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Perceived Barriers to Nearly Zero-Energy Housing: Empirical Evidence from Kilkenny, Ireland

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Abstract: In 2010, the Energy Performance of Buildings Directive announced that all new buildings are to be nearly zero-energy as of January 2021. Having reached year 2022, it can be said that the transition has proven to be slower than anticipated. Transition research has long acknowledged the potential impact of the human factor in the process of change. While there is a relative wealth of literature on end-users and their perceptions as recipients of change within the demand end of the market, research on professionals and their perceptions as actors in the process of change is limited. Thus, this study looks at the human factor in the supply end of the market by bringing professionals' perceptions to the forefront in its investigation of barriers to the implementation and uptake of nearly zero-energy housing in practice. As part of the project entitled Housing 4.0 Energy: Affordable and Sustainable Housing through Digitization, data were collected through a focus group and semi-structured interviews with housing professionals in Kilkenny, Ireland. Descriptive coding, inferential coding, and fact tracing revealed several identified barriers to be perceptions and not actual barriers to nearly zero-energy housing. Additionally, information dissemination and assimilation between policy and industry was identified as an overarching barrier. Therefore, the paper ends with recommendations to reduce delay factors at the supply end of the market, thus contributing to closing the gap between the development of policies and their implementation.

Keywords: nearly zero-energy housing; NZEB; barriers; perceptions; housing professionals; sustainability transition

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1. Introduction

In 2010, the European Parliament announced through Article 9(1) of the Energy Performance of Buildings Directive (EPBD) 2010/31/EU that all new buildings are to be nearly zero-energy as of January 2021 [1]. Back then, it was assumed that a decade is enough time for policy, industry, and society to assimilate this change [2] and take necessary action to make the transition toward a (nearly) zero-energy built environment. To facilitate this transition, European Member States (MS) were required to submit National Action Plans on nearly zero-energy buildings (NZEBs) at an early stage and to include intermediate targets for 2015. The review of submitted action plans in 2013 already called attention to an initial potential delay in the transition process toward NZEBs [3]. Consequently, in a preventative effort, the Directive required of European MS "a minimum percentage of new buildings" to be NZEBs by 2015 in its publication of recommendations and guidelines on the promotion of NZEBs. The publication even clearly refers to the implementation of NZEBs as an "obligation" stating that "[. . .] citizens buying newly constructed buildings or apartments in 2021 would expect the market to have evolved in line with these targets and buildings to be NZEBs" (p.L208/51) [4]. Yet, by 2018, notwithstanding the added emphasis on the mandatory compliance and urgency of accelerated action, 24% of European MS still did not have a detailed definition of NZEBs stated in legal documents [5]. Thus, it may well be argued that the transition toward NZEBs has been slower than anticipated even after taking

into account the latest required submission of updated National Action Plans in 2019 [6,7]. More importantly, this brings into question why the transition toward NZEBs has proven to be slower than anticipated despite the given decade for preparation and adjustment and the corresponding facilitating measures implemented throughout.

It has been argued and now recognized that energy or sustainability transitions entail societal and cultural changes just as much as technical changes [8–10]. This is reflected in transition research across disciplines where it has long been acknowledged that, to develop a proper understanding of the process of change, research needs to go beyond the particular subject of study and take into account the potential impact of people, otherwise known as the human factor, in their investigations [11,12]. This recognition of the human factor and the potential impact of characteristics such as perceptions, habits, and practices has particularly been growing in energy and sustainability transition research. Studies accounting for and investigating the interrelations between technological and social change are increasing. Within the context of NZEBs, after mono-disciplinary studies plateaued in the technical advancements around the performance of sustainability measures, research was directed namely to the investigation of end-users as the human factor obstructing change. End-users were approached as recipients of change, and studies centered around end-user behavior [9]. This underlines two main research gaps. First, while the assimilation of the role and importance of the human factor has become more common in NZEB research, the focus has been mainly on people on the receiving end, involved in the use of energy measures. Research has focused less on people on the delivering end, involved in the provision of energy measures within the overarching institutional context [9] resulting in fewer studies on the perceptions of professionals involved in the provision of NZEBs. Yet, the societal aspects of the institutional context where a sustainability measure is to be implemented are not restricted to market demand but also include market supply. That is to say, perceptions, habits, and practices are as impactful throughout the provision and implementation processes of sustainability measures as they are throughout their use [9–13]. In addition, it is important to establish a simultaneous understanding of the practices of both professionals and end-users in the study of change [9]. Second, interdisciplinary research argued that changing approaches and considering individuals as *actors* within a system, that is, their surroundings, would provide a better understanding of their practices within the mechanism toward change [13]. The distinction of individuals as *actors for change* from individuals *as recipients of change* maintains the importance of taking into account characteristics underpinning practices, such as perceptions, but it also allows the investigation of the potential impact one has on the other. Most importantly, this reversed approach purposely emphasizes the importance and potentially significant impact of people's actions, underpinned by their perceptions, in the process of change. This is equally applicable to professionals as it is to end-users considering they too could play a pivotal role within that process.

One of the primary and most common approaches to the evaluation of new policies and their implementation is the study of challenges or barriers [14]. In fact, one way to define a barrier is as an explanation for the reluctance to adopt change [12]. This makes the investigation of barriers particularly relevant to studies around energy or sustainability transitions. That said, with an overall aim to unravel the potential impact of the human factor within the provision of NZEBs, this study seeks to address the following main research question: *To what extent do the perceptions of housing professionals affect the identification of barriers to the implementation of NZEBs?*

Section 2 of this paper starts by setting the background around sustainability transitions by presenting the literature reviewed on barriers to the implementation and uptake of sustainability measures including NZEBs. It also highlights the predominant overlooking of professionals' perceptions in previous investigations of barriers. Section 3 traces the different ways perceptions were included in the few studies that did take them into account. Section 4 describes the iterative research process adopted in this study alternating between desk research, data collection, and data analysis. Section 5 then presents the research

methods behind the qualitative data collection. Section 6 describes the different approaches within the data analysis while simultaneously presenting the study outcomes. Section 7 discusses these outcomes in relation to previous studies. Section 8 covers policy implications, introduces corresponding recommendations, and concludes the paper by highlighting its contribution, identifying its limitations, and providing suggestions for future research.

2. Background

2.1. General Barriers to Sustainability Measures including NZEBs

To trace the development of the challenges faced in the implementation and uptake of sustainability measures in general including NZEBs in particular, the literature reviewed deliberately comprised research conducted at different points in time, spanning across different geographical contexts, covering different scopes, and adopting different perspectives (Table 1). With the exception of study number 5, all of these studies investigating barriers to the implementation and uptake of sustainability measures do so in consultation with a wide range of professionals. These include varying combinations of experts in regulation, social housing, local authorities and government agencies, architects, engineers, designers, consultants, developers, (sub)contractors, researchers, teachers, and policy makers. In other words, it can be said that the investigation of barriers to the implementation and uptake of sustainability measures including NZEBs has been extensively covered from all perspectives involved in their provision. What becomes noticeable then is that experts with different professional backgrounds identified a considerable number of similar barriers. Consequently, instead of tracing the development of challenges across time and across policy changes, what became evident through this combination of previous studies is actually the recurrence and persistence of a specific group of barriers despite the different professional perspectives adopted in their investigation. Table 2 lists the 10 most common barriers identified in previous literature. In this matrix, the most common barriers are entered as rows and the previous studies as columns (numbered 1 to 25, as they are listed in Table 1). An occurrence is marked by an "X" and the total number of occurrences is the addition of these marks. The barrier that has the highest number of occurrences is ranked 1, and the barrier that has the lowest number of occurrences is ranked, in this case, 5. When two barriers have the same number of occurrences, they are given the same rank.

