-specific barriers—otherwise known as *inferential coding* [34]. Inferential coding was crucial to the qualitative data analysis also because of the intra and interrelations of the institutional barriers. Although the focus group discussions were structured in a way that directly allows the identification of barriers within the five different

categories—financial, legislative, technical, cultural and overarching—the interrelation of these barriers prevailed and at several instances the statements of focus group participants (FP) covered several barriers at once be it explicitly or implicitly. An example would be:

“You are expected to meet building regulations, you can exceed them but this becomes like any other project [...] based on an individual basis. You do not get funding for exceeding the building regulations.”

(Statement 1, Kilkenny)

Through this statement, we are able to identify first the lenient building regulations barrier (LRB02) that describes current building regulations as more lenient than NZEB requirements. Second, we can extract the insufficient investment barrier (LRB19) describing the lack of government funding allocated to support the construction of NZEBs. This is underlined by a perception of higher costs (LRB01) that is automatically associated with NZEB design and construction regardless of the accuracy or validity of this perception. Third, we can sense the lack of priority and trade-off barrier that is about having to choose between affordability over zero-energy performance and not being able to achieve both (LRB17).

In other statements, the implicit indications of barriers are dominating. For instance:

“I think that the need for housing at the moment is pushing everything on at a particular speed and the urgency to get houses built and to get people into houses.”

(Statement 2, Kilkenny)

The statement above is an indication of the lack of awareness (LRB04) considering the participant’s perception of urgency is misplaced. In that statement, the imperative of all new dwellings to be near zero-energy is dismissed by the urgency to simply provide housing. When referring to the Irish Climate Action Plan 2019 and the detailed actions within, it becomes clear that this is not the case [29].

4. Results

The data analysis of this study mirrors the approach taken in the literature review as it followed a gradual process that started with a general overview of barriers to the implementation of H4.0E dwellings followed by a more detailed investigation of barriers within each context. Thus, the first part of this section lists the focus group outcomes that have been identified in previous studies and the second part introduces and defines the new barriers that were identified in the focus groups. This presentation of results sheds light on known factors that were still perceived as challenging to the implementation of NZEBs in 2019 in addition to generating new outcomes.

4.1. Barriers That Persisted in 2019

As mentioned above, this section highlights the similarities between this study’s focus group outcomes and the barriers to sustainability measures and NZEBs identified from previous literature. The outcomes are grouped as per the five categories previously determined. Thus, Table 3 lists the overlapping financial barriers, Table 4 lists the overlapping legislative barriers, Table 5 lists the overlapping technical barriers, Table 6 lists the overlapping cultural barriers and Table 7 lists the overlapping overarching barriers. The tables list the barriers with the corresponding supporting statements from the focus group discussions depending on the location where they are applicable. All barriers listed have been identified in at least one of the three different study contexts. Places of non-occurrence are indicated by ‘X’. As can be seen in Tables 3–7, all the most recurrent barriers previously mentioned in Figure 2 and defined in Section 2.3 also reappeared in the focus group outcomes of this study. However, 10 out of the 14 other barriers that were not as frequently mentioned in previous studies were also identified in this study’s focus group outcomes. These are the insufficient investment, the lack of priority and trade-off or the split incentive barriers under financial barriers; the inadequate policy, access to

land or lengthy governmental approval process under legislative barriers; the climate and geography barrier under technical barriers; the business as usual approach and community opposition barriers under cultural barriers; and the lack of involvement barrier under overarching barriers.

Table 3. Financial barriers that persisted in 2019.

