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Review

Evaluation of the Quality of the Housing Environment Using Multi-Criteria Analysis That Includes Energy Efficiency: A Review

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Abstract: The quality of the housing environment (HE) is an important issue that has a direct impact on the life of inhabitants. Aiming for quality in residential architecture begins with a well-designed HE, with the designing process being a value that is difficult to evaluate. Nowadays, a well-designed HE takes into account the energy efficiency of a building. An appropriate degree of thermal comfort, which is required by inhabitants, needs to be considered at the design stage. Designers can use building certification programs and multi-criteria analysis to motivate investors to construct buildings in accordance with energy efficiency requirements. These systems respond to the needs of energy efficiency, thermal comfort, sustainable heating, and ventilation. Defining ways and methods to evaluate quality in architectural projects will allow the value of the HE to be improved. For this purpose, a multi-criteria analysis of five systems that can be used to evaluate HE quality and energy efficiency in a temperate climate was conducted: (1) Building For Life 12, (2) Home Quality Mark, (3) Housing Quality Indicators, (4) Système D'évaluation De Logements (Sel), and (5) NF Habitat-NF Habitat HQE. This analysis concerned information about the systems, their applicability in practice, and the applied assessment measures. The article shows that the quality of the HE consists of specific factors that can be distinguished and indicated by evaluation systems. As a result of the carried out assessment of the housing environment, 13 original categories of building assessment criteria were defined. The results of the conducted analysis indicated that it is possible to: (i) identify factors for the improvement of HE quality; (ii) prepare objective systems for the measurement of the HE; and (iii) use such systems in practice, e.g., in the design industry, real estates, and public administration. Moreover, the systems can be used in legal regulations for updating urban policies.

Keywords: building design quality; energy efficiency; certification of buildings; residential buildings; thermal comfort

1. Introduction

Residential architecture has a significant impact on the structure of today's European cities. According to the statistics of the European Commission concerning the construction industry, housing construction accounts for 60% to 85% of new investments (depending on the country) Therefore, housing has a significant impact on people's lives—we spend most of our time at home. Research conducted by the European Commission shows that we spend on average 90% of our time indoors [1], almost 68.7% of which is spent at home [2]. People sleep, rest after work, and meet family and friends—they satisfy the basic human needs described by Abraham Maslow in his "hierarchy of needs". This is one of the reasons why the housing environment that we live in plays a significant role in our lives, which is also confirmed by Maslow [3]. The importance of the housing environment was discussed at the first Habitat conference concerning the human environment, which was held in Vancouver on 11 June 1976. In its declaration, it can be seen that "improving the quality of human life is the first and most important aim of any human settlement policy" [4]. Therefore, according to the authors, this is an important reason why the identification of measurable quality factors can increase the positive impact on the housing environment. Nowadays, a well-designed HE takes into account the energy efficiency of the building. In order to provide the inhabitants with an appropriate degree of thermal comfort, which is required by inhabitants, needs to be considered at the design stage. Designers can use building certification programs and multi-criteria analysis to motivate investors to construct buildings in accordance with energy efficiency requirements. These systems respond to the needs of energy efficiency, thermal comfort, sustainable heating, and ventilation. Defining ways and methods to evaluate quality in architectural projects will allow the value of the HE to be improved.

1.1. Energy Efficiency of the Housing Environment

The drastically increasing costs of energy consumption [5], a lack and limitation in the supply of energy resources during winter seasons, and the low quality of energy resources are all examples of reasons why homeowners and housing associations decide to improve the energy efficiency of existing buildings [6–8]. Improving the energy efficiency of residential buildings is an issue that is widely discussed in the professional and scientific community. This is due to the fact that housing environments are among the most commonly constructed buildings [9]. Research topics can be divided into two categories: (i) those related to the design and implementation of housing environments, with solutions that improve the energy efficiency of a building being taken into consideration; and (ii) those related to the retrofitting of the existing stock of housing environments [10].

Housing environments in which solutions that aim to reduce energy consumption are not included in the design and construction stage will be detrimental to the living conditions of residents [11]. Retrofitting buildings in order to improve energy efficiency, and the use of alternative renewable energy resources, will: (i) allow the cost of heating to be reduced; (ii) allow the cost of cooling to be reduced; (iii) allow thermal comfort in buildings to be improved [12]; and (iv) benefit the national energy saving demand strategy [12–14]. The authors of a research study on the motivations and barriers that investors face before improving the energy efficiency of retrofitted buildings identify factors that influence this, such as low direct benefits and long payback periods [15], postponing the decision to undertake construction work [16], and high initial investment costs [17].