Table 1. Summary list of studies included in the literature review.

Study Number	Publication Year	Study Location	Research Keywords	Research Perspective	Research Methods	Reference
1	2013	Europe	Sustainability, European energy policy, Energy efficiency in buildings	Regulation experts working within academic institutions, private companies, and public authorities such as ministries and energy agencies	Questionnaire	[15]
2	2007	UK	Legislation, Building specifications	Experts within the Royal Institute of British Architects (RIBA) involved in architectural practices in the UK	Questionnaire	[16]
3	2015	Spain	Sustainable urban transformation, Low-carbon transitions	Stakeholders from different levels of decision making with authority or interest in energy matters	Q methodology, interviews, review of relevant literature	[17]

Table 1. *Cont.*

Study Number	Publication Year	Study Location	Research Keywords	Research Perspective	Research Methods	Reference
4	2019	Australia	Sustainability transition, Low carbon, Green buildings	Sustainability consultants and advocates, energy and sustainability assessors, architects, and experts involved in teaching and research	Focus groups	[18]
5	2013	Germany	Energy efficiency, Low and zero carbon technologies	Private homeowners of single and semi-detached homes who carried out refurbishment measures	Questionnaire	[19]
6	2019	Chile	Energy policy, Nearly zero energy building	Local experts within the construction industry and the Chilean state including building professionals and researchers [1]	Literature review and focus groups	[20]
7	2018	International	Net zero energy buildings	Book—N/A	N/A	[21]
8	2014	Europe	Zero energy buildings	ZEBRA 2020 EU-funded project—N/A	N/A	[22]
9	2017	Southern Europe	Nearly zero energy building, Net zero energy building	Experts in national nearly zero-energy building regulations	Literature review and questionnaire	[23]
10	2021	Europe	Nearly zero energy buildings, European energy policy	Overview on the progress of the NZEB development in Europe—N/A	Desk study and literature review	[24]
11	2017	International	Sustainability, Housing	Experts in the prefab industry including consultants, architects/engineers, builders/subcontractors, developers, and manufacturers/distributors [1]	Literature review and questionnaire	[25]
12	2019	Brighton, UK	Low-energy, Housing	Local and national policy makers, housing associations, researchers, and not-for-profit practitioners	Literature review and expert interviews	[26]
13	2015	Sweden	Low-energy buildings, Passive houses	Experts within construction companies that build low-energy buildings	Interviews	[10]
14	2012	UNECE Region	Low-carbon transitions, Residential buildings	Policy framework	N/A	[27]
15	2016	England and Wales, UK	Sustainability, Zero carbon, Homes,	Practitioners within the Home Builders Federation (HBF) particularly involved in the construction of houses	Literature review and questionnaire	[28]

Table 1. *Cont.*

Study Number	Publication Year	Study Location	Research Keywords	Research Perspective	Research Methods	Reference
16	2017	International	Barriers to energy-efficient technologies, Building energy	Systematic literature review—N/A	Systematic literature review	[29]
17	2009	England, UK	Barriers, Zero carbon homes	Experts working within house building companies	Questionnaire and semi-structured interviews	[30]
18	2011	England, UK	Challenges, Low carbon, Housing refurbishment	Architects with housing refurbishment experience	Desk study, questionnaire, and semi-structured interviews	[31]
19	2015	UK	Barriers, Zero carbon homes	Developers, contractors, architecture and design consultants, experts within local authority and government agency with experience in low carbon homes	Semi-structured interviews	[32]
20	2007	England, UK	Barriers, Sustainability, Building	Experts in land use and planning regulations and in development and construction [2]	Literature review and interviews	[33]
21	2020	International	Critical barriers, Sustainable housing	Experts in affordable and sustainable housing studies	Literature review and questionnaire	[34]
22	2002	Netherlands	Institutional barriers, Sustainable construction	Institutions in the building and real estate sector	N/A	[35]
23	2018	Ghana	Barriers, Green building technologies	Engineers, architects, quantity surveyors, and project/contract managers with green building experience	Questionnaire	[36]
24	2017	Singapore	Barriers, Sustainable development	Project managers, consultants, quantity surveyors, design and facilities managers involved in green building projects (including residential projects)	Literature review, questionnaire, and follow-up interviews	[37]
25	2018	Chongquing, China	Barriers, Prefabrication	Experts with experience in off-site construction including professors, contractors, engineer project managers, and design directors	Questionnaire	[7]

[1] This study also included three European experts representing Germany, Spain, and Belgium (out of a total of 60 participants). [2] These studies also include end-users; however, the majority of the participants consulted remain experts involved in the field of study.

Table 2. Most common barriers identified in literature (adapted from [38]).

List of Barriers	Occurrence of Barrier in Previous Studies (Study Number)																									Total	Rank
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
Higher costs	X		X	X	X	X		X	X	X		X		X	X	X	X		X	X	X	X		X	X	19	1
Lack of awareness		X	X		X	X	X		X	X		X	X		X	X	X		X	X	X	X	X	X	X	19	1
Lenient building regulations			X		X	X			X			X	X	X	X	X	X	X	X	X	X				X	15	2
Shortage of skills	X	X		X		X	X			X		X	X			X	X		X	X		X		X	X	15	2
Cultural preferences	X		X		X	X			X		X		X	X	X		X		X		X	X		X		14	3
Lack of knowledge	X		X		X	X			X	X		X	X		X		X			X	X		X	X		14	3
Lack of adequate financial incentives		X	X	X		X		X	X	X					X			X	X	X	X	X		X		14	3
Business-as-usual mindset		X	X		X				X			X			X	X	X		X	X	X		X		X	13	4
Uncertainty and risks of innovation	X	X	X			X		X	X		X	X		X	X		X			X	X					13	4
Payback period and return on investment			X			X		X	X				X	X		X	X			X	X			X	X	12	5

2.2. The Factor of Perception

In previous studies on barriers to the implementation and uptake of sustainability measures including NZEBs, the terms perspective and perception are often used interchangeably. Lexically, a perspective is commonly defined as a way of thinking, an angle, or a viewpoint [39] while a perception is defined as a belief that is formulated based on impressions, appearances, and/or how things are seen [39–41]. Generally, perspective is more likely to influence perception. In other words, it can be assumed that individuals with different perspectives are more likely to have different perceptions of things. However, considering that perceptions are based on how things appear to be, the possibility for individuals with different perspectives to have similar perceptions cannot be dismissed. In the context of NZEBs, adopting the definition of perspective as a viewpoint can be translated into professionals constituting one perspective in comparison to end-users. Perspectives can also be more specific and the group of professionals itself can include different perspectives such as experts involved in housing policy, housing design, housing construction, or housing research among others. Distinctively, adopting the definition of perception as a belief that is based on how things appear, the identification of higher costs can constitute a perception in the context of NZEBs when it is based on an impression rather than a proper comparative investigation [26]. Accordingly, while current studies cover various perspectives through professionals with different expertise, the majority do not mention perceptions, and only a few focus on actually capturing the perceptions of professionals in their investigation. In other words, a possible explanation for the reaching similar outcomes despite adopting different perspectives could be the non-distinction between perceived identified barriers and actual identified barriers.