Code	Barrier	Kilkenny	Leuven	Almere
LRB01	Higher costs	"[...] you do not get funding for exceeding building regulations [...]."	"People do not want to use wooden cladding because of the higher maintenance costs."	"[...] the closer you get to zero (energy) then some of your costs really go up and then it starts affecting (affordability)."
LRB07	Lack of adequate financial incentives	"We cannot give money upfront unless the architect or engineer signed off and works have been completed."	"The reason why social landlords in Flanders are less focused on the realization of energy-neutral homes is the cost [...]."	"Now [...] the bank (is) saying [...] we want a guarantee that the house will be finished so what happens if someone [...] breaks his arm [...] the actual costs if you use a professional for this are higher because then you will have to pay these and then suddenly someone doesn't have enough income anymore."
LRB11	Payback period and return on investment	"If the first thing they learn is that the value of their security will be 0 in 15 years that will have a big bearing on their willingness to lend against the property."	X	"You need to show that you have enough income, you need to show that the house will have enough values [...] so your loan to value is valid."
LRB19	Insufficient investment	"[...] you do not get funding for exceeding building regulations [...]."	X	X
LRB17	Lack of priority and trade-offs	"[...] the answer will always be well if we could house 6 families instead of 4 families if that makes economic sense then that's what they will go with [...]."	"It is established that there is a constant trade-off between economy and energy efficiency. This trade-off is traditionally made at the level of the initial investment."	X
LRB23	Split incentive	X	"In the (social) rental sector it is generally the case that the landlord invests and the tenants has lower energy costs."	X

Table 4. Legislative barriers that persisted in 2019.

Code	Barrier	Kilkenny	Leuven	Almere
LRB02	Lenient building regulations	"You are expected to meet building regulations, you can exceed them but this becomes like any other project [...] based on an individual basis [...]."	"Low-carbon building is not yet part of the applicable standards within social housing. There are no specific guidelines for the use of materials."	X
LRB12	Limited authority	"(The) likelihood is the building is already pre-determined and pre-designed to a certain standard anyway."	"A problem that the social housing companies are confronted with is that they are tied to government contracts: public procurement."	X

Table 4. Cont.

Code	Barrier	Kilkenny	Leuven	Almere
LRB05	Unclear or conflicting policies	"It (similar designs) still doesn't get you away from your application for DAC (or fire certification. They're all individual schemes it's not something you can pre-certify."	"There is still no clear framework within which to work. If this framework exists and it is incorporated into spatial implementation plans, developments can proceed quickly."	X
LRB15	Inadequate policy	"When you do have land, you're working with local authorities on what the need is for the area."	"The realization of affordable housing should be a reason for municipalities to make semi-public and public land available in the form of long-term leases instead of selling the land to project developers."	"There is no land and it is not organized enough by national or local government to make available plots for self-build."
LRB18	Access to land	"[...] there is not land out there or the access to land to take complete control of it."	"The realization of affordable housing should be a reason for municipalities to make semi-public and public land available in the form of long-term leases instead of selling the land to project developers."	"It is difficult to realize such a project in urban areas. It is easier here because you have large lots." "Land price was one of the obstacles. There were difficult negotiations."
LRB25	Lengthy governmental approval process	"Something that should take 3 months takes 2 years and you go back there and you are re-applying and..."	X	"This (land-value determination) discussion took 2 years in this case [...]."

Table 5. Technical barriers that persisted in 2019.

Code	Barrier	Kilkenny	Leuven	Almere
LRB06	Uncertainty and risks of innovation	"New innovative technologies and techniques means unforeseen issues."	"To be able to make a good investment a client should [...] have insight into the initial investment [...] A lot of data is needed for this and unfortunately it is not always available."	"We had to do a lot of tests to showcase that the type of construction is strong enough to fit (building regulations)."
LRB03	Shortage of skills	"After the last downturn, we lost a lot of skills."		X
LRB08	Lack of expertise and experience	"It's also about the expertise [...] you see discrepancies (and) differences from one developer to another [...] this is a new enough system and the problems will manifest themselves a few years later [...]."	"If the tender is specifically aimed at prefab construction there is a risk that there will not be enough tenders, few companies specialize in this."	X
LRB26	Climate and geography	"An Irish problem has always been damp walls."	X	"[...] the floor downstairs [...] the whole thing is floating a bit above ground to keep it all dry."

Table 6. Cultural barriers that persisted in 2019.