There are more and more reasons to implement a systemic energy efficiency tool [18]. In a building that is optimized in terms of energy efficiency, it is possible to achieve up to a 90% reduction in operational primary energy [19]. However, it should be noted that despite negative forecasts, some investors are still not looking into the possibilities of improving the energy efficiency of their buildings. Due to this, the responsibility to educate building owners lies with the designers of housing environments. A very effective tool for this can be multi-criteria rating and certification systems [20]. These systems make the investor aware of what elements they should take care of in their investment if they want, for example, to reduce the costs of building maintenance.

1.2. Reasons for Measuring the Quality of Housing and Neighbourhoods

Arguments for implementing tools to assess residential architecture can be grouped into three categories: (i) socio-economic, (ii) educational, and (iii) environmental.

Socio-economic arguments: The main reason why countries such as the United Kingdom (U.K.) [21], Switzerland, and France have introduced rating systems for assessing the quality of housing environments is due to the need to improve the quality of life for inhabitants.

Improvements are possible with regard to two areas: improving the built environment and improving sanitation facilities [22]. In the first of these areas, residential architecture has a significant impact on the physical structure of the human environment. This is due to its basic function of providing a "shelter" and a space in which inhabitants live, in turn making housing one of the most developed investments. The quality of these developments is a fundamental component in the assessment of the local physical environment, whereas well-designed residential architecture improves the built environment and has a significant role to play in terms of the quality of human life [23,24]. The second area refers to the health situation of inhabitants, in which both physical and mental health can be made better by improving living conditions (including sanitation) [25,26]. An indirect economic factor resulting from the improved quality of housing environments and the health of inhabitants is a true reduction in expenditure in hospitals, care facilities, or clinics [27]. In this way, mental [28] and physical health [29] improve without generating any costs that are related to social care (e.g., benefits from the state). Economic constraints also generate income for the economy, as inhabitants can spend less time on sick leave (in hospitals or rehabilitation) and more time doing their jobs, whereas students can participate in school activities. Another argument in favor of introducing a rating system for housing environments is that it can be used in the real estate market. This is due to the fact that it can be used by people who are looking for a dwelling to buy or rent, as well as by developers and sales-related companies [30]. An objective tool to measure the quality of residential architecture would work well in the real estate market because clients would be able to receive extensive information regarding their decision of whether to buy or rent a property. In addition, investors and planners would be able to use such a system to obtain clear information about which aspects related to the design of a building should be considered. This general system for investors will result in an improved built environment. The system would also be applicable for decision makers in public authorities who deal with affordable social housing for rent. Due to this, it will be possible to verify if a project is compatible with the standards of living of inhabitants, and also if public funds are spent rationally. In the case of non-compliance with specific requirements, officials would have a tool in order not to grant funds for investments.

Educational Arguments: A possible way to educate the community (renters, buyers, and investors) is to objectively compare developments with each other so that the most interesting living environments can be highlighted. Objectively comparing housing environments is a difficult task that judges have to face when evaluating participation in a design competition for housing environments. This form of education reaches very large audiences, and such contests are often well publicized in the media and promoted by city administrators [31]. Highlighted investments create a level/standard, and therefore the worst investments may have a problem in finding inhabitants. Another educational value of a quality assessment system can be seen to be indicators that are appropriately identified. Education enables the promotion of good construction practices that will allow the negative impact of housing on the environment to be reduced by increasing the importance of the indicators of sustainable building development [32,33].

Environmental Arguments: Improving a city's operational efficiency and livability also brings improvements in housing quality and urban system resilience [34,35]. Cities and housing spaces have microclimates of their own, which are reflected in higher temperatures. This is due to the release of anthropogenic heat, the excessive deposition of solar radiation, the lack of green spaces, limited air circulation, and a reduced ability to reflect infrared radiation. The phenomena give rise to urban heat islands, which are present in many cities around the world [36,37]. Overheating in cities has a serious impact on the energy consumption of buildings, peaks of electricity consumption, concentrations of air pollutants, and the level of mortality and morbidity of the human population [38]. Therefore, these factors significantly influence the assessment of the quality of the housing environment by residents. Urban and building typologies have serious implications for the urban climate, and generally determine the magnitude of urban overheating [39]. Overheating of the urban climate can be reduced through urban greenery and sufficient evaporation sources, etc. [40]. Contemporary cities represent a mosaic of different habitats. These habitats include urban green spaces, which take different forms: forests, parks, wastelands and ruderal sites, lawns, ornamental plantings, and meadows. Urban green infrastructure provides a range of different ecosystem services. The most commonly provided services are improvements in the local climate and air quality, as well as in the use of recreational and sport areas [41,42]. Nielsen [43] found that parks are important biodiversity hotspots in urban environments [44]. Community gardens and urban agriculture are important from a biodiversity perspective [45,46]. However, urban greenery can also be a source of biogenic pollutants such as pollen and volatile organic compounds that can reduce air quality [47]. The issue of vegetation as a source of allergenic pollen has been highlighted in a number of papers [48,49].