2.3. Study Contribution

The fact that most of the studies on the barriers to sustainability measures including NZEBs consult professionals in their investigation makes professionals' input significantly deterministic of the recommendations and action plans these studies reach for better imple-

mentation and uptake. This only reinforces the importance of investigating and articulating professionals' perceptions in addition to adopting different perspectives. Recalling the importance of the human factor and characteristics such as perceptions in a transition process, a clear distinction must be drawn between the terms perspective and perception in the investigation of barriers to better gauge the latter and reach overall distinct outcomes. With that in mind, this study mainly questions why previous research predominantly undermined the potential impact of professionals' perceptions and has not dedicated a certain amount of attention to developing a proper understanding of them, especially within studies around the investigation of barriers. Considering the slower than anticipated transition toward a (nearly) zero-energy built environment, this paper aims to investigate and identify current barriers to the implementation and uptake of nearly zero-energy housing from the perspective of housing professionals. However, taking into account the role of professionals as actors and the potential impact of their perceptions in the process of change, this paper also aims to bring professionals' perceptions to the forefront throughout its process. It is not restricted to adopting different perspectives of professionals in its investigation but contributes to the discussion around barriers to NZEBs by going further and dedicating special attention to perceptions in the supply end of the market.

3. Professionals' Perceptions in Previous Studies

Acknowledging perceptions in the investigation of barriers can have different forms. Within the few past studies that did acknowledge perceptions in their investigations, some distinguished perceptions from perspectives when reporting their outcomes. Others recognized the importance of professionals' perceptions at an early stage, prior to gathering their data, and incorporated it into their methodology. Thus, this paper proceeds by identifying the different ways professionals' perceptions were included in previous studies on the barriers to sustainability measures including NZEBs. Two main categorizations were established, and studies were grouped accordingly.

3.1. Inclusion of Perceptions on an Empirical Level

On an empirical level, the most common way perceptions were included in the investigation of barriers to sustainability measures is through an explicit concurrence. This is the case when studies pre-identify barriers at an initial stage of the research based on the existing literature. Then, professionals participate at a later stage where they are asked to rate and/or discuss the pre-identified barriers that are given to them. In these cases, the perceptions captured are mostly around the significance, criticality, and importance of existing barriers [17,18,27,28,35,42]. While it is important to identify the barriers that are perceived to be most obstructive to professionals, this approach can have a limiting effect as it potentially influences professionals' input by providing them with pre-identified barriers from the outset. In other words, issues that have already been identified and addressed by previous studies are being repetitively referred to when there is a need for research to investigate more closely the reasons why previously identified barriers persist and why their corresponding remedial measures have also persistently failed to redress the situation.

Another way of including perceptions on an empirical level is to consider all barriers identified by professionals as perceived. Here, very few studies follow up their data collection phase with a fact-tracing phase. The most common barriers that were linked to professionals' perceptions were higher costs and the risk and uncertainty that are linked to the implementation of novel designs and technologies. In other words, when reporting higher costs as a barrier, it was recognized that professionals identified this barrier based on their impression and not on a thorough investigation of actual costs [26,30,35,37]. More particularly, this was based on the belief that anything outside of business as usual would result in more expenses [26]. In fact, professionals' perception that the business-as-usual approach is adequate enough was identified as a barrier itself in previous research on the implementation and uptake of energy-efficient technologies [37].

3.2. Inclusion of Perceptions on a Theoretical Level

On a more theoretical level of analysis, a study on the barriers and drivers to energy performance building labels recognized the potential impact of perceptions prior to their data collection and incorporated it into their methodology. Based on the diffusion of innovation theory, perceptions of housing professionals were linked to the rate of diffusion of the labels arguing that a successful diffusion depends on how advantageous it is perceived rather than on the actual objective advantages. The perceptions of professionals were then gauged through a questionnaire formulated based on this theoretically developed model [43,44]. A study on a city's low-carbon transition focused on professionals' perceptions of themselves in their investigation into the complexity of sustainability transitions and the role and interactions of professionals throughout. The study identified four different conceptual profiles of actors involved in the process of change: the follower, the visionary, the pragmatist, and the skeptic actors. It explained that while the follower believes change is more likely to be achieved following a top-down approach, the visionary believes that formal institutions are failing to address the urgent need for change and that a bottom-up approach supported by energy transition regulatory frameworks is more effective. The pragmatist recognizes the potential impact individuals have in the process of change; however, they accord a higher level of trust to public institutions and governance processes. Finally, the skeptic does not believe climate change is caused by human-related influences and is only driven by economic motives to achieve change. With these distinctions, the study highlighted the extent to which professionals who fall into the follower and skeptic discourse could obstruct others who fall into the visionary and pragmatist discourse and who are key to the initiation of change. Overall, through these four profiles, the study described how the perceptions professionals have of themselves could act as an incentive or as a deterrent to change [36]. Last but not least, an interdisciplinary categorization of theoretical barriers to energy efficiency that reflects the nested hierarchy of the model of socio-technical change repeatedly highlighted the potential impact of professionals' perceptions in the process of change. This impact was most prominent in the barriers that fall under the socio-technical regime category where outcomes are most influenced by the human actors and where the occurrence of change is the slowest. Particularly, the barrier of bounded rationality describes professionals as decision makers who overlook energy efficiency measures based on their embedded knowledge and previously established rules of thumb. Similarly, the barrier of inertia describes how professionals could actively oppose change by falling back on their habits and previously established routines in the workplace in an effort to avoid uncertainty and potential issues which could in turn result in the overlooking of adequate energy efficiency measures [12].

4. Research Process

Whether empirical or theoretical, having reviewed the different ways professionals' perceptions were included in previous research, this study engages in the discussion through several means. First, it prevents influencing professionals' contribution by purposely not adopting the explicit concurrence approach. It aims at initially seeking out the raw perceptions and knowledge of professionals around current barriers thus contributing to the need for research to investigate barriers more closely and gaining insight into the reasons behind their recurrence. Second, this study establishes a balance between empiricism and theory by recognizing perceptions throughout its process, from inception through to implementation and analysis of outcomes. Third, it adopts an iterative approach that alternates between desk research, data collection, and data analysis. The research process follows the initial explorative literature review and focus group with fact tracing and semi-structured interviews for the validation and finalization of outcomes. This is what enables the distinction of professionals' perceptions in its outcomes. This is of particular importance seeing as it is these implicit characteristics, namely perceptions, established habits, and embedded knowledge of professionals, that are the most difficult to identify and articulate and yet that could significantly disrupt the process of change [45].

Figure 1 depicts this iterative approach by illustrating how the study alternates between desk research, data collection, and data analysis through its different research stages along with a brief description of each stage. The following Section 5 describes in more detail the methods implemented throughout.