Code	Barrier	Kilkenny	Leuven	Almere
LRB04	Lack of awareness	"I think that the need for housing at the moment is pushing everything on at a particular speed and the urgency to get houses built and to get people into houses."	"Society has to make the switch."	X
LRB10	Lack of knowledge	"Lack of knowledge about how the system works makes people frustrated and pushes them to play around with switches not knowing how it affects the performance of the house."	"New technologies (such as underfloor heating) are no longer much more expensive, but the residents must be able and willing to deal with them."	"[...] this is different and far away from the standards and how we do things normally, can't be bothered."
LRB09	Cultural preferences	"[...] there is a mindset about timber frame in this country."	"The new techniques must be socially accepted."	"90% of the houses in Holland are built with concrete and bricks and that's what we are used to so suddenly starting to use wood is a bit different."
LRB16	Business as usual approach	"The department of housing in the government is more focused on traditional construction."	The social rental sector in Flanders has traditionally focused on building spacious traditionally built homes.	"Within the council, generally if you want to do an innovative project that does things a bit differently let's say 10% of the organization absolutely loves that and the other 90% thinks [...] this is different and far away from the standards and how we do things normally, can't be bothered."
LRB24	Community opposition	"It's not necessarily the local authority it's the neighbors. <i>Not in my backyard</i> sort of mindset [...] Even if the objections are trivial you will have councilors looking into it."	X	X

Table 7. Overarching barriers that persisted in 2019.

Code	Barrier	Kilkenny	Leuven	Almere
LRB13	Lack of communication and coordination	"You just have to (recognize) how nobody talks to each other [...] the big issue at the moment is between design and operation [...] sharing information is the most important thing and ultimately lowers costs and improves building performance [...] but it all comes back to everybody working together and that is the biggest issue in the construction sector."	"A framework and a vision are provided from the housing policy but it is very important that this is taken up locally."	X
LRB22	Lack of involvement	"A lot of Approved Housing Bodies now are working with developers and turnkeys."	X	X

4.2. New Focus Group Barriers

The focus group discussions led to the identification of several new barriers per different context. Table 8 lists these barriers to the implementation and uptake of H4.0E dwellings by distinguishing between categories and countries. The listing within the four categories does not follow any particular order. Place of occurrence is indicated with a 'Y'.

Table 8. Summary of focus group barriers to the implementation and uptake of H4.0E dwellings.

Category	Code	Barrier	Kilkenny	Leuven	Almere
Financial	FGB01	Inconsistent financial schemes benchmarks	Y		
	FGB02	Cost of certification	Y		
	FGB03	Self-build mortgage scheme	Y		Y
	FGB04	Loan to security scheme	Y		
	FGB05	Residual counting			Y
Legislative	FGB06	Profit maximization		Y	
	FGB07	Individual certification schemes	Y		
	FGB08	Local authority design requirements	Y	Y	Y
	FGB09	Long period of testing and development			Y
	FGB10	Social housing design requirements		Y	
	FGB11	Restrictions on small dwellings		Y	
	FGB12	Restrictions on compact construction		Y	
Technical	FGB13	Lack of standards	Y	Y	
	FGB14	Dwelling lifespan	Y		
Cultural	FGB15	Thermal comfort perception	Y		
	FGB16	Societal daily habits	Y	Y	
	FGB17	Lack of information		Y	Y
	FGB18	Perception of timber dwellings	Y		Y
	FGB19	Perception of small dwellings		Y	
	FGB20	Perception of self-build			Y
	FGB21	Reluctance to move		Y	