1.3. Evaluation of Living Environments

There are many reasons to evaluate the quality of residential architecture, and also reasons to improve knowledge in this field. At the same time, it is difficult to characterize all these reasons unequivocally. Research in this discipline is basic and fundamental, and the obtained results can affect a large part of society. Defining the factors (that influence the quality of housing environments) and their measurement methods is an important task in the process of improving people's living conditions [50].

In order to achieve these objectives, it is helpful to use tools that measure the quality of HE. One of the main reasons for the measurement is the need to indicate that a quality factor has been included in the project, improving the quality of a housing development [51,52]. At the same time, it is noticeable that some of the quality factors correlate with each other, which poses a problem when describing them unambiguously, and also when giving them appropriate priority. Only when all elements influence a factor is it possible to achieve the best possible quality results [53]. For example, factors that improve conditions of the existing built environment can be measured by defining appropriate standards (factors), with respect to architectural, urban, natural, social, or educational aspects, as well as good engineering practices used in the construction of buildings [54,55] and designing a safe space [56,57].

The issue of the quality and measurability of housing environments has been tackled by various research groups, including psychologists, sociologists, geographers, ecologists, engineers, urban planners, and architects. As a result, this issue has been studied by various interdisciplinary groups, which analyzed its detailed aspects. In the analyzed papers, authors of research on the evaluation of housing environments often focus on one or a few areas without covering the whole issue. Moreover, it is difficult to find research papers that discuss systems for: evaluating housing environments, comparing them with each other, and drawing conclusions for further research. The identification of these quality factors in the housing environment can provide many possibilities of their use. Therefore, the authors want to show that the quality of housing environments consists of specific factors that can be distinguished and indicated by evaluation systems. In this paper, an analysis of evaluation systems is presented. These tools can easily measure some factors related to the quality of the housing environment. Moreover, the systems are described in a synthetic way and in three categories: general information about the system, how to use the system, and the criteria (defined by the system) that are subject to assessment.

Selected systems for the evaluation of housing environments will be presented. Based on the conclusions from the evaluation system analysis (according to the methodology, Figure 1), it will be possible to present the classification of quality factors whose application and implementation at a stage of housing environment design will facilitate to provide a quality place to live, complying with the needs of today's inhabitants.

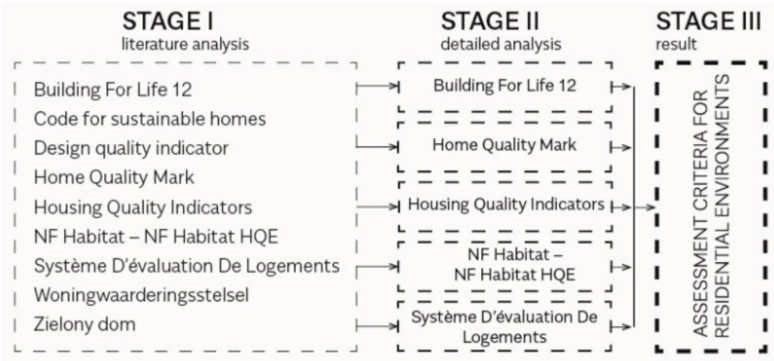


Figure 1. Scheme of methodology.

2. Materials and Methods

The main objective of this article is to analyze selected multi-criteria assessment systems that are applied in Europe in order to evaluate the quality of housing environments. These studies should be classified as fundamental in relation to the human-built environment. To achieve the research aim, the paper is divided into the stages described below, as shown in Figure 1.

Stage I: Literature analysis concerning multi-criteria systems for assessing buildings. Three main criteria were used to select the systems for the analysis: (i) a thematic scope—multi-criteria systems that can be applied to evaluate housing environments; (ii) a temporal scope—includes systems that were used from the year 2000 to 2022; and (iii) a territorial scope—systems applied in Europe in temperate climates. Based on the analysis of the nine systems shown in Table 1, it was possible to identify the scope of the selected systems for detailed analysis. The selection criteria are discussed in the key to Table 1.

