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Towards Active Buildings: Stakeholder Perceptions of the Next Generation of Buildings

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Abstract: Several regulations and standards have been developed to reduce the carbon footprint of buildings, but these have failed to provide a clear pathway to a net zero future. Hence, we recently introduced the Active Building Code (ABCode). This provides guidance on reducing the environmental impact of the next generation of buildings, termed Active Buildings (ABs), through their synergy with the grid. This paper aims to illuminate the regulatory landscape, justify our initial proposal for the ABCode, and reveal opportunities and challenges to the popularisation of ABs. Twelve online focus group discussions were conducted, with thirty stakeholders in total, all selected on the basis of their expertise. A grounded theory approach identified five core themes in such discussions. These strongly overlap with what is incorporated in the ABCode, suggesting the code successfully captures issues important to experts. Stakeholders defined ABs as responsive buildings and proposed both energy and carbon are considered in their assessment. They hence aligned with the definition and evaluation framework proposed by the ABCode. Finally, stakeholders considered people's tendency to prioritise capital cost as the greatest challenge to the popularisation of ABs, and the increasing demand for healthy environments as its greatest opportunity.

Keywords: active buildings; decarbonisation; stakeholder engagement; focus groups; grounded theory

Citation: Nikolaidou, E.; Walker, I.; Coley, D.; Allen, S.; Fosas, D.; Roberts, M. Towards Active Buildings: Stakeholder Perceptions of the Next Generation of Buildings. *Energies* **2022**, *15*, 5706. https://doi.org/10.3390/en15155706

Academic Editor: F. Pacheco Torgal

Received: 1 July 2022
Accepted: 3 August 2022
Published: 5 August 2022

1. Introduction

A climate emergency has already been recognised by several countries, making the need for decarbonisation imperative [1]. Some of these countries have now passed laws to formally set net zero targets, with the UK being the first major economy in the world to legislate for such a target by 2050 [2]. This must undoubtedly affect the design, construction, operation, maintenance, and disposal of buildings, as these are some of the largest contributors to energy consumption and Carbon Dioxide (CO_2) emissions [3]. However, current building regulations and standards are lagging behind the trajectory needed to mitigate climate change, as they do not promote holistic decarbonisation solutions [4].

In more detail, buildings are commonly treated as passive users of energy, not as active parts of the energy network. However, thanks to technologies such as solar panels and batteries, buildings can now fully support a bi-directional relationship with the grid and hence provide it with a greater flexibility, which is vital to meeting net zero [5]. Active Buildings (ABs) aim to exploit this missed opportunity. These are buildings that produce, store, and release energy in response to their own demand, but also to the needs of the grid [6]. Thanks to this synergetic relationship, ABs can actively contribute to the decarbonisation of both the building and energy sectors. By reducing peak demands, they can also greatly curtail the need for network reinforcement and for any associated investment costs [7]. By taking into account real-time information such as time-of-use tariffs, ABs can also provide their tenants with considerable financial benefits [8].

If we were to adopt this approach, stakeholders would need clear guidance on what an AB is, and also on how its performance should be assessed during the design and in-use stages. The easiest way to do this would be via some form of building code. We hence recently launched an initial proposal for such a code called ABCode1 [9]. Additional iterations are expected to be developed in the future to reflect the evolving circumstances of both the built environment and the grid, and ultimately ensure that we are on track for net zero carbon. As closing the performance gap is required to truly achieve net zero carbon, ABCode1 defines contractual obligations such as a post-occupancy evaluation by the design team. The performance assessment of buildings is based on a scale (rather than a simple pass/fail philosophy) to enable freedom in design. More information can be found in [9]. Note that, although ABCode1 and this paper make references to the industry in the UK, the AB concept is internationally applicable.

This paper aims to:

1. Reveal what is missing from existing regulations and standards,
2. justify our ABCode1, and
3. identify any opportunities and challenges to the popularisation of ABs that should inform future iterations of the ABCode, as well as relevant regulations and standards.

Towards this aim, twelve focus group discussions were conducted, with a total number of thirty stakeholders, all selected on the basis of their extensive experience within the building or energy sector. Section 2 describes all the steps of data collection and analysis. Section 3 presents the main outcomes of the discussions, reflecting the core themes that were identified using a grounded theory approach. Section 4 highlights the most important outcomes and discusses their overlap with what is already included in the ABCode. It also discusses the opportunities and challenges that the next generation of buildings may face, and that should inform future iterations of the ABCode and policy. Section 5 summarises the main conclusions and opportunities for further research.

2. Materials and Methods

2.1. Data Collection

Focus groups were used in this study to gain an insight into industry thinking, and a feel for any opportunities and challenges to the real-world implementation and dissemination of the AB concept. Focus groups are a qualitative approach [10], often used when seeking to understand what is important to the defined participant population [11]. They often precede quantitative approaches and are particularly valuable when researchers do not yet know exactly what questions should be asked quantitatively [12]. They do not seek to sample representatively from a population, and usually are not used to test specific hypotheses. Rather, they are a method of seeking novel insights about a topic that may not have occurred to researchers spontaneously. Although individual interviews are likely preferable when covering contentious topics, the social interaction found in focus groups can provide additional layers of understanding—such as when one participant raises an idea, and the others enthusiastically agree. The method was ideal here, where it was clear that experts would have views on building energy, but it was not yet clear exactly what form these might take or what they might encompass.

Twelve online focus group discussions were conducted, with each group comprising two or three participants (thirty in total) and the moderator/facilitator (one of the authors). Conducting face-to-face focus group discussions was not feasible due to social distancing measures to reduce the spread of COVID-19. Online focus groups are, however, able to generate adequate data, often leading to a higher number of solutions and a greater satisfaction among participants, compared with their face-to-face counterparts [13]. They are also not restricted by the need to assemble participants in a single physical location, hence being associated with significant savings in time, cost, and CO_2 emissions [14].

Prior to each discussion, participants signed a consent form (distributed via email) digitally, after they had read the accompanying information sheet. The latter outlined the context and scope of the study, without, however, providing details on the AB concept. That offered participants a greater freedom of expression during the discussion, as they expressed their opinion on the future of the built environment and its regulatory context—before hearing about the aspirations of the ABCode.

Each discussion was carried out in a one-hour session. Participants were initially asked to introduce themselves. The main session started with a general discussion about the future of the built environment in light of the net zero target, and the extent to which current regulations and standards push things forward enough to hit such a target. The moderator allowed the discussion to flow freely, keeping interventions to a minimum—particularly in the beginning—so that participants could set priorities and bring to the fore issues that concerned them [15]. Aiming to capture the views of participants on the AB concept, the session continued with a more specific discussion about ABs. Participants were first asked to provide their own definition of "active". After the moderator presented a brief overview of the up-to-date research conducted by the authors around ABs [9], participants shared their project-specific thoughts.

All discussions were videorecorded with the agreement of all participants. This was enabled by the communication platform that was used for the purposes of the study (Microsoft Teams). Recording is recommended for qualitative research and especially for focus group sessions as it facilitates keeping track of who says what, as well as capturing any important aspects of the group's interaction [16].

2.2. Participant Recruitment

Participant selection is a key phase in planning a focus group discussion. However, as group discussion is a qualitative method used to understand a topic at a deeper level, its planning is more concerned with the value of data collected, rather than the number of participants recruited. This means that data are collected from a purposely selected group of individuals having the capacity to provide relevant information, rather than a statistically representative sample of a population [17]. Such a sampling strategy is commonly called purposive (or purposeful) sampling, as participants are selected purposely to yield rich information [18]. To maximise the "richness" of collected information, individuals are selected based on the assumption that they possess knowledge and experience relevant to the topic under examination [19].

Hence, in this study, purposive sampling was used to select focus group participants, whose extensive experience in the building or energy sector could help us better understand the current landscape, justify our initial proposition for the ABCode, and identify opportunities and challenges to the widespread deployment of ABs. In this context, the selected participants were experienced industry practitioners having a variety of backgrounds and work experience (i.e., architecture, engineering, sustainability consulting, energy supply/management, and housing development). Engaging stakeholders across the whole building value chain was needed to capture diversity in perspectives and identify responsibilities for ensuring intended outcomes [20]. The professional role of each stakeholder that participated in each focus group is listed in Table A1 in Appendix A (from stakeholder no. 1 (S1) to stakeholder no. 30 (S30)). All participants were recruited via email.