4.2.1. Focus Group Financial Barriers to H4.0E Dwellings

The contextual financial barrier of inconsistent benchmarks for green financing (FGB01) applicable to Ireland describes, as its name implies, the lack of consistency between different financial institutions when it comes to their benchmarks around the implementation of sustainability measures. In a way, this barrier was perceived to reflect the institutions' willingness to lend underlining the interrelation with the lack of financial incentives barrier (LRB07). The cost of certification barrier (FGB02) also applicable to Ireland entails the cost implications of certification applications needed for a design's approval. In Ireland, certification applications entail both designer and consultant fees. Consultant fees are perceived to be higher than designer fees. This was identified as obstructive to the uptake of H4.0E dwellings because even when dwelling designs are being replicated, certification costs would still be high due to these consultant fees. In other words, these fees could potentially counter the cost savings that would be achieved through the replication of H4.0E dwelling designs. The contextual financial barrier of self-build mortgage scheme (FGB03) is applicable to both the Irish and Dutch contexts. Currently, mortgage schemes are obstructive for low to middle-income households interested in building their own small, low-carbon and (near) zero-energy home as mortgage requirements in both contexts contest the affordability and innovation of the project. Within the Irish private sector, to avoid potential risks, the established financial schemes are set in a way that does not necessarily encourage innovation. The process of obtaining a mortgage requires most of the works to be completed and signed off by an architect and/or an engineer. Funds cannot be released otherwise, thus making it more difficult for individuals to obtain the necessary support to build their own H4.0E dwelling. In Almere, current financial schemes within the private sector also require a project completion guarantee from self-builders in case of injuries. This challenges the affordability aspect of self-building since it automatically changes the income brackets for applicants that would qualify for the scheme (Statement 3). This recalls the established loan to security scheme highlighted by participants in Kilkenny (FGB04) that was linked to the reluctance of financial institutions to lend (LRB07) under the assumption that the value of the security would depreciate faster because these dwellings have shorter lifespans compared to traditionally built dwellings (FGB21).

“[...] the bank (is) saying [...] we want a guarantee that the house will be finished so what happens if someone [...] breaks his arm [...] the actual costs if you use a professional for this are higher because then you will have to pay these and then suddenly someone doesn't have enough income anymore.”

(Statement 3, Almere)

The next contextual financial barrier identified in Almere is interrelated to policy and concerns the land price determination. In theory, land price is determined based on residual counting (FGB05) where building costs are subtracted from the market value. This was perceived as obstructive because a decrease in building costs would lead to higher land costs and contest the savings made through self-building depending on the municipalities' standardized land quotas. Last but not least, participants in Flanders perceived the established economic model as an overarching barrier to the provision of affordable housing in general. It was highlighted that as long as profit maximization (FGB06) is the main goal, successfully implementing and upscaling affordable and zero-energy housing is challenging.

4.2.2. Focus Group Legislative Barriers to H4.0E Dwellings

Under legislative barriers, the focus group discussion in Ireland identified the individual certification scheme (FGB07) as significantly challenging to the rapid uptake of H4.0E dwellings. The scheme requires an individual application for each certification needed per dwelling. Among these certifications are the Disability Access Certificate (DAC) or the Fire Certificate and the pre-certification of dwellings for those is not possible. Therefore, regardless of whether or not the dwelling designs have been replicated, the length of process stays the same. The next barrier applicable to the Irish context is also applicable to the Flemish and Dutch contexts and involves local authorities' design requirements (FGB08). In some instances these can be limiting and restrictive. In Flanders, these design requirements were perceived to be particularly restrictive to small-scale living (FGB11). Participants highlighted that although minimum living area requirements differ from one municipality to another, most of them exceed the largest H4.0E dwellings design living area. In the Netherlands, H4.0E dwelling designs also need to comply with the land use plan but this was not perceived as constraining as the long period of testing and development to pass building regulations which is the only other legislative barrier identified in Almere (FGB09). In Flanders, design requirements were also perceived as constraining within the social housing sector where they aim for universality of design to facilitate the allocation process (FGB10). Participants described these requirements as traditional and outdated in a way that encourages spacious dwellings. They were also perceived as too prescriptive to the extent of being obstructive especially when it comes to the adoption of energy-efficient technologies and innovative designs like small-scale living. Within land subdivision policies, participants in Leuven identified a restriction to compact construction (FGB12). It was highlighted that in Flanders, it is often the case to assign not more than one dwelling per a relatively large plot of land and this was perceived as inefficient and preventive of the provision of dwellings (Statement 4).

“The discussion should not really be about the realization of a small residential unit on a building plot but about the realization of a number of units on a plot.”