Table 1. A summary of evaluation systems provided for the analysis, with a set of criteria for selecting examples for further analysis.

No.	Name of the System	1.	1.1.	2.	3.	4.	5.
1	Building For Life 12	yes	yes	yes	yes	P, A	yes
2	Code for sustainable homes	yes	yes	ending in 2006	yes	A, E	no
3	Design quality indicator	yes	no	yes	yes	A	no
4	Home Quality Mark	yes	yes	yes	yes	P, A, E, S	yes
5	Housing Quality Indicators	yes	yes	yes	yes	P, A, E, S	yes
6	NF Habitat—NF Habitat HQE	yes	yes	yes	yes	P, A, S	yes
7	Système D'évaluation De Logements	yes	yes	yes	yes	P, A	yes
8	Woningwaarderingsstelsel	yes	yes	-	yes	A, S	no
9	Zielony dom	yes	yes	no	no	E	no

Key: 1. Thematic scope—is it possible to evaluate the housing environment? 1.1. Is the main aim of the system to evaluate housing environments? 2. Temporal scope—was the system used between 2000 and 2020? 3. Territorial scope—has the system been applied in Europe? 4. Diversity of schemes—what is the leading objective of the analysis: spatial (P), architectural (A), ecological (E), and social (S) 5. Availability of literature in terms of: (i) general information on how to use the system; (ii) assessment criteria; and (iii) application of the system in practice.

Stage II: Detailed analysis of the research of five building evaluation systems, which were selected from the prepared database of systems. The examples presented in Table 1 were selected according to the following criteria: (i) the selection of varied evaluation systems that will allow a detailed analysis of material (spatial, architectural, and environmental) and non-material (social) factors to be presented; and (ii) the availability of research literature for verifying the system in terms of: (i) general information on how to use the system; (ii) assessment criteria; and (iii) application of the system in practice.

Stage III: As a result of five detailed analyses of selected multicriteria evaluation systems, by which the quality of residential environments can be assessed, a summary analysis of the evaluation factor will be presented.

3. Systems of Multicriteria Analysis

The presented paragraph about ways to evaluate housing environments provides evidence of how housing quality can be measured in practice. It proves that the increasing knowledge of subject allows delivery of high-quality living spaces that consider, e.g., sustainability, economic availability, and the needs of today's society. Five systems are characterized, which represent a tool to objectively evaluate, compare, and improve the quality of housing projects in Europe.

The analyzed tools present a variety of evaluation methods and criteria, making it possible to obtain insightful and multifaceted partial conclusions. The diversity of criteria in the tools is caused, e.g., by aims and reasons for which a given system was created. Analyzing the assessment tools, by examining their advantages and disadvantages, and also by understanding the criteria that have a positive impact on designed housing environments, will allow a variety of quality factors to be identified. However, the structure of the evaluation systems is similar for all the reviewed examples. The inclusion of quality criteria at the design stage allows for a real improvement in the future quality of the lives of inhabitants. This is due to the fact that the quality criteria, and their importance, are based on specialized knowledge and are often the conclusion of work developed in an interdisciplinary group of experts. The criteria that are based on the current knowledge and research on residential architecture are often updated to include elements that are seen to be annoying for today's city inhabitants, such as waste segregation, access to sustainable transportation, the impact of buildings on climate change, or environmental approaches to the construction of buildings.

For each of the five systems that are described, the same information about the methods of using the system will be presented, the criteria for evaluating the system, and the system's applicability. The systems were selected based on the availability of research material, the variety of examples, and their potential for use in the design of housing environments. Quality factors were divided into the following categories: (i) architectural, (ii) spatial, (iii) ecological, and (iv) social, as shown in Figure 2.

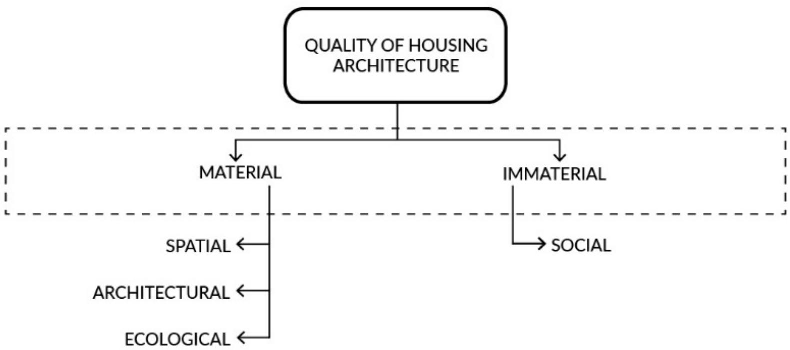


Figure 2. Scheme of quality factors.