As, given the aims of the study, there was no need to generate a representative sample, the total number of groups (and hence of participants) was dictated by the "saturation" point (i.e., the point at which no new themes were emerging from discussions) [21]. Saturation is commonly applied in qualitative research as a criterion for terminating data collection and/or analysis [22]. As suggested by Krueger and Casey [23], an initial round of focus groups was conducted (five in this study). Since no saturation had been reached after the end of these sessions, additional participants were recruited and a second round of (seven) focus groups were conducted. Running additional sessions allowed the themes that emerged from preceding groups to be further explored [24]. By the end of the second round, no new themes were raised.

There is no "magic number" for how large groups should be and "more is not necessarily better" [25]. Small groups can yield valuable data, offering more space to participants to discuss emerging themes in greater detail [26]. A low number of participants per group is particularly advantageous in the case of complex topics [27], and was hence preferred in this study. Specifically, triads and dyads were chosen, as they provide a balance between the group and the individual context, allowing participants to become familiar with the topic and reflect on what they hear from others while still having ample opportunity to contribute [28].

2.3. Data Analysis

A range of established analysis techniques exist to guide the interpretation of qualitative data in a semi-systematic fashion. Grounded theory is a popular qualitative approach to theory generation, originally developed by Barney Glaser and Anselm Strauss [21] and often referred to as Glaserian grounded theory [29]. This promotes the concept of emergence (i.e., the generation of a new theory directly from data collected), through the method of comparative analysis. In more detail, the researcher first immerses themselves in the data by listening to the recordings and keeping notes to become familiar with the text. In the next step, the researcher codes the text (i.e., attaches keywords to text segments). For example, a statement such as *"What we need most is guidance from government"* might be coded under a label such as *"Need for regulation"*. Coding generates core categories that can provide an easily recognisable description of any emerging themes. Categories emerge through the process of "constant comparison" (i.e., defining codes and comparing them to any previously identified codes). To continue with our example, the researcher might look how often *"Need for regulation"* was noted across all the focus groups. This iterative process allows codes to be aggregated hierarchically by noting conceptual similarities and differences. Codes that demonstrate conceptual links can be grouped together to form a category. For example, the codes *"Whole-life perspective currently ignored"* and *"Incentives for improving energy efficiency currently missing"* were here grouped together to form the category *"What is missing from existing regulations/standards?"*.

It is difficult to accurately define subsequent steps, due to the close interplay of data analysis and data collection in the search for saturation [30]. This means that new data may have to be collected as the analysis proceeds, until nothing new is being discussed about the emerging themes. Such a "joint theoretical sampling and analysis" is suggested by Glaser and Strauss [21], as it can support the true emergence of a new theory. Combining purposive and theoretical sampling may thus be used to generate well-grounded categories and ultimately a well-grounded theory, with a second round of focus groups being therefore needed to sufficiently investigate emerging themes [24]. Data instances are constantly compared by the researcher to finalise categories and integrate them into an overarching theory, after going through one or more refinement rounds [31]. Refinement rounds may include splitting categories, converting several categories into one, or renaming them, in an effort to make analysis more explicit [30].

Figure 1 shows the main steps of data collection and analysis (based on a grounded theory approach) which were implemented in this study. Section 3 will describe the main study outcomes (i.e., the views of stakeholders on the future of the built environment and the AB concept). As suggested in the literature [32,33], the description of outcomes is accomplished by presenting the emergent theory with the core themes that were identified using a grounded theory approach (five in this study).

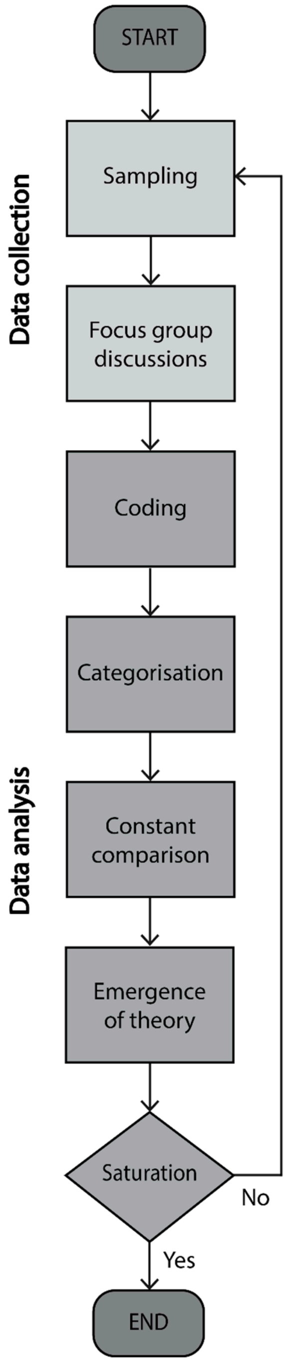

Figure 1. The main steps of data collection and analysis (based on a grounded theory approach) which were implemented in this study.

3. Results

Results are presented below as five main themes, each with several subthemes. The themes are presented in chronological order, reflecting any important topics that emerged from the general discussion about the future of the built environment, and then from the more specific discussion about ABs. Subthemes (i.e., the bullet points) are then presented in descending order, from the aspect that received the most attention to the one that received the least. They are also illustrated to show how many and which groups referred to each aspect.

3.1. Theme 1: What Is Missing from Existing Regulations/Standards?

This theme emerged from the initial general discussion about the future of the built environment in light of the net zero target, and the extent to which current regulations and standards push things forward enough to hit such a target. Discussion revealed the key aspects that are missing from regulations and/or standards, putting the net zero target at risk. The subthemes that emerged are described below and are also illustrated in Figure 2.

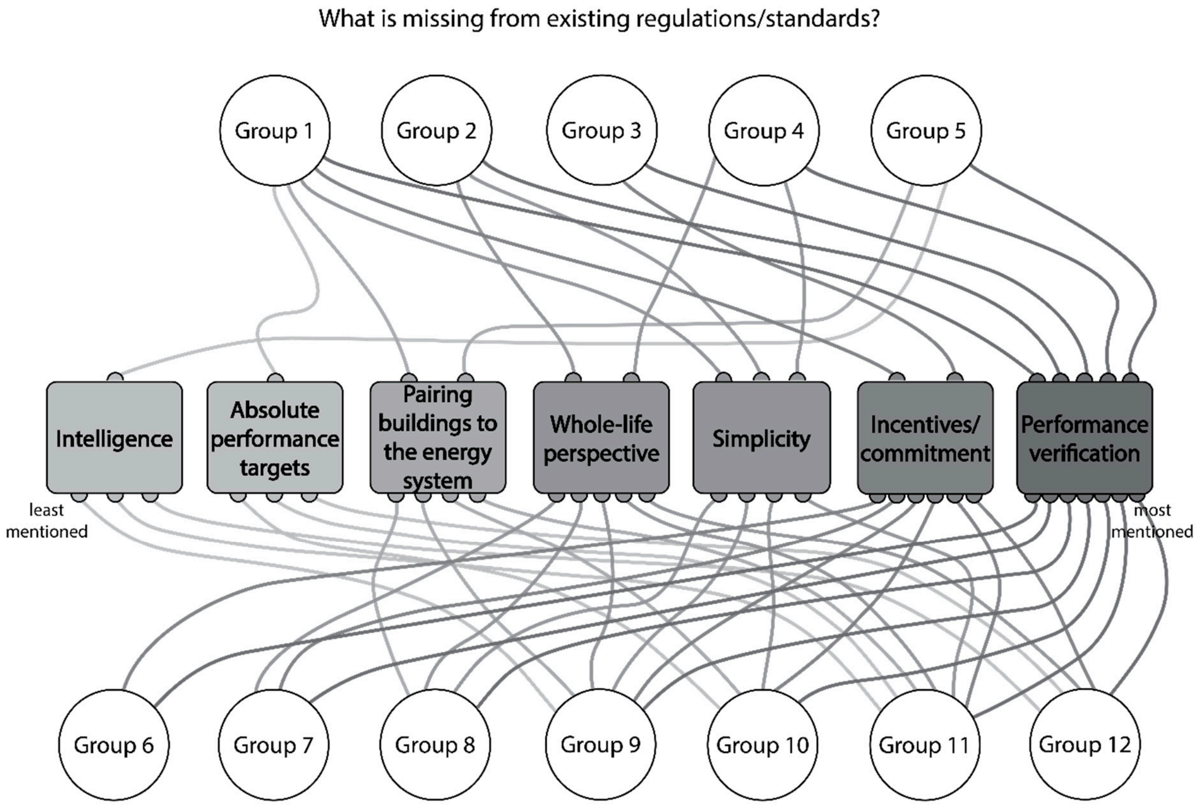

Figure 2. A stakeholder–issue interrelationship diagram demonstrating what is missing from existing regulations/standards according to different groups of stakeholders.