(Statement 4, Leuven)

4.2.3. Focus Group Technical Barriers to H4.0E Dwellings

With regard to aiming for a low embodied carbon, the lack of standards (FGB13) was identified as a barrier in both Kilkenny and Leuven. Participants perceived the absence of clear guidelines on the use of materials as challenging to the design of a low embodied H4.0E dwelling let alone its uptake. Additionally, participants in Leuven pointed out the absence of standards on modular construction which was also perceived as constraining to the uptake of H4.0E dwellings (Statement 6). In Kilkenny, the dwelling's shorter lifespan

(FGB14) was perceived as potentially constraining and as mentioned above this barrier is interrelated to others like the financial barrier of willingness to lend.

“Low-carbon building is not yet part of the applicable standards within social housing. There are no specific guidelines for the use of materials.”

(Statement 6, Leuven)

4.2.4. Focus Group Cultural Barriers to H4.0E Dwellings

According to FP in Kilkenny, a combination of occupants’ perception of thermal comfort (FGB15) and their daily habits (FGB16) can result in their reluctance to change energy sources (Statement 5).

“As a society, we decide if the room is warm enough by touching the radiator. [...] because the hand on the radiator is not warm enough even though the actual temperature in the room is 21 degrees they would say the heating system is not working.”

(Statement 5, Kilkenny)

Participants pointed out that traditional heating systems like radiators have been around long enough for people to make use of them in different indispensable ways. For instance in summer Irish occupants use radiators to dry clothes and that cannot be replaced by new systems like mechanical ventilation. This opinion was shared by participants in Leuven who claimed that occupants are used to traditional heating and ventilation systems to a point that they would still choose them over new systems regardless of the fact that they have been made more affordable. The barrier of lack of information (FGB17) also concerns potential occupants. In Leuven, the lack of information was linked to the incorrect use and operation of innovative technologies which could have a significant impact on the overall energy efficiency and performance. In Almere, the lack of information was linked to the uncertainty that revolves around the performance of a self-built dwelling considering this is still a new practice. This is an underlying barrier to the barrier of ‘perception of self-build’ (FGB20). Other H4.0E dwelling characteristics that provoke a negative perception are the timber frame (FGB18) and the small size of the dwelling (FGB19). In Kilkenny and Almere, participants highlighted that people do not perceive timber framed dwellings as robust and durable or resistant to water respectively. Participants in Leuven pointed out that people in Flanders tend to link small dwellings to tiny houses or ‘container’ homes that are usually found in gardens, orchards or nature. This negative perception only reinforces people’s reluctance to move (FGB21) from their larger family homes which is another cultural barrier that was identified in Leuven.

5. Discussion

5.1. A Context-Specific Investigation

The importance of a context-specific investigation was repeatedly manifested throughout this study. In the first instance, it was demonstrated through the distinction between general barriers that had been previously identified by literature and persisted in 2019 and the other focus group barriers specific to the H4.0E dwellings. The barriers that persisted in 2019 are the ones that were identified in previous studies and identified again by this study’s focus group participants. They are the barriers that persisted despite different research scopes, times, methods or geographic contexts. Examples of barriers that persisted in 2019 and that are common to all three contexts are the perception of higher initial costs, inadequate policy, access to land, lack of financial incentives, uncertainty and risks of innovation, cultural preferences and the business-as-usual mindset. Other examples of barriers that persisted in 2019 and that are common to at least two of the three contexts are the lack of awareness, the lack of knowledge, the lack of communication and coordination, the shortage of skills, the lack of expertise and experience, the loose building regulations, the unclear and conflicting policies, the limited authority, the lack of priority and trade-offs and the long payback periods and return on investment. The second manifestation is