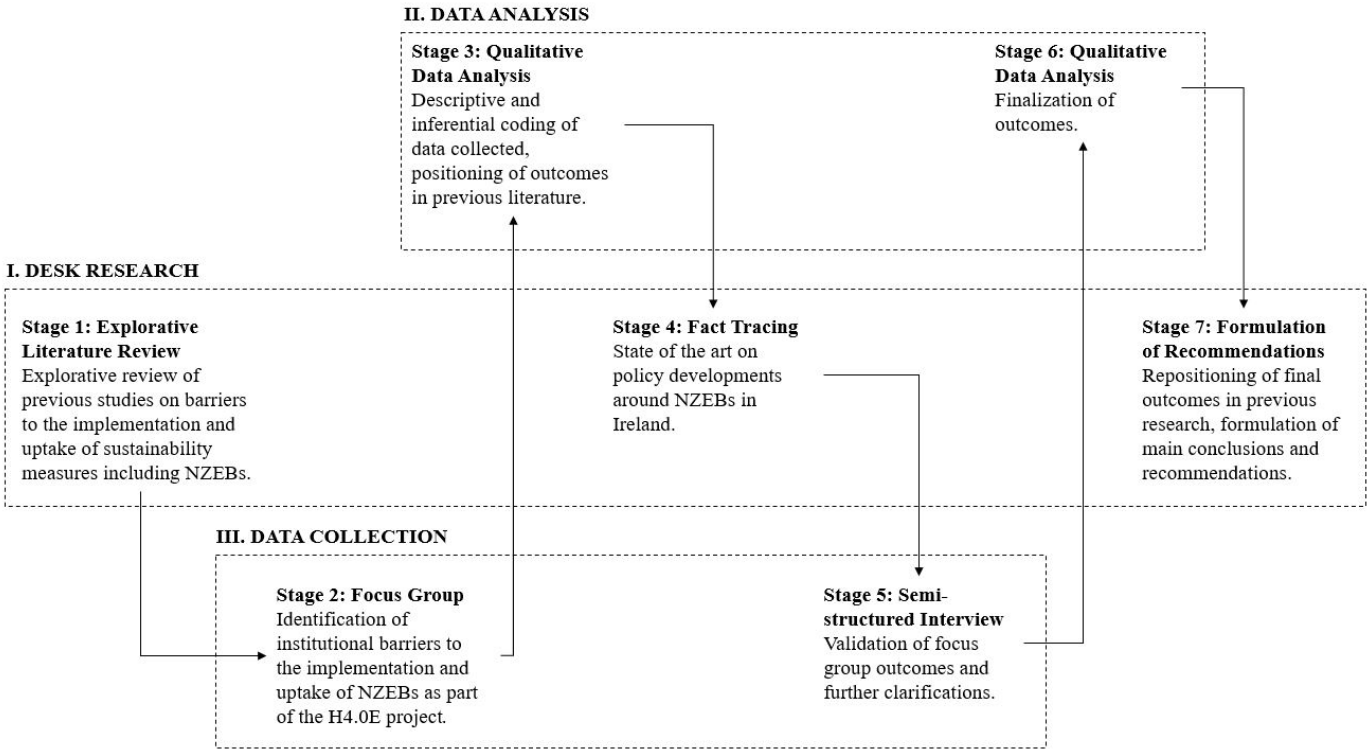

Figure 1. Iterative research process.

5. Research Methods

5.1. Desk Research

Overall, a wide range of documents were consulted in this study. In an initial stage, the desk research consisted of an explorative review of the literature to establish an understanding of the development of barriers to the implementation and uptake of NZEBs. For that, three main research concepts were used: institutional barriers, the built environment, and energy efficiency. The main keywords derived from these concepts and used in the search queries are as follows: challenges, obstacles, hindrances, together with building and/or housing and low-energy, low carbon, (near) zero-energy, zero-carbon. The main search engines consulted are Scopus, Google Scholar, and the Delft University of Technology search engine. The main sorting principle that determined whether or not an article was included in this study was the explicit address of barriers in its text. In other words, studies that did not explicitly address barriers in their text were discarded. This selection process resulted in 25 references ranging from academic journal articles and conference proceedings to textbooks. The outcomes of this initial explorative review are presented in Section 2.1, Table 1, where previous studies are listed according to their year of publication, study location, main keywords, research perspectives, and methods. Figure 2 depicts how the collection of keywords used in these 25 references falls within the research concepts of this study. At a later stage, the desk research revolved around establishing the state of the art on policy development around NZEB implementation in Ireland. To that end, different types of documents were consulted such as government publications, reports, and European projects' websites. In total, 7 main documents were referred to. These include the Irish Climate Action Plan, the Irish National Energy and Climate Action Plan, its following quarterly progress reports, the European Commission Assessment Report, and a report published by Ireland's Expert Group on Future Skills Needs.

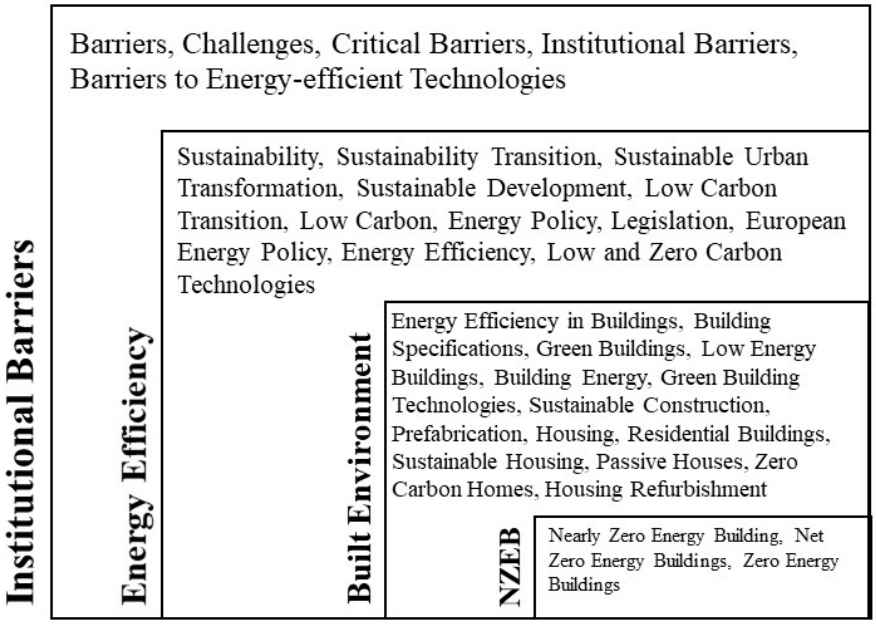

Figure 2. Main research concepts and derived study keywords.

5.2. Data Collection

The qualitative data of this study were collected through the conduction of focus groups and semi-structured interviews as part of a larger ongoing research project entitled Housing 4.0 Energy: Affordable and Sustainable Housing through Digitization (H4.0E) funded by Interreg North-West Europe [46]. Data collection was conducted in Kilkenny, Ireland, and it was carried out between the months of April and December 2019.

5.2.1. Focus Group

Focus groups are recognized to enable the collection of data that are dense in content and rich in details, even more so when the topic addressed is complex and requires a nuanced and granulated understanding [47]. This is particularly valuable to this study where the aim is to capture professionals' perceptions, an implicit characteristic that was found difficult to pin down by previous research. Focus groups are also known to allow participants to openly discuss and share different views on the research topic [48], another aspect that is of value to this study where the aim is to make a clear distinction of perceptions amongst various perspectives.

Focus group participants were recruited by nomination [49] which allowed the selection to include experts representing housing associations, social housing, local and regional authorities, the governmental housing department, financial institutions, and researchers, engineers, and architects in the field. In other words, the focus group gathered decision makers involved in housing regulation, design, implementation, and local and regional provision thus ensuring an overall balanced and representative composition. In the end, a total of 9 housing professionals were present falling within the recommended average range of 8 to 12 participants and not exceeding the maximum of 15 [50]. Table 3 provides the different profiles of the focus group participants by listing them according to their expertise, years of experience, and the professional sector they represent. Due to cancellations, developers representing the private housing sector were missing which is recognized as a potential limitation to this study.

Table 3. Focus group participant profiles.