3.1. Building for Life 12

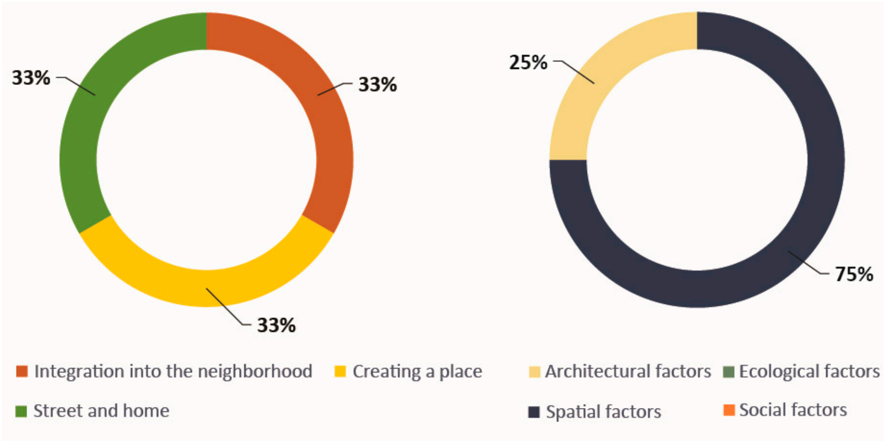
Building for Life 12 (BfL 12) is a market-leading certification system in England, and is used for the planning of both new residential buildings and whole neighborhoods. The provisions of the document have been officially approved by the government. The document is intended to encourage local communities, authorities, and developers to engage in joint discussions. As a result, high-quality housing projects will be developed and will satisfy the expectations of all the parties involved in the construction process [58].

The BfL 12 project has lived to work on five editions, the first being in 2012, thanks to the Building for Life Partnership (made up of three organizations: Commission for Architecture and the Built Environment (CABE), Design for Homes, and Home Builders Federation. The current fifth edition is from 2016 and was written by David Birkbeck (founder of Design for Homes) and Stefan Kruczkowski (urban planner and expert at the Design Council). The system was created as a result of the need to systematize and improve the quality of new residential environments designed in England. The BfL 12 system is a kind of industry guide to designing good places to live, in which the authors formulate and present their key issues in the form of open questions, in turn making the document more accessible to the local community and all participants in the design process. People using BfL 12 do not have to pay user fees, and therefore the authors encourage people to use it free of charge and to use it to refer to local plan developments [58]. Unlike other certification systems used in the building industry, BfL 12 does not require a specially qualified professional to operate and coordinate the system. All that is required is meticulous familiarization with all twelve questions (main and supplementary).

One of the reasons for the success of BfL 12 is that it has been implemented within the national spatial policy and promoted by national agencies. This helps local authorities to create local policies related to the planning and design of high-quality residential environments. An example of the BfL 12 system being put into practice is the County Durham Spatial Policy Supplement document, which was implemented in the northeast of England in 2019. The County Durham Plan [59] aims to improve and promote design standards that directly affect the quality of the residential environment. The document explicitly dictates that designers incorporate aspects of BfL 12 into their projects. Additionally, the evaluation system also helps city officials determine the quality of the development in question. For this purpose, the document introduces "Internal Design Review" methods (Internal Design Review), which are presented in a dedicated form for each of the twelve main questions. The evaluation criteria, with their breakdown into factors, are shown in Table 2, and their analysis is shown in Figure 3.

Table 2. Quality evaluation criteria—system Building For Life 12.

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
1	Integration into the neighborhood	Connections	P	8.33%
2		Facilities and services	P	8.33%
3		Public transport	P	8.33%
4		Meeting local housing requirements	P	8.33%
5	Creating a place	Character	A	8.33%
6		Working with the site and its context	A	8.33%
7		Creating well-defined streets and spaces	P	8.33%
8		Easy to find your way around	P	8.33%
9	Street and home	Streets for all	P	8.33%
10		Car parking	P	8.33%
11		Public and private space	P	8.33%
12		External storage and amenity	A	8.33%



(**a**) (**b**)

Figure 3. (**a**) The % share of categories when evaluating quality. (**b**) System % share by type of factor: spatial (P), architectural (A), ecological (E), and social (S).