through the inclusion of three pilot projects, out of which two have similar project characteristics. Both the Irish and Flemish pilot projects are focused on delivering dwellings for low-income households on waiting lists within the social housing sector whereas the Dutch pilot project is focused on assisting low to middle-income households in the private housing sector in self-building their dwelling. Contrary to what would be expected, there were not as many commonalities between the Irish and the Flemish contexts in the identification of H4.0E specific barriers. The third instance where the importance of context can be demonstrated is when a closer analysis of participants' statements is conducted. This is when local peculiarities can be identified and precedence can be determined. A straightforward example would be occupants' perceptions of H4.0E dwellings. In the Irish and Dutch contexts the negative connotation and uncertainty concerned the timber frame of the dwellings, in the Flemish context the focus was on the small size of the dwelling. There is even a nuance in the perception of timber framed dwellings as participants in Kilkenny discussed the robustness of the structure, whereas participants in Almere mentioned the resistance to water over time. The distinction between contexts allows the allocation of precedence of the information distributed during the promotion of H4.0E dwellings. In other words, in the Irish context, precedence would be given to information on the strength and robustness of timber framed dwellings. In the Dutch context, the focus would be directed towards highlighting the durability and resistance of timber frames to water, and in the Flemish context, campaigns would focus on highlighting the benefits of living small. Another example would be the barrier of access to land. It is a barrier that was identified in previous studies and in all three focus groups so it would qualify as a general barrier. However, looking closer into each context, it becomes clear that the definition of access to land differs per pilot. In Kilkenny, access to land was linked to limited authority considering it is dependent on local authorities preferences and requirements. In Leuven, access to land was associated with regulations around the allowable number of dwellings to be built on a plot. Often it is limited to one house per a relatively large plot which was perceived to discourage the uptake of the smaller H4.0E dwellings. In Almere, apart from the non-availability of land in urban areas, land accessibility was linked to affordability and the determination of land value based on residual counting. Thus, branching out of the general barrier of land accessibility, three different context-specific barriers were identified through a closer look into context-specific data, thus leading to three different policy suggestions.

5.2. Policy Suggestions

Having identified barriers to the implementation of H4.0E dwellings that are more specific to each of the three contexts, more relevant suggestions to overcome them can be formulated. Once again, considering each of the category of barriers as an institution on its own and recognizing the complexity of intra-relations within and interrelations with the other categories, one must recognize the potential impact of one policy suggestion under a certain category on one or several barriers in other categories. In line with that reasoning, while the categorization adopted throughout this paper is implemented to the policy suggestions, potential interrelations are also highlighted when applicable.

5.2.1. Financial Policy Suggestions

In Ireland, establishing common benchmarks for the financing of sustainability measures and ensuring consistency could facilitate the implementation and uptake of NZEBs. Revisiting the cost certification scheme by balancing out designer and consultant fees or potentially establishing a new scheme uniquely tailored for small, low-carbon, (near) zero-energy dwellings could help promote their uptake. Financial institutions could redirect their established schemes—or tailor new ones—towards encouraging new designs and the implementation of measures that exceed basic regulations especially boosting low to middle-income individuals in the private sector. Additionally, providing financial institutions with information around the dwelling designs, their lifecycle analysis and

costs and keeping them informed about design developments could add reassurance with regard to the loan to security scheme and make up for the absence of a business model. The provision of this type of detailed information on NZEB designs could also help improve the engrained profit maximization drive of financial institutions in Flanders. In the Dutch context, revisiting the completion guarantee requirement would encourage self-builders with lower incomes. When it comes to the land price determination, in practice municipalities work with standardized land quotas. In the case these quotas are computed based on traditional construction methods, then savings can still result from the implementation of innovative construction methods including self-building. Thus, establishing this balance between building costs and land price by ensuring the capitalization on savings from self-building could be more encouraging for lower-income self-builders.

5.2.2. Legislative Policy Suggestions

The individual certification scheme barrier specific to the Irish context is a manifestation of the interrelations between barrier categories as it was also identified as a barrier under the contextual legislative barriers. Revisiting the established individual certification scheme in Ireland with a focus on the Disability Access Certificate and the Fire Certificate especially for small, low-carbon, and (near) zero-energy dwellings could accelerate the process of design approval leading to the promotion of their uptake. In the Dutch context, a potential solution to go around the long design testing and development process that preceded the implementation of H4.0E dwellings would be to standardize such small, low-carbon, and (near) zero-energy dwelling designs. In 2016, the EPBD's recommendation report had already stated that European MS policies are rather vague when it comes to the specific support of NZEB and their contribution to achieving NZEB targets. Consequently, a recommendation for a stronger connection between NZEB, MS policies and their corresponding measures had already been made in 2016. When it comes to the lack of standards in particular, the publication stated that more than two-thirds of EU MS already have measures in place to strengthen building regulations and energy performance certifications. In addition to that, a recommendation was made to establish a monitoring mechanism that verifies the fulfillment of NZEB requirements and consider setting up sanctions in case these requirements are not fulfilled [4].