- **Performance verification**

All groups noted the lack of any compulsory scheme for post-occupancy evaluation for all building types, as "it is not only about how to get the right metrics to measure performance during the design process, but also how to get the actual data when the building is in use" (S5). Several stakeholders reported examples of real-world buildings which experience a significant gap between design and in-use performance, and attributed it to the lack of an obligatory feedback loop which would force designers to go back to buildings and verify performance. A data-driven approach was thus thought to be vital for "understanding how we are using buildings" (S12), "carrying those lessons into new projects" (S24), and "closing the gap between what we predict buildings will do and what they actually do" (S13). Closing the performance gap is ultimately the only way to deliver buildings that are truly net zero carbon in operation, which cannot be currently guaranteed due to the fact that "the Building Regulations do not make sure that buildings do perform" (S17) and that "most certification schemes are lax" (S18). As an example, S10 claimed that "With a south-facing roof, an air source heat pump, and a 2.4 kW solar panel system, a house can be net zero carbon in terms of heating and hot water. But we need a 4 kW solar panel system to truly make it net zero carbon in operation". Such a discrepancy is caused by the omission of any unregulated loads from the Building Regulations and the majority of zero carbon definitions for buildings, as these "isolate the building performance from the occupant performance" (S26). Hence, there was a consensus among all stakeholders on the need to move from a design-focused approach (which is solely driven by compliance targets) to a performance-focused approach (which also makes sure that there is no gap between design and in-use performance).

- **Incentives/commitment**

Several stakeholders referred to a general absence of incentives for building and operating low-energy buildings, which favours the inertia of developers, contractors, private owners, and end users. People do not really value energy as *"this is not expensive enough"*, which means that *"they will not take decisions voluntarily"* and hence that *"a way of reminding them the value of energy needs to be found"* (S2). To make energy matter, both incentives and penalties need to be mandated by *"clear standards"* (S12) that have *"a clear trajectory"* for the future of the built environment (S13). Respondents discussed how the Government should launch *"some kind of carbon incentive"* (S16) such as *"the reduction of VAT on retrofit projects"* (S29) as, for the time being, *"pursuing a higher level of performance is purely a value-add from a planning perspective"* (S24). Such an incentive may come with a *"commitment agreement"* (S7) to ensure a high level of performance in use, similarly to a *"design, build, and operate contract"* that often accompanies district heating projects (S27). This will also motivate developers and contractors who, in the absence of national legislation, *"take every opportunity to reduce cost"* and therefore, without legislation, *"building to higher standards is just not going to happen"* (S15). In order to *"push things beyond standard practice"* (S29) and *"increase market demand"* (S25), a *"radical change in building procurement"* (S12) and a *"new approach by local authorities"* (S21) are also required.

- **Simplicity**

Respondents saw a simple, well-understood formula as key to the widespread adoption of regulations and voluntary standards that promote decarbonisation. As highlighted by S20, *"People need to understand quickly. Otherwise, they get bored and move on"*. S23 similarly claimed that *"We need to come with a few simple words that we all understand, which will then become the common currency for everybody"*. A simple formula could also be effortlessly embedded in the early stages of the building design process, where there is the greatest potential to increase the energy efficiency of buildings. As stated by S16, *"Early stage is everything. By the time you have gone through planning, you know all your materials, the width of your walls, the size of all your windows and doors, whether you are having shading in your external envelope or not, and how much space you have. What are you going to do to the design to make it significantly more efficient, after you have already signed all these things?"*.

- **Whole-life perspective**

Several groups referred to the lack of a whole-life perspective and the common tendency of people to mostly care about capital cost, thus being unwilling to invest an additional amount to improve whole-life performance—even if the payback period is short. This was correlated with the Government's attitude to building as, according to S5, *"Regulations focus on the capital phase. They do not really deal with the whole-life performance of buildings"*. S9 also stated that *"We are missing the whole-life perspective. It is the regulations that sets the standards and influences the market, so it is up to them to drive a new way of thinking"*. This new way of thinking should emphasise that high-performance buildings are not as expensive as people usually think if they are seen from a whole-life perspective, as they can result in significant benefits over the buildings' lifespan, such as reductions in operational cost. As an example, S8 mentioned that *"Based on our evidence from houses that are built to low energy standards, tenants can save about £1000 per year on their fuel bills . . . This can also help to address fuel poverty"*. In addition to lower energy bills, high-performance buildings are accompanied by benefits for the health, wellbeing, and comfort of their end users, as *"they come with a certain level of quality . . . and a healthy indoor environment"* (S30).

Adopting a whole-life perspective, considering the embodied carbon that is commonly ignored by regulations and standards, is also essential for minimising carbon emissions and thus our environmental footprint. Several stakeholders expressed their concerns about the lack of respect for nature, as *"we are still looking at properties in terms of their economic value, not their environmental value"* (S8) and *"we are just beginning to have a conversation about the embodied energy of materials, which is a real problem"* (S12). They also acknowledged the need to put more emphasis on embodied carbon because *"this cannot be done more efficient [sic] over time"* (S16) and also because, as we move towards low-energy buildings, *"embodied carbon becomes a fairly substantial proportion of the whole-life carbon"* (S28).

- **Pairing buildings to the energy system**

Defining the interaction between buildings and the energy infrastructure is key to avoiding the most carbon-intensive electricity and ultimately delivering net zero. Energy Performance Certificates (EPCs) do not, however, capture such an interaction, as *"the Standard Assessment Procedure (SAP) assumes that the carbon intensity of the grid is fixed, which is not correct"* (S11). Another issue is that buildings are commonly not treated as active participants in the wider network, despite the *"flexibility products they can provide to the National Grid, such as a frequency response service, to keep it balanced"* (S3). Making the most of low-carbon electricity and providing flexibility services call for the use of storage technologies, which *"will become a vital part of building design, whether it is thermal mass, storing hot water, or storing electricity"* (S11). Nevertheless, storage remains a missed opportunity as it is *"currently ignored by designers"* (S18) and *"not incentivised or even quantified by any national legislation"* (S22).

- **Absolute performance targets**

Assessing the performance of buildings in relation to notional buildings (as proposed by the Building Regulations) leaves space for inefficient building shapes. According to S24, this is the reason why *"the Building Regulations and current certification schemes do not push things forward"* and also why *"relative targets should not be used"*. Absolute performance targets are needed to award well-performing building forms and prevent designers from developing poor design solutions. An additional reason is that they provide a project team with tangible targets during the building design process. As underlined by S30, *"We need a target because otherwise, people are at a loose end. Lots of practices have signed up to the RIBA's declaration of climate emergency. But what are they going to do, tangibly?"*. At the same time, as noted by S4, the defined targets *"should not overly restrict the freedom of architects"*, with several stakeholders advocating the use of a scale rather than a definite number against which to judge the performance of buildings.

- **Intelligence**

Smart building technologies are critical in allowing buildings to optimally interact with the grid while responding to the needs of their end users, but these are not yet precisely defined in regulations and standards. A few stakeholders referred to the great importance of delivering intelligent buildings, as these can *"save a lot of carbon and support the grid in doing that"* (S11) and also *"respond to the needs of the occupants"* (S20). At the same time, stakeholders expressed their concerns about the lack of such requirements in legislation, even though the technology is out there, such as certified smart meters which *"know what energy has gone in and what energy has been exported from a building"* (S11) and *"could be used to build predictive models"* (S27). Such a reticence was partly attributed to data privacy issues, which should be, however, surmounted to harness the power of open access data—instead of *"each project reinventing the wheel and trying to find data"* (S30).

3.2. Theme 2: What Is an AB?

This theme emerged when the researcher introduced ABs. Participants were initially asked to provide their own definition of "active", without any prior knowledge of the term. The subthemes that emerged are described below and are also illustrated in Figure 3.