Participant Code	Expertise	Years of Experience	Professional Sector
FGP01	Retail management, Mortgage advisory	15 years	Financial Institution
FGP02	Engineering	12 years	Housing and Planning, Local Government
FGP03	Business management, EU projects officer	23 years	Regional Authority
FGP04	Engineering	Undisclosed	Local Authority
FGP05	Research and organizational development	13 years	Social Housing
FGP06	Architecture	30 years	Construction
FGP07	Property and project management, Building surveying	21 years	Social Housing
FGP08	Building information modeling training and certification	Undisclosed	Design Standards
FGP09	Engineering, energy, and sustainability management	10 years	Non-profit Energy Agency

As previously mentioned, this study did not provide participants with the previously established list of the most common barriers identified throughout the literature review. Both to avoid bias and to allow the generation of new insights, the focus group content consisted of open-ended, explorative, and engaging questions around the following key themes: housing policy, planning and land use policy, financial schemes, energy policy, building regulations and standards, and cultural habits and preferences (Table 4). Additionally, the focus group discussion was divided into two rounds. The first round explicitly addressed the current implementation of nearly zero-energy dwellings in Kilkenny. The second round addressed the general upscaling of nearly zero-energy housing within Ireland which entailed a change of location, ownership, tenure type, target group, and income range. With the participants' consent, the focus group discussion was recorded and transcribed, and a summary of preliminary outcomes was created.

Table 4. Focus group guiding questions.

Category	Theme	Focus Group Open-Ended Questions
Institutional Barriers	Housing policy	What are the potential housing laws, regulations or policies that would prohibit/inhibit the realization of near zero-energy dwellings?
	Planning and land use policy	What are the planning or land use policies that would hinder/facilitate the realization of near zero-energy dwellings?
Financial Barriers	Financial schemes	Which economic policies or financial schemes could prohibit/inhibit the realization of near zero-energy dwellings?
Technical Barriers	Energy policy	What energy policies or standards are positively or negatively affecting the implementation of such projects?
	Building regulations and standards	What are the current general and technical building regulations prohibiting/inhibiting the realization of near zero-energy dwellings?
Cultural Barriers	Cultural habits and preferences	What are the cultural norms, habits or preferences that would prohibit/inhibit a successful implementation of near zero-energy dwellings?
Miscellaneous	N/A	What are the additional barriers or inhibitors faced in the upscaling of near zero-energy dwellings?

5.2.2. Semi-Structured Interviews

After data were generated from the interactions of the different housing professionals, two follow-up semi-structured interviews were conducted with two H4.0E pilot representatives involved in the implementation of the H4.0E dwellings in Ireland (Table 5). Consulting pilot representatives after gathering initial data from external housing professionals explicitly opposed general input gained from industry to input gained based on an

existing, ongoing project (H4.0E). This facilitated the distinction between actual barriers and perceived barriers. The interview proceedings enabled H4.0E pilot representatives to clarify and/or validate focus group data, provide more details on the design and construction of the H4.0E nearly zero-energy dwellings in Ireland, and elaborate more on the barriers that are being encountered in the process. The summary of preliminary outcomes was focal to the content of the interviews as the aim was, first, to prevent any misinterpretations and, second, to build upon the data that were collected during the focus group. Accordingly, interviewees were free to build the conversation and the list of interview questions was formulated thereafter, based on the validation or additional clarification of preliminary outcomes. Together with the summary of preliminary outcomes, it was shared two weeks prior giving interviewees enough time to prepare their feedback. The semi-structured interviews were organized in the form of online meetings followed by email exchanges, and with the interviewees' consent, exchanges were transcribed and documented for analysis.

Table 5. Interview participant profiles.

Participant Code	Expertise	Years of Experience	Professional Sector
SIP01	Energy Engineering	17 years	Non-profit energy agency
SIP02	Architectural Engineering	13 years	Non-profit energy agency

6. Data Analysis and Results

This section describes the different stages of the data analysis and gives detailed examples of the reasoning leading to the final study outcomes. It starts with descriptive and inferential coding which focuses on the analysis of the focus group discussion. It then moves to fact tracing where, through another desk study, focus group outcomes were cross-checked with the simultaneous policy developments. Lastly, it presents the validation and clarification of outcomes through the analysis of the follow-up semi-structured interview discussions.

6.1. Descriptive and Inferential Coding

The qualitative data analysis process mirrors this research's iterative approach alternating between data analysis, data collection, and desk research. At the outset, an initial screening of focus group outcomes allowed the recognition of the most common barriers that were pre-identified in the literature review and that recurred in this study. In that way, the pre-identified most common barriers listed in Table 2 served as the main thematic groupings throughout what is known to be the *descriptive coding* phase [51]. Descriptive coding was followed by *inferential coding* where second and third data screenings were conducted [51]. The implications of the inferential coding phase were twofold. First, it allowed the identification of barriers implicitly inferred in participants' statement. In some instances, implicit indications of barriers were dominant which is a direct manifestation of the density and high level of detail known to be characteristic of qualitative data [47]. Second, it also highlighted the extent to which barriers are intra- and interrelated to each other. Statement 1 demonstrates how both explicit and implicit barriers can be extracted out of one focus group participant statement.

> "The other thing is, we are making houses more airtight, we are bringing mechanical forms of ventilation (but) it is still out there whether that is actually good for the person living in the property. [. . .] I know you mentioned air quality and I don't know the question is out there for me." (FGP06, FG Statement 1)

This statement explicitly manifests an uncertainty and reluctance in the adoption of new technologies. Implicitly, this statement suggests an underlying preference for the business-as-usual approach. Overall, it does imply a potential lack of awareness with regard to the urgency of action when it comes to the implementation of measures to facilitate the transition toward a nearly zero-energy built environment. Following both descriptive and inferential coding, this initial phase of data analysis revealed that all the most common

barriers listed in Table 2 recurred one way or another in the focus group outcomes. The codebook presented in Table 6 demonstrates how these pre-identified barriers extracted from past literature recurred in the focus group. It lists the barriers' codes, descriptions, and corresponding participants' statements. With regard to the number of occurrences, while some would argue that the most significant barriers are the ones that are mentioned the most [10], others state that importance does not go hand in hand with frequency. There are barriers that, although not as frequently mentioned, would lead to a significant obstruction to the implementation of a sustainability measure when they occur [26]. As such, significance is not attached nor restricted to frequency in this study. Nevertheless, the number of comments per barrier is included in Table 6. Overall, this presentation of results sheds light on the fact that previously known factors or challenges to the implementation of NZEBs were still perceived as challenging in 2019. More importantly, keeping in mind that the pre-identified list of barriers were not disclosed to participants, this supports the assumption that a possible explanation to the reaching similar outcomes could be the non-distinction between perspectives and perceptions of housing professionals.

6.2. Fact Tracing

At this stage of the study, it was important to establish an updated understanding of the state of the art with regard to the most recent policy developments around measures addressing the transition toward NZEBs. Accordingly, the descriptive and inferential coding phase was followed by a fact-tracing phase [21]. The particular focus of this second desk research was government proceedings, reports, and websites that are most relevant to the development of NZEBs within the Irish context [3,52–54]. Statement 2 demonstrates how focus group participants stated that current building regulations are not established as per a nearly zero-energy performance. This was identified as a potential barrier since aiming for zero energy is not mandatory.