The barrier of local authority design requirements that is common to all three contexts is also addressed, whether implicitly or explicitly, by the MS action plans. In the Dutch Climate Agreement, based on the recognition that an energy transition is not only a technical transition but also a social transition, a district-oriented approach is suggested. It entails the involvements of local residents in the decision-making process and the organization of potential interventions whether they are on a community level or on an individual dwelling level [28]. In the Irish Action Plan, several actions address the role of local authorities among which Action 65 aims to develop and establish a climate-action toolkit and audit framework for Local Authority development planning to drive the adoption of stronger climate action policies [29]. In the Flemish context, revisiting social housing design requirements that prioritize universality to facilitate tenant allocation and giving precedence to efficient designs rather than universality could help the uptake of H4.0E dwellings. Additionally, adopting a different approach in the subdivision of land giving precedence to area development rather than parcel-based could help lift the restrictions on small-scale living and compact construction. In fact, area development was incorporated into the measures listed in the Flemish NECP [35,36]. The fact that these barriers are still being identified despite previous recommendations and efforts to solve them could suggest an imbalance between policy and its implementation as one is moving ahead and the other is falling behind.

5.2.3. Technical Policy Suggestions

The technology supporting NZEB designs can no longer be considered risky or problematic in itself as it has been implemented and tested numerous in previous studies and

projects. This is partly why this study only resulted in the identification of two contextual technical barriers to the implementation and uptake of H4.0E dwellings. The first being the lack of standards was addressed under the legislative policy suggestions highlighting yet another manifestation of the interrelations between the institutional categories. However, in the Flemish context the lack of standards was mentioned specifically regarding the low-embodied carbon and building materials. While a dwelling's embodied carbon has been gaining importance, going beyond guidelines and developing mandatory standards could encourage and facilitate the design, implementation and uptake of NZEB dwellings with a low embodied carbon. The second contextual technical barrier was raised from concerns around the H4.0E dwelling lifespans in comparison with the lifespans of traditionally designed and build houses. This contextual technical barrier can be linked to the foundational barrier of a lack of information around H4.0E designs. To really help the promotion of H4.0E dwellings it is important to make sure that the necessary information is made available to housing professionals. The provision of clear and detailed information around their designs and lifecycle analysis and costs could help overcome the perception that H4.0E or NZEB dwellings have shorter lifespans. Moreover, giving regular updates on design progress, performance and outcomes of similar projects could compensate the uncertainty that often comes with novelty.

5.2.4. Cultural Policy Suggestions

It is well recognized now that an energy transition or shift entails societal changes as much as it requires a technical one. Thus, the barriers associated with people's perceptions, habits and preferences, be it in a societal setting or a professional one, are some of the first and most common barriers identified in literature. Accordingly, the various measures to facilitate a cultural shift have also already been identified and are well known by now. In fact, the EPBD's 2016 recommendation report had already stated that more than two-thirds of EU MS have in place measures to increase awareness and education around NZEBs [4]. Raising awareness and changing mindsets through the education system is one of the measures listed in the Belgian NECP [35,36]. Similarly, the Irish Climate Action Plan dedicated numerous actions with the aim to increase the knowledge and awareness of people and shift their perceptions and preferences [29]. These include the encouragement and promotion of sustainable communities through the development of innovation champions [23,29]. In other words, champions are volunteers willing and motivated to adopt and promote change be it innovations in industry or new attitudes in society. They can be a source of information to their surroundings. They can set an example and provide constant support. They would be easier to reach and more available and capable of making on the ground impact. Increasing people's level of involvement and decision making power through the district oriented approach is the equivalent Dutch suggestion explained in their Climate agreement [28].