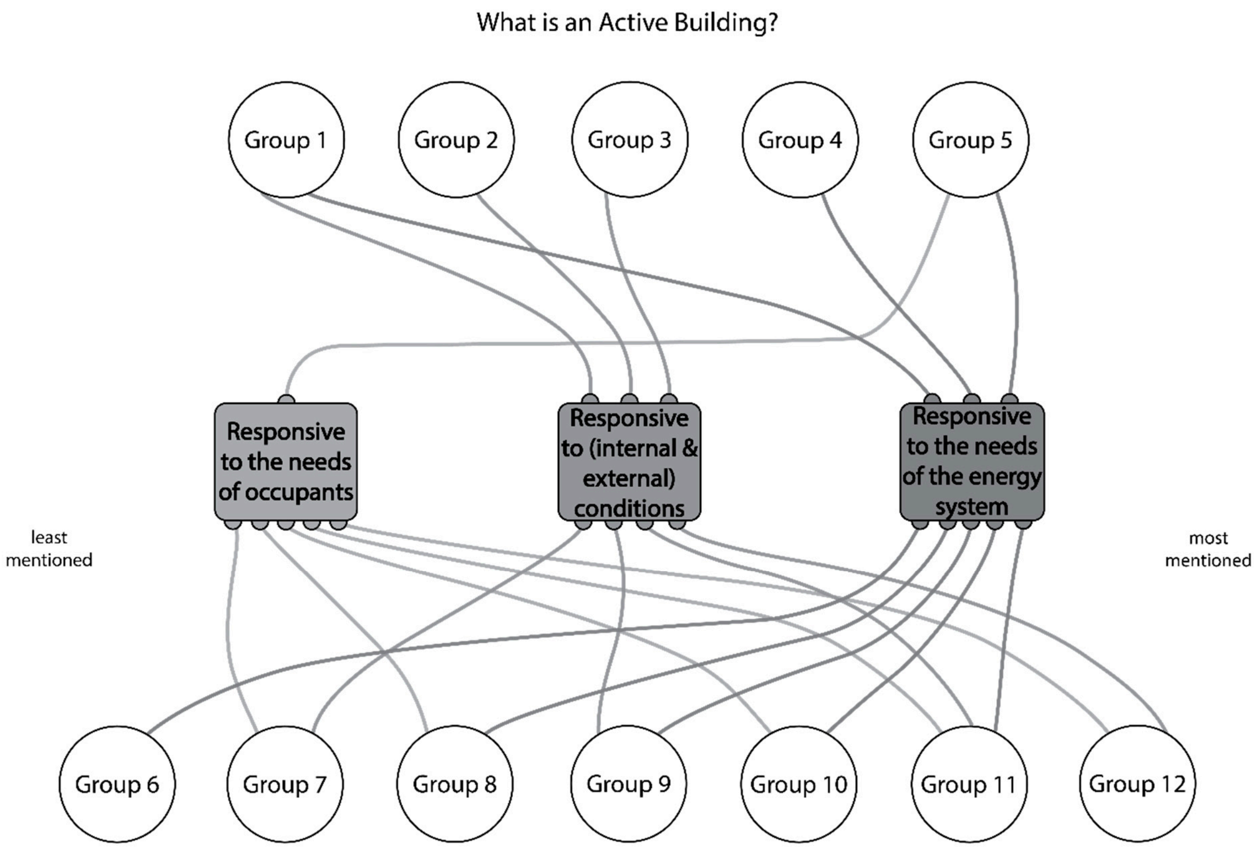

Figure 3. Definitions of an active building according to different groups of stakeholders.

- **Responsive to the needs of the energy system**

Several groups correlated the term "active" with the interaction between buildings and the energy infrastructure, as they considered this key to maximising cost efficiency and delivering net zero. ABs were defined as *"active participants in the wider network, responding to price signals or constraints"* (S3) and as *"active parts of a dynamic system, helping avoid infrastructure upgrade"* (S1). They were also described as *"buildings that produce and store renewable energy, playing an active role in the grid decarbonisation"* (S9). Bringing all these definitions together, ABs are *"buildings that respond to the needs of the energy grid, with aspects like demand response and storage being part of classifying a building as an AB"* (S19).

- **Responsive to (internal and external) conditions**

Several groups linked the term "active" with buildings being responsive to changes in their conditions, with the aim of optimising their energy and carbon performance. ABs were characterised as buildings that *"have an active control of what is going on"* (S21) and *"respond directly to inputs, such as the weather"* (S26). In addition to responding to any real-time changes, ABs should *"adapt to different needs in the long term as part of a circular economy strategy, whether this is the building fabric, shading systems, or mechanical systems"* (S5). ABs should thus advocate *"a different approach to design"* which is based on *"adaptability"* (S28). This means that, whatever the timescale is, ABs should be able to *"react to internal and external conditions"* (S6).

- **Responsive to the needs of occupants**

Half of the groups associated the term "active" with buildings that are responsive to the needs of their occupants. In particular, ABs were defined as buildings that *"interact with their end users"* (S25), *"provide for their needs, such as heating and cooling"* (S11), and ultimately *"promote their health and wellbeing"* (S18). Hence, ABs should *"respond to whatever the user* *wants them to do"*, this being achieved with the help of *"a user-centred control that does not force the user to modify their lifestyle radically"* (S23).

3.3. Theme 3: How Should the Performance of an AB Be Assessed?

This theme emerged after the moderator had introduced the AB concept. The proposed metrics for assessing the performance of ABs are described below and are also illustrated in Figure 4.

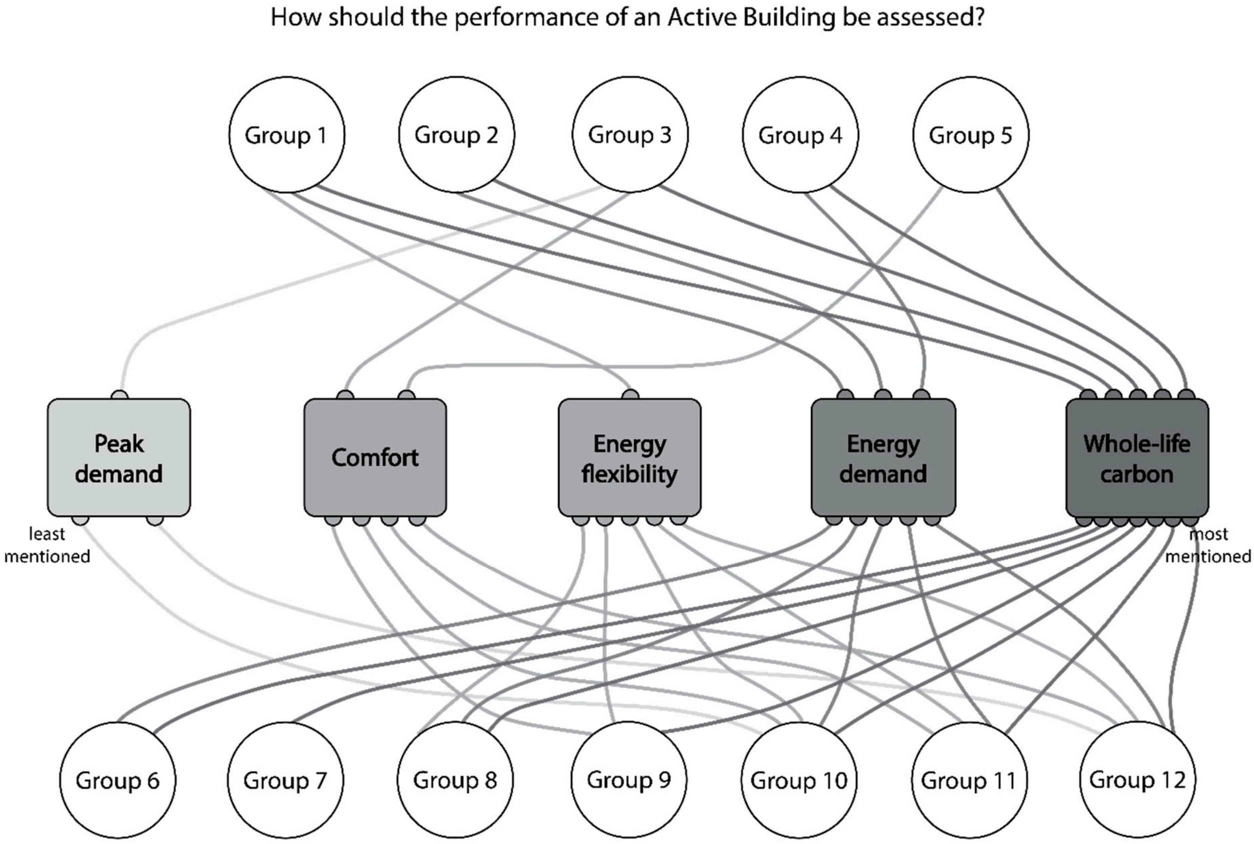

Figure 4. Metrics for assessing the performance of an active building according to different groups of stakeholders.