> "You are expected to meet building regulations, you can exceed them but this becomes like any other project it is assessed based on an individual basis." (FGP03, FG Statement 2)

However, referring to governmental proceedings, the Irish National Energy and Climate Action Plan (NECP) states that, starting the first of November 2019, all new dwellings will be built to NZEB standards. The implementation of more stringent building regulations is mentioned again under existing measures [52]. Additionally, Action 56 of the Irish Climate Action Plan concerning the publication of "a methodology for compliance to NZEB in all new buildings" was reported as complete in the first progress report covering all actions within quarters 2 and 3 of 2019 [53]. Thus, it could be argued that this barrier is perceived rather than actual considering it contradicts the policy developments that were occurring simultaneously. In turn, this perception itself becomes the barrier to the implementation and uptake of NZEBs.

By adopting the same approach, the opposite can be said about the shortage of skills barrier as it can indeed be categorized as an actual barrier according to most recent policy documents (FG Statement 3).

> "After the last downturn, we lost a lot of skills." (FGP06, FG Statement 3)

Even though the shortage of skills has been addressed in the Irish Climate Action Plan and the Irish NECP [52,55], it was still recognized as constraining in the 2020 assessment report of the European Commission [56]. This was also confirmed by Ireland's Expert Group on Future Skills Needs in 2020 which indicates that this barrier persists [57]. In that manner, fact tracing weighed in on the distinction between barriers that have already been addressed in policy documents and existing barriers that remain to be addressed. Accordingly, Table 7 lists barriers that were addressed in Irish policy documents by providing the corresponding references and listing the policy action numbers where applicable. It also provides the justification such as an example of the corresponding policy measure to address the barrier in question. It states its latest policy status, where applicable, all leading to its final

classification as a perceived or actual barrier. Considering the intra- and interrelations between all barriers, in some cases, there are several actions or measures that address a single barrier. In other words, the classification of barriers as actual or perceived is not a straightforward process as it entails a combination of measures acting together. However, this process still allows the formation of a preliminary understanding on the balance between housing professionals' perceptions and current policy developments.

Table 6. Codebook for the analysis of focus group transcript (adapted from [38]).

Barrier	Description	Example Statement	Number of Comments
Higher costs	Additional costs of implementing sustainability measures compared to standard construction and measures imposed by current policy and regulations (includes hidden, maintenance, and conservation costs).	"[. . .] you do not get funding for exceeding building regulations [. . .]." (FGP03)	31
Lack of awareness	The event when people, be it end-users or professionals, do not realize the magnitude of climate change consequences and the urgency of action. It can be manifested as a lack of demand for sustainability measures.	"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." (FGP02)	10
Lenient building regulations	Less stringent current regulations that do not require the sustainability measure in question.	"You are expected to meet building regulations, you can exceed them but this becomes like any other project [. . .] based on an individual basis [. . .]." (FGP03)	5
Shortage of skills	Concerns the implementation of sustainability measures within the construction sector. Includes the lack of training.	"After the last downturn, we lost a lot of skills." (FGP06)	17
Cultural preferences	Unwillingness to stray away from traditional designs, technologies, or materials and accept or adopt new ones.	"[. . .] there is a mind-set about timber frame in this country." (FGP04)	17
Lack of knowledge	The non-consideration of sustainability measures that go beyond existing policies and regulations generally associated with a lack of interest in sustainability.	"We are building to building regulations as far as we're warranted [. . .]" (FGP07)	8
Business-as-usual approach	Applicable when the decision making is based on established rules of thumb due to the reluctance to go beyond what is already known or required by current policy and regulations.	"The department of housing in the government is more focused on traditional construction." (FGP02)	11
Uncertainty and risks of innovation	Reluctance to adopt new methods and designs and use new materials and technologies due to insufficient testing and lack of experience in implementation, maintenance, and management.	"New innovative technologies and techniques means unforeseen issues." (FGP05)	13
Lack of adequate financial incentives	Reluctance to loan partly reinforced by insufficient testing and lack of supporting evidence resulting in the absence of adequate and supporting schemes.	"We cannot give money upfront unless the architect or engineer signed off and works have been completed." (FGP01)	13
Payback period and return on investment	Specifically applicable to developers or investors including financial institutions.	"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." (FGP03)	18

Table 7. Perceived versus actual barriers addressed in Irish policy and other official documents.

Barrier	References *	Action	Justification	Status **	Outcome
Higher costs	1–5	N/A	The European Commission requires the determination of NZEB regulations based on the cost optimization method. This requirement has been addressed in several EU MS action plans.	N/A	Perceived
Lack of awareness	6	68	Promote awareness and understanding of EPC [1] and provide Project Assistance Grants, training, and other support to public and private sector organizations to implement EPC projects.	Ongoing	Actual
Lenient building regulations	6	56	Measure: publish methodology for compliance with NZEB in all new buildings.	Complete	Perceived
Shortage of skills	6	50	Support relevant professional bodies in the development of training specifications/ courses for the design of NZEB and deep retrofit buildings.	Ongoing	Actual
Uncertainty and risks of innovations	7 and 8	N/A	The technology behind NZEBs is available and proven. Technology is going even further, and the main focus now is shifting toward energy-plus buildings that contribute to energy generation rather than break even.	N/A	Perceived
Lack of adequate financial incentives	6	44, 54	Establish a Steering Committee and Working Group to design a new financing scheme to provide easier-to-access tailored finance for SMEs [2] and residential energy efficiency investment utilizing the European Commission's Smart Finance for Smart Buildings loan scheme.	Complete	Perceived
Payback period and return on investment	6	45	Develop a tool to deliver a roadmap to individual homes to achieve BER [3] B2, cost-optimal, and NZEB.	Complete	Perceived

* 1: [3], 2: [4], 3: [58], 4: [52], 5: [59], 6: [60], 7: [6], 8: [61]. ** The focus group was conducted in April 2019. Accordingly, the statuses of actions mentioned in this table were based on the progress reports published in 2019. 1 EPC: Energy Performance Contracting. 2 SME: Small and Medium Enterprise. 3 BER: Building Energy Rating.

6.3. Validation and Clarification of Outcomes

As previously mentioned, interviewing H4.0E pilot representatives enabled input that is based on actual current experiences happening during the H4.0E project. Consequently, the data collected at this stage of the research process allowed a straightforward identification and/or confirmation of *actual* barriers. For example, interview statement 1 is an indication of the general lack of knowledge barrier amongst housing providers manifested through the non-consideration of sustainability measures that go beyond existing policies and regulations at the time. This renders the lack of knowledge an *actual* barrier to NZEBs. Implicitly, this statement also indicates a general lack of awareness on the urgent need to shift toward a zero-energy built environment that is manifested through that same lack of effort in exceeding the mandatory requirements. Thus, this reconfirms a lack of awareness as another *actual* barrier to NZEBs.

> "In this Technical Guideline (TGD) is outlined a minimum standard that all buildings must comply with. Unfortunately, the LAs (local authorities) took and take this minimum requirement as a benchmark." (SIP01, IW Statement 1)

Other examples can be found in interview statement 2. On the one hand, this statement is an explicit example of the extent to which the reluctance to adopt innovative measures of design or construction obstructs and delays the project implementation. It is a direct manifestation of the perception of uncertainty and risks linked to innovation rendering this

barrier a *perceived* barrier to NZEBs. On the other hand, it also exposes the business-as-usual approach and its potentially obstructive effect amongst individuals in the sector rendering it an *actual* barrier to the implementation and uptake of NZEBs.