3.2. Home Quality Mark

The Home Quality Mark (HQM) is an independent certification system for new housing in England, Scotland, and Wales, which was developed by the Building Research Establishment (BRE). BRE is also responsible for one of the most popular BREEM building rating schemes—used in more than 70 countries. The criteria developed for the HQM are based on the latest scientific research on issues such as energy efficiency, noise reduction, water management, and air quality. The system is one of the few to include issues such as climate change and carbon reduction. The HQM quality mark was designed to provide a reliable rating system for new housing developments. Developers can use the system to ensure that flats and buildings have been built at a high level of quality with respect to the environment. Every HQM-certified house fulfils higher standards than the minimum values specified, e.g., in the English building law. The system can also be used by potential buyers of apartments, as the certificate provides reliable facts, e.g., about the exploitation costs of a property and its technical condition [60].

There are many reasons for using the HQM system. By constructing a building with an impact on the quality of realization, which is included in the detailed guidelines, it is possible to improve the health and well-being of inhabitants. This is because good-quality houses require less renovation and repair, saving worries, time, and money. Another exemplary advantage of the system is the complex idea of not degrading the environment through the construction of the building. Buildings constructed according to this system are energy efficient and have a high energy performance. At the same time, the system has a tool to provide a positive net benefit from biodiversity or new plantings of trees and plants, compensating for losses caused by the construction of a new building [61]. These topics are formulated in 13 main qualitative categories [62]. The evaluation criteria, with their breakdown into factors, are shown in Table 3, and their analysis is shown in Figure 4.

Table 3. Quality evaluation criteria—Home Quality Mark system.

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
1	Transport and Movement	Public Transport Availability	P	3.0%
2		Sustainable Transport	P	3.4%
3		Local Amenities	P	3.2%

Table 3. *Cont.*

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
4	Outdoors	Identifying Ecological Risks and Opportunities	E	1.4%
5		Managing Impacts on Ecology	E	1.8%
6		Ecological Change and Enhancement	E	2.4%
7		Long Term Ecological Management and Maintenance	E	1.6%
8		Recreational Space	P	4.4%
9	Safety and Resilience	Flood Risk	P	3.8%
10		Managing Rainfall Impacts	P	3.8%
11		Security	S	1.8%
12	Comfort	Indoor Pollutants	A	2.4%
13		Daylight	A	2.6%
14		Noise Sources	A	0.8%
15		Sound Insulation	A	1.8%
16		Temperature	A	3.4%
17		Ventilation	A	2.6%
18	Energy	Energy and cost	A	12.0%
19		Decentralized Energy	E	1.6%
20		Impact on Local Air Quality	E	3.0%
21	Materials	Responsible Sourcing	A	5.0%
22		Environmental Impact of Materials	E	5.0%
23		Life Cycle Costing	E	2.4%
24		Durability	A	1.4%
25	Space	Drying Space	A	0.6%
26		Access and Space	A	2.2%
27		Recyclable Waste	A	2.0%
28	Water	Water Efficiency	A	3.4%
29	Quality Assurance	Project Preparation	A	1.2%
30		Commissioning and Testing	A	2.2%
31		Inspections and Completion	A	3.2%
32	Construction Impacts	Responsible Construction Practices	A	1.0%
33		Construction Energy Use	A	1.0%
34		Construction Water Use	A	1.0%
35		Site Waste Management	A	3.0%
36	Customer Experience	Aftercare	S	0.8%
37		Home Information	S	0.0%
38		Smart Homes	A	1.6%
39		Post Occupancy Evaluation	S	2.0%