- **Whole-life carbon**

All groups discussed the critical role of quantifying the carbon performance of ABs in meeting the net zero carbon target. Stakeholders stated that the question designers should be asking themselves during the design process is *"how carbon negative would the building have to be in use to wipe out the embodied carbon in the build?"* (S10). This means that they should be *"looking at the whole picture"* and *"having a target for whole-life carbon performance"* (S4), so they can *"achieve potential savings in both the operational and embodied carbon sides"* (S22). These two *"should be thought of together"* (S18) to *"save carbon now"* (S30) and ultimately *"save the planet"* (S11). Hence, there is a need for *"a scale that captures the spectrum of carbon performance of buildings and ultimately their impact on the environment; for example, A to be net positive and G to be harmful to the environment"* (S24). Stakeholders emphasised the increasing need to quantify the embodied carbon performance of buildings and even *"consider a building as a multitude of lifecycles"* (S21). This is due to the fact that *"as the grid decarbonises, the operational carbon emissions of a building just drop off. But you can never undo the embodied carbon emissions that went into that building"* (S28). In addition to considering any upfront embodied carbon emissions, using whole-life carbon as a performance metric implies that we must also account for any embodied carbon emissions that occur during the in-use and end-of-life stages. As we move towards a circular economy, whole-life carbon may also include any embodied carbon emissions that occur beyond a building's lifecycle to encourage *"designing for disassembly"* (S18), and ultimately *"reduce the amount of natural resources used in buildings"* (S23). This calls for more holistic carbon assessments during the building design process, although *"unfortunately, there is not a single tool that perfectly works from day one until the last day of the design of a project"* (S25).

- **Energy demand**

Several groups advocated the use of an energy metric for assessing the performance of ABs. Stakeholders suggested that *"we have to start with reducing energy demand"* (S1), and called for the incorporation of *"a kWh metric"* (S13). Using such a metric *"can push architecture/passive design"* (S4), while also providing different stakeholders with *"something that is measurable"* (S26) and can be judged *"against predicted performance values"* (S5). *"Focusing on energy demand"* (S24) will be increasingly needed *"as buildings are moving towards electrification"* (S18). In other words, *"As electricity gets closer to zero carbon, you do not want to just focus on carbon as a standard metric for buildings. You also need to focus on energy"* (S27). This may also imply *"some consideration of the consumption at a community scale"* (S19).

- **Energy flexibility**

Six groups highlighted the importance of including some measure of energy flexibility in the performance assessment of ABs. In particular, energy flexibility is important as *"the ultimate goal is not to draw energy from the network during peak hours"* (S3). At the same time, flexibility is anticipated to *"become more important over time, as there will be a lot of green energy"*, which means that *"adding renewables onto the system at a period of low demand may be a bad idea, as there is the chance that you will produce loads of solar energy and you have nowhere to put it"* (S3). The ABCode should therefore account for *"the benefit of energy storage"* (S22) and provide *"a standardised way of assessing how flexible a building is"* (S19), with such a flexibility potentially varying *"from inter-seasonal all the way through to second-by-second"* (S27). This could also be seen as *"a positive contribution to the national infrastructure"* and thus as *"a way of demonstrating a neutrality, or even a positivity"* (S24).

- **Comfort**

Half of the groups referred to the need for a comfort metric for assessing the performance of ABs. Stakeholders stated that *"comfort should not be hindered by any decision that aims to minimise carbon"* (S22), as this is *"a predominant focus"* (S23). That is, in addition to considering any carbon and/or energy metric, *"thermal comfort should not be neglected"* (S25), as *"how the occupant wants to live is an important driver"* (S11). A few stakeholders also discussed the importance of visual comfort, as *"people value the quality of light"* (S30).

- **Peak demand**

Three groups proposed that peak demand is incorporated in any rating system for evaluating the performance of ABs. Peak demand was considered *"a crucial aspect of a net zero new build"*, as it indicates *"what demand the building will put on the grid"* (S29). Hence, it also determines *"when the electrical grid operator may have to turn on dirty, expensive power plants that typically sit unused"* (S6). This means that *"when the peak demand gets smaller, the cost gets smaller"* (S24).

3.4. Theme 4: What Are the Challenges to the Expansion of the AB Concept?

This theme emerged from the discussion about ABs, where participants were asked to provide their opinions on the newly introduced AB concept. The main perceived challenges to the widespread deployment of ABs are described below and are also illustrated in Figure 5.

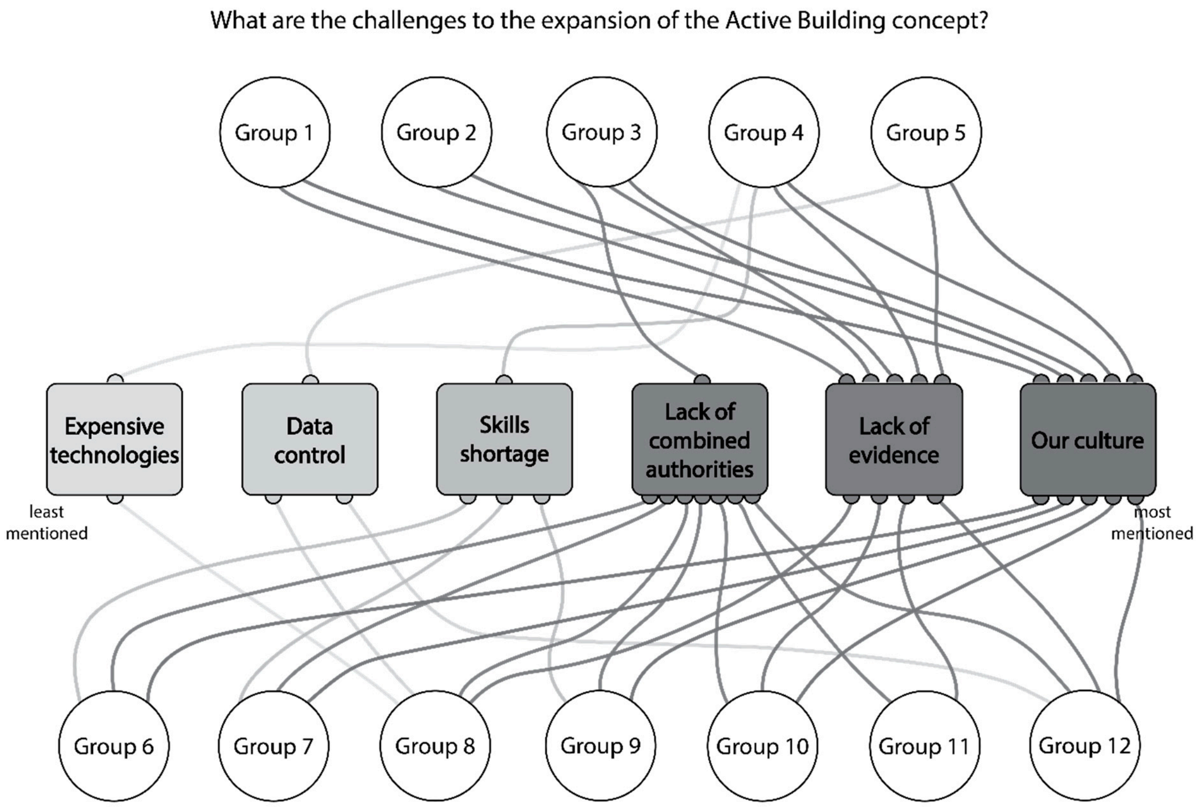

Figure 5. Challenges to the dissemination of active buildings according to different groups of stakeholders.

- **Our culture**

Almost all groups highlighted the role of our cultural mindset in the dissemination and acceptance of the AB concept, as this affects customer demand and hence drives the market. In more detail, several stakeholders referred to the importance of embedding sustainability in our culture *"so people automatically do things"* that can improve the energy performance of buildings (S2). However, stimulating interest around sustainability remains a challenge as *"the carbon fluency of the general population is not there"* (S24) and *"people have to be nudged into doing the right thing"* (S13). Convincing developers to go beyond the Building Regulations and adopt the ABCode may similarly be challenging, as for them it is *"a cost–benefit analysis"* (S8) and it is therefore difficult to *"encourage them to be interested in the life-cycle cost of buildings at the expense of the capital cost"* (S5).