There are several reasons that could explain the fact these well-known cultural barriers persist despite the already established recommendations and measures to overcome them. One of them might be linked to the general approach to understanding and identifying people's reluctance to change. The context-specific cultural barriers identified in this study highlighted different nuances in people's perceptions that vary according to their location. Increasing people's exposure to new dwelling sizes, building materials, construction methods and energy systems is a well-known way to change the negative connotations they associate with small, timber-framed dwellings. However, redirecting the focus of publicity campaigns towards the robustness of timber in Ireland and its durability and resistance to water in the Netherlands could have a more significant impact on people. Promoting self-building is another campaign focus relevant to the Dutch context that could help increase their market uptake. In Flanders, publicity campaigns would focus on highlighting the benefits of small-scale living to contest their associations with container homes and reduce their reluctance to move. Moreover, providing information that highlights the various benefits of H4.0E dwelling designs such as their affordability, energy efficiency and all

the resulting energy and cost savings could be a more effective approach complementing the information that focuses on the harm traditional designs and construction can do to the climate. Additionally, finding alternative solutions to people's social daily habits, like the use of the radiator for drying clothes in Ireland, could reduce their reluctance to change. Organizing workshops, trainings or demonstrations to tenants at an early stage to help them shift their established habits linked to traditional building systems and thermal comfort perceptions. Workshops provide tenants the necessary information around the operation of their new technologies. In that way, organizing workshops could prevent the misuse of these technologies and limit additional maintenance costs. This is a well-known measure and it is also being implemented throughout the H4.0E project [31]. Last but not least, organizing workshops on a neighborhood level is less common but it is another way of keeping people informed, ensuring their involvement in the implementation process and increasing their cooperation on a community level.

6. Conclusions

This study's outcomes contribute to the discussion around barriers to NZEBs and near zero-energy housing by highlighting the importance of conducting context-specific investigations rather than reaching generalizable outcomes, especially considering that policies and regulations around NZEBs have significantly evolved over the years and are now more detailed and complex. This was done by first tracing the evolution of general barriers to NZEBs by distinguishing between barriers to sustainability measures, barriers to NZEBs and barriers to NZEBs that persisted in 2019. Then it captured the perceptions of the housing industry in three different contexts through its qualitative data collection and analysis leading to the identification of new contextual institutional barriers. Nuances and differences in precedence between the three pilot countries were highlighted, thus allowing the formulation of more specific and context relevant policy suggestions. The policy suggestions provided enable housing professionals including policy makers to tailor corresponding measures and action plans to overcome them.

To reach its outcomes, this study adopted a triangular methodological approach combining desk research, qualitative data collection and qualitative data analysis. Future research can contribute further to the analysis of outcomes and formulation of policy suggestions by complementing this approach and retracing the methodological steps taken through conducting a follow-up interaction with housing professionals. The outcomes presented herein can be foundational and used as a starting point to the structure of interviews or questionnaires. Through this application of the Delphi research method, contextual barriers and solutions can be explored and developed further to achieve effective policy implications. Additionally, while the aim of this study was to highlight the importance of a context-specific investigation hence to focus on its contextual outcomes, a second stage of research can focus on the other more general barriers identified, referred to herein as the barriers that persisted in 2019. The context-specific investigative approach introduced in this paper can be adopted to establish a detailed outline of the development of these general barriers through time in their corresponding contexts through a simultaneous detailed review of context-specific policy documents. The analysis of new contextual outcomes already highlighted a potential gap between policy and its implementation in industry. Adopting a context-specific approach to re-evaluate the barriers that persisted in 2019 would add new context-specific insight into the reasons behind this persistence despite previously formulated recommendations and implemented efforts to overcome them, thus closing the gap. Last but not least, it is worth mentioning that the COVID-19 pandemic happened during the same years the shift to NZEBs was meant to happen. In fact, the pandemic was identified as one of the main reasons behind delayed actions in the recent Irish progress reports. While the pandemic is an undeniable significant barrier to the implementation of H4.0E dwellings and uptake of NZEB, it was not taken into account in the analysis of this study's outcomes. The reason behind its exclusion is the fact that the focus groups that generated this study's data were conducted prior to the pandemic.

Therefore, future research on barriers to NZEBs can focus solely on the ones caused by the pandemic to investigate the impact COVID-19 has had on the implementation and uptake of NZEBs.

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