> " [. . .] individuals do not want to be held responsible if a new type of design fails, so they are very cautious [. . .]. Even it would be in their favour [. . .]"
>
> (SIP02, IW Statement 2)

Overall, the iterative research process followed in this study and the combination of methods implemented succeeded in distinguishing the perceptions of housing professionals. It differentiated between barriers that are based on perceptions and actual barriers. Table 8 demonstrates how both perceptions and actual barriers were validated by pilot representatives in the semi-structured interviews by listing barrier codes, descriptions, and participant statements. Table 9 provides a summary of this study's outcomes where it can be seen that more than half of the most common barriers that recurred in focus group outcomes were based on perceptions and were not actual barriers.

Table 8. Codebook for the analysis of semi-structured interview transcript.

Barrier	Description (Listed in Table 6)	Example Statement	Outcome
Lack of awareness	The event when people, be it end-users or professionals, do not realize the magnitude of climate change consequences and the urgency of action. It can be manifested as a lack of demand for sustainability measures.	"Even it would be in their favour it takes a lot of time and effort to [. . .] convince the LAs for adapting highly efficient, low energy and low carbon options [. . .]" (SIP02)	Actual
Cultural preferences	Unwillingness to stray away from traditional designs, technologies, or materials and accept or adopt new ones.	"Even the fact that the quality of recent build timber construction is up to a high-quality standard the old picture of a failed timber frame house is shaping the behavior and opinion." (SIP02)	Perception
Lack of knowledge	The non-consideration of sustainability measures that go beyond existing policies and regulations generally associated with a lack of interest in sustainability.	"In this Technical Guideline (TGD) is outlined a minimum standard that all buildings must comply with. Unfortunately, the LAs (local authorities) took and take this minimum requirement as a benchmark." (SIP01)	Actual
Business-as-usual mindset	Applicable when the decision making is based on established rules of thumb due to the reluctance to go beyond what is already known or required by current policy and regulations.	"[. . .] we need to take on extra time and effort to convince the responsible auteurs to take on better values and to invest in future proved buildings" (SIP01)	Actual
Uncertainty and risks of innovation	Reluctance to adopt new methods and designs and use new materials and technologies due to insufficient testing and lack of experience in implementation, maintenance, and management.	" [. . .] individuals do not want to be held responsible if a new type of design fails, so they are very cautious [. . .]. Even it would be in their favour [. . .]" (SIP02)	Perception

Table 9. Summary table of outcomes.

Barrier	Method		Outcome
	Fact Tracing	Follow-Up Interviews	
Higher costs	⊗		Perception
Lack of awareness	⊗	⊗	Actual
Lenient building regulations	⊗		Perception
Shortage of skills	⊗		Actual
Cultural preferences		⊗	Perception
Lack of knowledge		⊗	Actual
Business-as-usual mindset		⊗	Actual
Uncertainty and risks of innovation	⊗	⊗	Perception
Lack of adequate financial incentives	⊗		Perception
Payback period and return on investment	⊗		Perception

7. Discussion

7.1. A Shift in the Model Composition: Housing Professionals' Perceptions as the Obstacle

In an investigation of barriers, one can distinguish three main features composing the overall barrier model: the obstacle, the subject, and the action. The obstacle is defined as the obstructive entity, the subject consists of the entity that is affected by the obstruction, and the action comprises the phenomenon that is being prevented [12]. In this study, implementing and upscaling nearly zero-energy housing would qualify as *the action*. This action would have an impact on the environment altogether which includes virtually everyone rendering all people the *subject* of obstruction. The consultation of housing professionals in the process of identifying barriers, or *obstacles*, insinuates they are an objective and external entity to the model composition, unaffected by or unaffecting the overall investigation. While this research approach does generate valuable insight on the transition process, shifting the model composition and looking at housing professionals as a subjective element with subjective perceptions having the potential to become obstacles themselves reveals an entirely different list of impediments. This study allowed the distinction of these perceptions and demonstrated several times over how a shift in approach could potentially lead to a change in outcome.

In this study, the barrier of higher costs that describes concerns around the extra costs specific to nearly zero-energy housing due to all the added energy efficiency measures and that underlines a trade-off between energy performance and affordability is a manifestation of participants' perceptions because it was formulated with reference to the costs of traditional dwelling designs as a benchmark. Instead, if the costs of new-build housing designs complying with the soon-to-be mandatory building regulations were considered as the benchmark, higher costs may not have been identified as a barrier. Additionally, the affordability of new-build nearly zero-energy housing is currently being addressed in policy documents and the development of NZEB regulations [4]. This echoes findings from previous studies recognizing this same barrier as based on an impression rather than an investigation of actual costs [26,30,35,37]. The barrier of uncertainty and risks of innovation that describes in this particular study participants' concerns around airtightness and mechanical ventilation systems was revealed to be a manifestation of perceptions. Current research has surpassed uncertainties about technologies within nearly zero-energy housing, and the literature is now focusing on energy-plus housing [61]. The barrier of lenient building regulations that portrays nearly zero-energy housing as exceeding current mandatory requirements was also revealed to be a perception seeing as policy documents state that NZEB regulations are to be enacted starting the second half of 2019 [52]. Additionally, focus group statements describing lenient building regulations or governmental entities giving precedence to housing provision rather than a zero-energy performance can be said to portray a dependence of housing professionals on higher authorities. Recalling the follower-type depiction of professionals, this becomes a manifestation of professionals' perception of themselves believing that change is more likely to be achieved

following a top-down approach. This was identified as a cognitive barrier itself in previous research [36]. Overall, given that these barriers, or perceptions, persist despite research and policy documents stating otherwise is an indication of the strength of the overarching preference for the business-as-usual approach, another finding that echoes previous study outcomes [26,37]. In fact, this recalls the theoretical barriers of bounded rationality and inertia that describe professionals falling back on previously established knowledge, resisting change to avoid uncertainty, potentially resulting in the overlooking of adequate energy efficiency measures [12].

7.2. The Overarching Barrier of Information Dissemination and Assimilation

This study's data collection was conducted throughout the year 2019. On a general level of analysis, it can be said that housing professionals were consulted about the implementation and uptake of nearly zero-energy housing in the same time frame as corresponding policy and regulations were being developed [60]. Relevant dates around the implementation of NZEB regulations and construction were already released. Even when final documents were still in progress, drafts and draft assessments were being published. In other words, NZEB information was available regardless of whether or not it was still under review, and it was only a matter of months before the NZEB regulations were enacted. This parallelism underlines a potential gap between (inter)national policy makers and local practice. It suggests a lack of awareness and knowledge of the soon-to-be mandatory, more stringent building regulations. The fast development of technology potentially leading to the unawareness of professionals has already been flagged by previous research as impeding the "future success of delivering a more sustainable built environment" ([26], p. 144). Indeed, an earlier study on the feasibility of zero-carbon homes marked a 6-year gap between industry's expectations and actual policy goals when asking professionals about their perceptions on a realistic timeline for the transition [17]. Another study attributed the increasing gap between industry, technology, and policy to professionals' perceptions of their own overestimated level of knowledge on current designs and technologies [36]. In hindsight, this begs the question: Is the gap between policy developments and local practice caused by a lack of awareness of housing professionals and a persistence of the business-as-usual approach? Or does the overarching barrier behind this gap lie within information dissemination? Or perhaps a combination of both? What is certain is that a successful transition toward a nearly zero-energy built environment requires policy and industry to coincide. While a top-down approach has been recognized as most effective for the implementation of new regulations, the current gap suggests that it might not be enough and highlights a potential flaw in how information is being transferred.