- **Lack of evidence**

The majority of groups discussed how there was a lack of evidence of the real-world benefits that would arise from adopting the AB concept. Stakeholders claimed that there is a need to *"build a database of evidence"* (S29) which shows that *"the actual buildings reflect the expected performance"* (S8) and ultimately acts as a *"business case"* for embracing the AB concept (S28). In the absence of such evidence, it may be difficult to *"convince clients that it is actually worth doing it"* (S23), as clients need to be aware of the implications of building to the AB standard, such as the *"CapEx and OpEx arguments"* (S18), and ultimately of *"the return of their investment"* (S25). The absence of evidence may also discourage planners from adopting the AB concept. In the absence of planning policies, it will then be highly unlikely to *"see the higher level of investment required to build to higher standards"* from the developers' point of view (S24).

- **Lack of combined authorities**

Eight groups pointed out the need for *"a combined authority"* (S7) to ensure the mass adoption of the AB concept. Stakeholders claimed that there is still a lack of *"local connectivity"* in terms of both thinking and acting (S15), which detrimentally affects *"advocacy"* in terms of decision making—and ultimately of committing to building to a better standard (S18). To tackle this problem, local authorities should take a more active role, as there is currently *"a huge lag between planning and practice"* due to the fact that *"the planning policies of local authorities still refer to a performance that barely passes the Building Regulations"* (S30). Such a lag is thought to be a barrier to a greener building sector, as it neither *"allows for design teams to opt for the better solution"* (S22) nor *"forces contractors to do it"* (S15).

- **Skills shortage**

Four groups referred to the lack of experience in delivering ABs and the associated skills gap among stakeholders as a potential challenge to the dissemination of the AB concept. That is, even though *"skills are necessary on site to bring the building together"* (S8), there is *"a labour shortage"* (S22). Additionally, there is *"a skills shortage in terms of professionals with a knowledge and experience of how to deliver well-performing buildings"* (S20) as, for instance, *"there is a very low number of architects who have carried out an embodied carbon analysis on a full building"* (S16). This means that *"there is a risk added to proposals and submissions from contractors about hitting the target or not"* (S22), which will remain until *"building construction goes through a disruptive change … to achieve better quality"* (S12).

- **Data control**

Despite its significant role in securing the optimal performance of ABs, data control may prove to be challenging. This is due to the fact that data access and management must be performed with permission from occupants, as *"you cannot just hack into their Wi-Fi and check their energy consumption"* (S10). Nevertheless, this may be difficult to achieve in practice, as *"there is a real reticence with sharing data"* (S30). In the absence of required data, there may then be the question *"whether the savings promised can be achieved"* (S18).

- **Expensive technologies**

Two groups considered the cost of technologies as a potential challenge to the widespread adoption of the AB concept. In particular, S8 claimed that *"some technologies are still expensive"*, with S18 similarly stating that *"the integration of systems can be a barrier"*. However, both stakeholders pointed out that technologies are expected to become cheaper over time due to an increase in demand.

3.5. Theme 5: What Are the Future Opportunities for the AB Concept?

This theme emerged from the discussion about ABs, where participants were asked to provide their opinion on the AB concept. Any opportunities that emerged are described below and are also illustrated in Figure 6. Note that such opportunities may represent areas that have already been considered by the ABCode but could be further developed in the future, as they describe emerging approaches, technologies, and products that are expected to become increasingly relevant on our way to decarbonisation. Hence, they could also be thought as additional arguments for adopting the AB concept.

- **Health, wellbeing, and comfort**

Several groups highlighted the increasing importance of delivering buildings that constantly provide for the health, wellbeing, and comfort needs of their occupants. Delivering a healthy indoor environment was thought to be gaining popularity among clients, as *"COVID will accelerate existing trends, one of which is to move towards more sustainable and heathier buildings"*, with end users already *"demanding highly sustainable buildings"* and clients *"trying to demonstrate a benefit in the market"* (S20). Securing wellbeing is also key, as it is associated with *"the improved concentration and productivity of building users"* (S16), as well as with *"how active people are"* (S30). Given that *"a home is probably the biggest investment anyone ever makes"* (S23), making end users *"feel comfortable … is a predominant focus"* (S24). This will become even more critical over the next few years as *"we might get more heatwaves"* (S27), with overheating thus being *"the next decade challenge"* (S11).

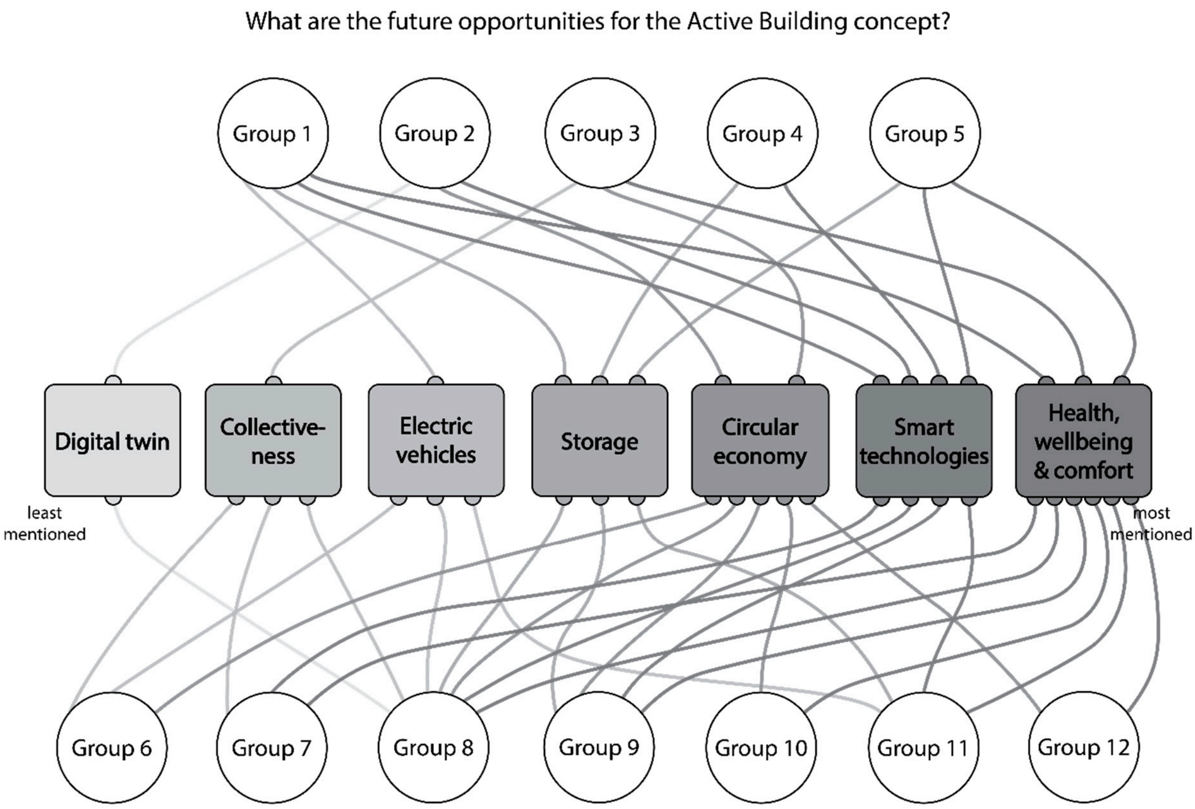

Figure 6. Future opportunities for the dissemination of active buildings according to different groups of stakeholders.

- **Smart technologies**

Eight groups underlined the increasing popularity of smart technologies and their active role in optimising the performance of ABs. Smart technologies, such as *"artificial intelligence (AI)"* (S15), have started to *"become popular in several sectors"* (S5) as they support *"automation"* (S27). Such technologies are currently promoted by the ABCode, which emphasises the need to *"have something measurable, such as metered energy use"* to quantify building performance (S26) and ultimately enable *"smart control as a whole"* (S27). As ABs are expected to *"move with evolving technology"* (S20), their definition is *"agile, as we will see enormous innovation in technology"* over the coming years (S11). To fully harness any technological innovation, we would need a clearer definition and regulation of data sharing to overcome the currently observed *"reticence with sharing data"* (S30).

- **Circular economy**

The growing interest in circular economy was considered another future opportunity for ABs. Stakeholders stated that *"we talk a lot about the importance of circularity in building design . . . and embodied carbon in buildings especially"*, but *"there is no standard out there that dictates how you do this"* (S29). By considering embodied carbon as part of its rating system, the ABCode was found to be *"holistic"* (S28). The recent emergence of relevant concepts, such as *"Buildings as Material Banks"* (S21), *"regenerative design"* (S24), and *"biodiversity"* (S23), demonstrates the need to take into account the embodied energy of materials, quantify the life-cycle environmental impact of buildings, and ultimately transition from linear to circular economy.