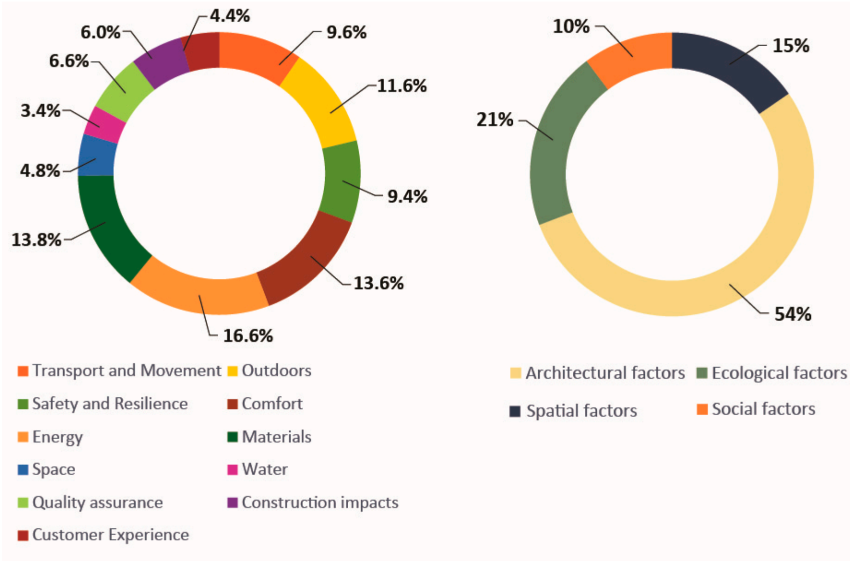


Figure 4. (**a**) % share of categories when evaluating quality. (**b**) System % share by type of factor: spatial (P), architectural (A), ecological (E), and social (S).

The BRE Institute has certified a development of 100 Lancaster Grange homes in Bricket Wood, Hertfordshire (England), with the Home Quality Mark being used for the first time in 2018. By using the system, developer Crest Nicholson is giving homebuyers a guarantee that their new homes are designed and built to high standards. They have a low environmental impact, low running costs, and provide health benefits. The Lancaster Grange development includes communal green spaces, play areas, and cycle and footpaths, with its close location to Radlett town center allowing easy access to schools or workplaces.

3.3. Housing Quality Indicators

Housing Quality Indicators (HQI) is a tool for measuring and evaluating the quality of existing, retrofitted, or designed housing environments. The main objective for the authors from DEGW was the need to create a tool that would have a real impact on the market, and which would improve housing conditions in the U.K. [63,64].

The program was initiated by the Department of Environment, Transport, and the Regions and Housing Corporation, public agencies that have been responsible for funding affordable housing in the U.K. By implementing the HQI system, it was possible to evaluate the quality of housing in relation to the costs it had incurred, already at the design stage. A positive evaluation ensured that public funding achieved the best price-to-value ratio [65]. The assessment instrument was used to evaluate projects that received funding from the National Affordable Housing Program (NAHP) in the years 2008–2011 and from the Affordable Homes Program (AHP) in the years 2011–2015. The first version of the system was developed and published in February 1999 [66]. A major aspect of the HQI tool is its ability to assess a variety of residential projects—both public and private—according to established guidelines. The HQI tool consists of ten indicators, each with a series of questions to be answered. Through them, developers and architects can make well-informed design decisions that result in high-quality housing while respecting the economic balance of the investment [63].

In 1999, the project authors (DEGR specialists) conducted a series of pilot tests to verify the HQI system in practice. For this purpose, they carried out tests on a group of 31 housing developments in the U.K. The groups differed from each other in terms of scale, location, and the number of inhabitants, with the only common point being their contemporary time of construction. The qualified buildings were both new buildings and modernizations of, e.g., city-center townhouses, which were implemented in the last five years. The authors of the research invited various institutions that build social housing, and also developers representing the private sector. The developers were all asked to propose three investments of different scales and quality—one being better and one being slightly worse. This element was difficult for private investors to fulfill, as evidenced by the representation of the private sector of only 30% [67].