7.3. The Role of Information Dissemination in a Transition Process

The importance of information dissemination and the critical role it plays in a transition process has been raised in many previous studies. Corresponding measures and recommendations have already been identified and previously formulated [12,22,23,62,63]. However, the majority of these recommendations were initially directed at end-users, and very few in comparison had housing professionals as their target audience. Meanwhile, the transfer of information, new policies, and regulations to relevant housing professionals can be as challenging as the transfer of information to end-users [7]. Intensive knowledge transfer between housing professionals is known to be essential to achieve actual rather than incremental change [64], even more so when recalling the fragmented decision-making process present in complex sustainability transitions such as the shift toward a zero-energy built environment [25]. Thus, a lot can be learned if these same findings were directed toward housing professionals. For instance, when it comes to learning new information, it is argued that people are selective about which information to accept and assimilate. They are passive rather than active information seekers [12]. Keeping in mind the fast-developing technologies/policies and the overwhelming amount of information available, looking at this study's outcomes through this lens could explain why focus group participants were poten-

tially not up to date with the latest policy developments around NZEBs. Another example concerns the rational-actor assumption that accounts people as actors who respond rationally to the information that is made available to them. Previous research on end-user behavior revealed that reasoning is ineffective [62,63]. Within the context of this study, this could justify why the lack of awareness of housing professionals is still a barrier even though the NZEB concept was introduced more than a decade ago and the urgency to transition toward a zero-energy built environment is continuously increasing. Last but not least, research on end-users' decision-making process suggested that a timely and measured integration of information provision throughout the process is most effective for the actual implementation of desired outcomes [22]. Within the context of this study, the absence of key actors to effectively transfer the most recent policy developments could explain the desynchronization between policy developments and the knowledge and awareness within local practice.

8. Conclusions and Policy Implications

8.1. Policy Implications and Recommendations

All in all, there is a need for innovation in information dissemination within the provision end of the market be it on a general level between policy and local practice or on a more detailed level between housing professionals themselves. Maintaining the shift in model composition and referring back to the insights gained from previous research directed at end-users leads to the formulation of several suggestions specific to housing professionals and the provision of NZEBs. First, the provision of NZEB information should be more consistently and systematically linked to concrete situations and/or opportunities in a particular context. Just like information provision should be integrated into end-users' decision-making process [22], policy and regulatory information provision should be integrated into the process of new housing provision through the inclusion and training of key intermediaries. These trained experts should be incorporated at key decision-making moments that local authorities, social housing associations, private developers, or other housing professionals encounter throughout the process of housing provision.

Second, recalling the formulation of information that is vivid, clear, concise, and customized to the specific context in question [12,22,23,62,63], the distributed NZEB information should be personalized and tailored to the situational context of its targeted audience for a more impactful dissemination. Within the communication channels amongst housing professionals, this would entail varying necessary NZEB information to fit the professional field it is addressing. Just like the successful diffusion of labels for highly efficient housing required a formulation that is contextually compatible with the professionals implementing them [43], policy regulations and expert knowledge need to be actively translated to tailor the expertise and interests of the targeted audience of housing professionals: architects, engineers, contractors, developers, and local authorities, among others. Thus, the training of intermediaries would not only cover NZEB-related information and regulation but also communication skills to develop the ability to address different housing professionals according to their different interests and goals. Additionally, developing an understanding of housing professionals' different expertise and interests is of particular importance in the attempt to overcome the challenging, complex, and fragmented decision-making process that occurs in practice when implementing NZEBs.

Third, referring back to the introduction of sustainability champions that would increase the likelihood of creating an environmentally aware community [22,62,65], the number of NZEB practices should significantly increase through industry advocates or pilot projects within local authorities. If the rational-actor reasoning is applied to housing professionals, it can be expected that the availability of information on NZEB design, benefits, regulations, and the overall urgency of action would provoke concern and result in the smooth adoption of the relevant changes. However, focus group outcomes revealed the prevalence of the business-as-usual approach despite very soon to be mandatory regulations, an occurrence confirmed by previous research stating that raising awareness is not enough to change long-established perceptions and habits [62]. Thus, implementing

the reverse hypothesis that starts with the implementation of environmental practices underlines the need for a bottom-up approach to work in tandem with the top-down regulations. In other words, imposing new regulations alone on housing professionals is not enough, and there is a need to simultaneously shift the business-as-usual approach through industry advocates and pilot projects to achieve a successful transition of the industry as a whole. This reversed approach would particularly help increase the likelihood of raising openness within housing professionals to more effectively integrate NZEB information.

8.2. Concluding Remarks

The main aim of this paper was to demonstrate the importance and potential impact of the perceptions of professionals involved in the provision of NZEBs when identifying barriers to their implementation and uptake. In doing so, this study's engagement in the discussion of energy or sustainability transition is twofold. On a general level, not only did this study recognize the importance of the human factor in the process of change, but it also incorporated it in its investigation. Through its shift in model composition, individuals were involved as actors and not just recipients within the process of change. On a more specific level, this study contributed to narrowing the research gap around experts' behavior within the context of NZEBs by setting the perceptions of professionals as the focal point of its investigation of barriers to the implementation and uptake of nearly zero-energy housing.

Falling back on this paper's main outcomes, more than half of the identified barriers were revealed to be perceived and not actual barriers. That is to say, the explicit distinction of the factor of perception throughout the study's iterative research process did indeed succeed in articulating housing professionals' perceptions. First, purposely choosing not to adopt the explicit concurrence approach in the identification of barriers allowed the prevention of bias when gauging professionals' current knowledge and perceptions around existing barriers to the implementation and uptake of nearly zero-energy housing. Second, following up the qualitative data analysis with fact tracing allowed the establishment of an updated understanding of the state of the art with regard to the most recent policy developments addressing the transition toward NZEBs. This initiated the distinction between perceived and actual barriers. Namely, the barriers of higher costs, lenient building regulations, cultural preferences, uncertainty and risks of innovation, lack of adequate financial incentives, and the payback period and return on investment barriers were identified as perceptions and not actual barriers. Third, seeking out input from professionals involved in an ongoing project led to the validation of outcomes such as the negative perception of innovative sustainability measures or designs translated into the uncertainty and risks of innovation barrier. It also allowed the validation of overarching barriers such as the lack of awareness, the lack of knowledge, and the strength of the business-as-usual approach. Last but not least, distinguishing the factor of perception within the identification of barriers shed light on a potential significant gap between policy developments and local practice indicating an overarching potential barrier to information dissemination and assimilation. Thus, this paper called for innovation in information dissemination be it between policy and industry or between housing professionals themselves which in turn was the focus of the suggestions and recommendations formulated.

Finally, though insightful, this paper's outcomes are specific to the study context in question. Considering the scarcity of research on the human factor in the supply end of the NZEB market, precedence was given to identifying professionals' perceptions and to demonstrating their potential impact on the identification of barriers to nearly zero-energy housing. Rather than increasing sample size for more generalizable outcomes, the paper takes a closer look into the detailed qualitative data collected from a small sample. This is what allowed the distinction of perception, an implicit characteristic that is initially difficult to identify and articulate. Thus, having established this initial demonstration, future research can build upon this study to investigate professionals' perceptions across larger samples and within different contexts.

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to the following reasons:

- The study did not include participants who were unable to provide informed consent.
- No videos, pictures or other identifiable data are stored.
- The study did not include participants that are in dependent positions to the investigator.
- It was not necessary for participants to participate in the study without their knowledge or consent at the time.
- The study does not actively deceived participants.
- The study does not collect personal sensitive data such as financial data, location data, data relating to children or vulnerable groups.
- No substances are used in the study, no blood or tissue samples are taken, no pain is inflicted as a result of the study and the study does not risk causing psychological stress or anxiety.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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