- **Storage**

Half of the groups highlighted the increasing importance of storage in enabling both ABs and the grid to be net zero carbon, while providing their users with all the required services. Storage is anticipated to be *"absolutely critical in meeting capacity in the future"*

(S22), as *"how do you manage to have a stable grid that relies entirely on renewables when you have no idea when it will be sunny or windy enough"* (S9). That is, as we *"electrify transport and heating"* (S3), *"storage almost becomes more important than generation"* (S11). Given that *"upgrading infrastructure can be very expensive"* (S1), *"the capacitance of the building needs to be more thought about"* (S18) and this is why *"distribution network operators are starting to procure local flexibility services"* (S27). That creates a need for *"a standardised way of assessing how flexible a building is"* (S19). Since this is currently provided by the ABCode, there is the belief that the code *"will be embraced as there is nothing else out there"*, with *"utilities and grid operators being the ones that will start to push the adoption of such an approach"* (S19). That is, *"instead of having huge facilities that store energy, you have thousands or millions of ABs that do it for you"* (S8).

- **Electric Vehicles (EVs)**

Four groups stated that the connectivity to EVs will provide ABs with a greater flexibility, therefore further contributing to the reduction in the stress on the grid. In particular, given that *"the ban on combustion vehicle sales has been brought forward to 2030"*, *"EVs are going to become more prevalent"*, which means that there should be *"integration of transport into building design"* (S27). The popularisation of EVs is expected to bring *"Vehicle-to-Everything (V2X) technologies"* to the fore, hence creating *"a natural link"* between EVs and ABs (S18) that can *"reduce the drain from the network"* (S3).

- **Collectiveness**

The benefits of the applicability of the ABCode to a community of buildings were discussed. In addition to any environmental or financial benefits, such as *"cost sharing"*, the *"cultural aspect"* of applying the AB concept at collective level was also highlighted (S6). That is, treating ABs as *"clusters of buildings"* can be translated into *"working together in terms of energy, water, etc."* (S17), but also *"creating a collective, caring culture that adds value to the user experience"* (S7).

- **Digital twin**

Two groups claimed that the integration of digital twin technology will bring additional real-world benefits for ABs and the grid. Although *"digital twin is missing at the moment"*, its popularity is expected to rise as, for example, *"the Greater London Authority (GLA) will start to ask developers to provide data"*, which will trigger multiple benefits including the ability *"to define the energy demand in a given area and calculate the carbon intensity of the grid"* more easily and with greater certainty (S4).

4. Discussion

4.1. Stakeholder Perceptions of the Next Generation of Buildings

In light of the declared climate emergency and in view of the 2050 net zero target, we need to re-evaluate the current process of designing, constructing, and operating buildings [34]. In the last few years, environmental activists (e.g., Greta Thunberg) and groups (e.g., Extinction Rebellion) re-emphasised climate change and the urgent need to reduce our CO_2 emissions [35,36]. However, existing building regulations and standards do not sufficiently capture this ambition, putting the net zero target at risk [4]. In the present study, focus group discussions with experienced industry practitioners revealed the aspects that are currently missing from existing regulations and standards, namely (from the aspect that received the most attention to the one that received the least): performance verification; incentives/commitment; simplicity; whole-life perspective; pairing buildings to the energy system; absolute performance targets; and intelligence.

To accelerate decarbonisation, such aspects must be taken into account when developing or revising relevant frameworks. In more detail, *performance verification* is critical in closing the performance gap and truly achieving net zero carbon buildings. *Incentives/commitment* can help to reduce the resistance of developers, contractors, private owners, and end users to pursuing high levels of performance at the expense of capital cost. *Simplicity* is required to ensure the widespread adoption of any standards that promote decarbonisation, starting from the early stages of the design process. A *whole-life perspective*, including the consideration of embodied carbon, is essential for minimising the CO_2 emissions of buildings. *Pairing buildings to the energy system* is key to avoiding the most carbon-intensive electricity and making the most of low-carbon electricity. *Absolute performance targets* can award well-performing building forms and prevent designers from developing poor design solutions, while acting as tangible targets throughout the design process. *Intelligence* allows buildings to optimally interact with the grid, while responding to the needs of their end users.

As part of the focus group discussions, stakeholders also shared their opinion on the future generation of buildings, termed Active Buildings (ABs). That is, they provided their own definition of "active", without having any prior knowledge of the term that might have biased their answers. They all interpreted "active" as responsive, with such responsiveness referring to (from the most common to the least common answer): the needs of the grid; any internal or external conditions; and the needs of the occupants. The majority of stakeholders discussed the need for *responsiveness to the needs of the energy system*, as this is key to maximising cost efficiency and ensuring net zero carbon. Other stakeholders prioritised the *responsiveness to internal or external conditions*, with the aim of delivering buildings that respond to real-time changes, but also adapt to needs in the long term as part of the emerging circular economy concept. The *responsiveness to the needs of occupants* was considered a top priority by several stakeholders, as buildings should always ensure the comfort, health, and wellbeing of their end users.

With respect to the metric(s) we should be using for assessing the performance of the next generation of buildings, opinions varied from one group to another, and even within the same group, as people were divided between a focus on energy and a focus on carbon. In particular, several stakeholders advocated the use of *energy demand*, as this can be easily measured after the building is occupied and judged against predicted values. Stakeholders stated that such a metric will become increasingly important as buildings are moving towards electrification and electricity moves closer to zero carbon. Some stakeholders referred to additional energy-related metrics and in particular to *energy flexibility* and *peak demand*, due to their impact on the grid. On the other hand, several stakeholders stated that energy metrics do not reflect the variations in the carbon intensity of the grid and suggested the use of *whole-life carbon* for rating buildings. In addition to quantifying operational carbon, such a metric captures the embodied carbon in buildings which, given our transition to low-energy design, is becoming a substantial proportion of whole-life carbon. Quantifying embodied carbon is challenging, however, due to the low number of practitioners that have experience in carrying out such an analysis, and also the lack of tools and datasets that can support a holistic assessment of carbon. Finally, the need for a *comfort* metric was highlighted, as user experience is an important driver in designing the built environment [37].

4.2. Do Stakeholder Perceptions Agree with What Is in the ABCode?

A notable overlap was observed between the views of stakeholders and the aspirations of the Active Building Code (ABCode), which largely justifies our initial ABCode proposal [9]. All stakeholders highlighted the need to change the way we are currently designing, constructing, and operating buildings, if we are to achieve net zero carbon by 2050. The aim to optimise environmental performance was the main reason why stakeholders emphasised that the next generation of buildings should respond to the needs of the grid. It was also the reason why they advocated using both energy and carbon metrics for assessing the performance of ABs. This fully aligns with the "do no harm" philosophy behind the ABCode [38], which recognises the need to deliver buildings that satisfy the needs of their occupants, but in a way that is cognisant of the climate emergency. Such a vision is promoted by the two main principles found in the ABCode: *whole-life sustainability* and *energy network support*. These can be evaluated with the help of the following metrics: *embodied carbon*; *energy consumption*; *renewable energy production*; and *energy flexibility*.

Despite their significant role in achieving net zero carbon, such principles and metrics are commonly ignored by regulations and standards. However, several stakeholders highlighted that embodied carbon is becoming a priority as, given that we are moving towards low-energy buildings, this is turning into a large proportion of whole-life carbon. Several stakeholders also emphasised that energy flexibility is becoming more important over time as, given that renewable energy production is becoming more popular, the use of storage technologies will be playing a vital role in achieving a stable and decarbonised grid. Such stakeholder perceptions justify the need for a more holistic way of thinking and acting, as promoted by the ABCode. At the same time, as well as having an active philosophy, the ABCode is also able to evolve over time and reflect the time-varying circumstances of both the building and energy sectors.

4.3. What Are the Future Opportunities and Challenges to the Dissemination of ABs?

After getting familiar with the AB concept (i.e., following the relevant presentation delivered by the moderator), stakeholders shared their opinion on the challenges to its dissemination. The list of challenges covers both technical and cultural aspects, namely (from the aspect that received the most attention to the one that received the least): our culture; lack of evidence; lack of combined authorities; skills shortage; data control; and expensive technologies. Our *culture* was found to be the greatest challenge to the dissemination of ABs, as our tendency to prioritise capital expenditures has a direct impact on market demand. The *lack of evidence* of the real-world benefits of the AB concept may also prevent planners and developers from widely adopting it. However, this challenge is expected to be addressed in the future, as a growing number of ABs are being constructed and monitored (although this of course raises new questions about data openness). The *lack of combined authorities* which obliges developers to build to a high standard is a further barrier. The *skills shortage* (in terms of both labour and professionals with knowledge and experience of how to deliver well-performing buildings) may be another obstacle due to the associated risk about hitting performance targets. *Data control* may also prove to be challenging, as there is a general reticence with sharing data. Additionally, a few stakeholders considered the *cost of technologies* as a challenge to the widespread adoption of the AB concept—although this is expected to be alleviated over time due to a foreseeable increase in market demand.

Finally, stakeholders referred to future opportunities for developing as well as marketing the AB concept. These again included both technical and cultural aspects, namely (from the aspect that received the most attention to the one that received the least): health, wellbeing, and comfort; smart technologies; circular economy; storage; electric vehicles; collectiveness; and digital twin. Delivering ABs that constantly provide for the *health*, *wellbeing*, *and comfort* needs of their occupants was found to be the greatest opportunity for the AB concept. This is due to the increasing demand for healthy indoor environments, which can be partly attributed to the mindset cultivated during the COVID-19 pandemic. The growing interest in *circular economy* is another opportunity for the popularisation of the ABCode, as its metrics quantify the life-cycle environmental impact of buildings (note that these metrics are expected to be refined in the future, as the building sector becomes greener and additional data become available). The integration of *smart technologies*, *storage* systems, and *electric vehicles* will provide ABs with greater flexibility and ultimately enable both the building and energy sectors to reach net zero. These are already promoted and incentivised by the ABCode, but are expected to grow further as such technologies are rapidly evolving. Note that technologies will also provide end users with an optimal experience, but they will not substitute for a good building design in the first instance. A *collective culture* can arise from the applicability of the AB concept to communities of buildings, therefore adding value to user experience. The integration of *digital twin* technology is expected to improve the interoperability between ABs and the grid.

5. Conclusions

There is a general agreement among industry practitioners on the need to change the current process of designing, constructing, and operating buildings to hit the 2050 net zero target and ultimately tackle the climate emergency. However, building regulations as well as the majority of voluntary standards are lagging behind the trajectory needed to achieve net zero carbon. Despite the direct link between buildings and the grid, regulations and standards lack such a holistic way of thinking. This is undoubtedly a missed opportunity for the decarbonisation of both sectors. In this context, we launched the Active Building Code (ABCode) [9]. This is a new building code that promotes the synergetic relationship between the grid and the next generation of buildings, termed Active Buildings (ABs), to help both the energy and building sectors achieve net zero.

This paper aimed to reveal the aspects that are missing from regulations and standards on our way to decarbonisation, to justify our initial proposal for the ABCode, and to uncover opportunities and challenges to the widespread deployment of ABs. Twelve online focus group discussions were conducted with the help of thirty stakeholders, all having an extensive experience in the building and/or energy sector. This data collection method was suitable for this study, as stakeholders were expected to have views on the next generation of buildings, but it was not yet clear what these might encompass. A grounded theory approach was used to analyse the discussions, revealing conceptual similarities and differences in what respondents said. This analysis resulted in five overarching themes, which revealed the aspects that should be considered when designing the next generation of buildings and which should hence be incorporated in regulations and standards. Notably, the themes clearly overlap with what is included in the ABCode, suggesting the code successfully captures issues important to experts. This justifies its emphasis on the synergetic relationship between buildings and the grid.

In particular, the data analysis revealed that existing regulations and standards are putting the net zero target at risk as they are missing crucial aspects, namely, *performance verification*, *incentives/commitment*, *simplicity*, *whole-life perspective*, *pairing buildings to the energy system*, *absolute performance targets*, and *intelligence*. When asked to provide their own definition of "active" without having prior knowledge of the term, all stakeholders defined ABs as *responsive* buildings, whether that encompasses the needs of the grid, any internal and external conditions, and/or the needs of occupants. With respect to the metrics we should be using for assessing the performance of ABs, views were divided between *energy* and *carbon*, with several stakeholders suggesting the consideration of both and therefore agreeing with the evaluation framework suggested by the ABCode. Potential challenges covered both technical and cultural aspects, namely, *our culture*, *lack of evidence*, *lack of combined authorities*, *skills shortage*, *data control*, and *expensive technologies*.

Finally, thanks to its ability to promote a synergetic relationship between buildings and the grid and eventually contribute to the decarbonisation of both, the ABCode was found to be heading in the right direction and also providing stakeholders with a tangible recognition of their efforts to tackle the climate emergency. Thanks to its active philosophy, the ABCode is able to evolve over time to reflect the changing circumstances of both the built environment and the energy infrastructure. Future iterations of the ABCode may hence need to adjust its initial principles and metrics to deal with evolving issues, such as the definition of whole-life carbon, and ultimately ensure that we are on track for decarbonisation. They may also better encapsulate the opportunities that were noted by stakeholders, namely, *health*, *wellbeing*, *and comfort*, *smart technologies*, *circular economy*, *storage*, *electric vehicles*, *collectiveness*, and *digital twin*. Additional stakeholders may be recruited in the future to allow us to statistically analyse responses and draw conclusions about the response patterns of different stakeholders (e.g., architects, engineers, developers, etc.). The stakeholder perceptions that were captured by this study could inform regulations and standards to make sure these drive down carbon in all building projects, while being widely comprehended and accepted.

Author Contributions: Conceptualisation, E.N., I.W. and D.C.; methodology, E.N. and I.W.; validation, E.N. and I.W.; formal analysis, E.N. and I.W.; investigation, E.N.; writing—original draft preparation, E.N.; writing—review and editing, E.N., I.W., D.C., S.A., D.F. and M.R.; visualisation, E.N.; supervision, I.W., D.C. and S.A.; project administration, E.N. and D.C.; funding acquisition, I.W., D.C. and S.A. All authors have read and agreed to the published version of the manuscript.

Funding: This study was conducted in the context of the Active Building Centre Research Programme (EP/V012053/1), which is funded as part of the UKRI Transforming Construction Challenge. The programme brings together ten leading universities, businesses, and service providers to develop and test innovative ideas and technologies that will enable the construction industry to transform into a net zero emissions sector.

Institutional Review Board Statement: Any ethical considerations were included in the Ethical Implications of Research Activity form and submitted electronically through the ethics forms system of the University of Bath. In August 2020, the form was reviewed and approved by a Second Reader (i.e., an independent member of staff) and the Head of Department.

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

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to warmly thank the industry practitioners who participated in the focus group discussions for their valuable input.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Anonymised list of participants.

Group	Stakeholder	Position	Company
G1	S1	Director	Sustainability Consultancy
	S2	Architect	Architectural Design Practice
	S3	Senior Technical Specialist	Electric Vehicle Consultancy
G2	S4	Environmental Consultant	Engineering Consultancy
	S5	Director of Innovation	Engineering Consultancy
G3	S6	Sustainability Director	Engineering Consultancy
	S7	Senior Consultant	Development Consultancy
G4	S8	Director of Growth	Housing Association
	S9	Sustainability Consultant	Sustainability Consultancy
G5	S10	Managing Director	Housing Association
	S11	Founder and Managing Director	Energy Management Company
G6	S12	Founder and Architect	Architectural Design Practice
	S13	Founder and Engineer	Building Physics Consultancy
	S14	Architect	Architectural Design Practice
G7	S15	Director	Architectural Design Practice
	S16	Sustainable Design Advisor	Architectural Design Practice
G8	S17	Head of Sustainability	Architectural Design Practice
	S18	Sustainability Director	Architectural Design Practice
	S19	Senior Research Engineer	Manufacturing Company
G9	S20	Associate	Architectural Design Practice
	S21	Embodied Carbon Lead	Engineering Consultancy
	S22	Director	Engineering Consultancy
G10	S23	Director	Architectural Design Practice
	S24	Sustainability Manager	Architectural Design Practice
G11	S25	Associate Director	Engineering Consultancy
	S26	Associate	Architectural Design Practice
	S27	Insight Lead	Electricity System Operator
G12	S28	Senior Structural Engineer	Engineering Consultancy
	S29	Environmental Designer	Sustainability Consultancy
	S30	Sustainable Development Adviser	Professional Body

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