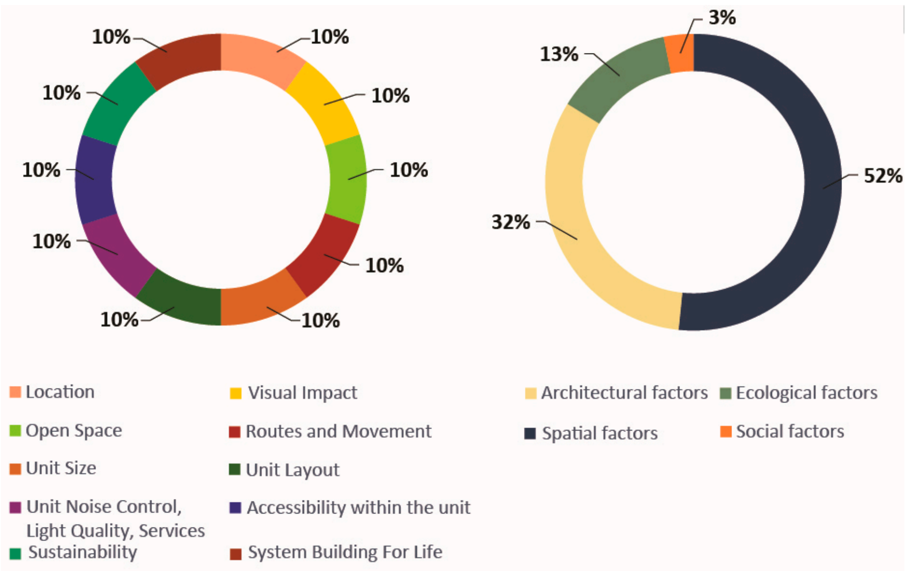
According to the pilot research, the HQI system has been shown to be successful as a tool for measuring the real quality of housing. However, the authors noted the need for further work on the system in order to increase its usefulness in the private sector. The measurements were carried out by both inhabitants and specialists, in turn confirming that the evaluation method is practical and can be used by all interested participants. In the research, the lowest score was obtained by a modernized tenement house in the city center, which was also the oldest building in the represented group. The best result—77%—was obtained by the youngest building, in which a prototype smart home system was introduced. The average final score among the respondents was 55%. This result was very interesting, as it indicated that the good points of the developments were their location and visual aesthetics, while the lowest-rated categories were building accessibility and sustainability [67,68]. The evaluation criteria, with their breakdown into factors, are shown in Table 4, and their analysis is shown in Figure 5.

Table 4. Quality evaluation criteria—Housing Quality Indicators system.

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
1	Location	Amenities—how close are they?	P	80%
2		Liabilities—how close are they?	P	10%
3		Noise sources—how close are they?	P	10%
4	Visual Impact	Visual Impact—overall visual effect and relationship to local character	P	33%
5		Layout—relationship of buildings to each other, open areas and site	P	33%
6		Landscaping—excluding private open space	P	33%
7	Open Space	Site security	P	20%
8		Shared areas in flats	P	10%
9		Children's play	P	20%
10		Private and shared open space	P	16%
11		Characteristics of garden/ private/ shared open space	P	9%
12		Car parking	P	25%
13	Routes and Movement	Routes and movement	P	50%
14		Access to the unit	P	50%
15	Unit Size	Unit type by area	A	75%
16		Units by living spaces	A	25%
17	Unit Layout	Total number of units being assessed and scored	A	50%
18		Additional features	A	50%

Table 4. *Cont.*

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
19	Unit Noise Control, Light Quality, Services	Noise reduction characteristics	A	27%
20		Quality of light, aspects and prospects	A	18%
21		Standard of service provision	S	24%
22		Additional features–services	A	25%
23		Adaptability	A	6%
24	Accessibility within the Unit	Accessibility within the unit	A	100%
25	Sustainability	Code for sustainable homes		
26		Ecohomes	E	100%
27		Rehabilitation		
28	System Building for Life	Character	P	25%
29		Roads, parking, and pedestrianization	P	25%
30		Design and construction	A	25%
31		Environment and community	E	25%



(**a**) (**b**)

Figure 5. (**a**) % share of categories when evaluating quality. (**b**) System % share by type of factor: spatial (P), architectural (A), ecological (E), and social (S).

3.4. Système D'évaluation De Logements (Sel)

Système D'évaluation de Logements (SEL) is one of the oldest tools for measuring and assessing the quality of housing environments. It was developed in 1975 in Switzerland, on the order of the federal government, to analyze the growing state-funded social housing [69,70].

The system has received several updates. The first edition, in 1975, contained 66 criteria for evaluating new developments under the federal housing finance program. Later updates were mainly aimed at adapting the system to today's actualities and trying to make the tool as practical as possible. In 2000, the criteria were reviewed and reduced to 39 indicators [71]. The current version of the SEL system was published in September 2015 by the Federal Housing Office (Office ederal du logement). The number of criteria was reduced to 25 indicators, and grouped into three categories: living place; housing development; and dwellings. The tool was tested for its usefulness in responding to contemporary housing problems such as urban sprawl, energy overconsumption, or population growth in urban agglomerations. The system has also been updated with new criteria to improve the level of participation of future inhabitants and the local community in the design of the housing environment. The system gives more points for the design of land development that improves both the quality of life for inhabitants and the quality of the built environment, which have positive effects on the local community [71].

The SEL system was used to present a building evaluation and comparison in the series "Residential Buildings in Comparison" (Wohnbauten im Vergleich), by Paul Meyer-Meierling. The series, published between 1997 and 2004, consisted of more than 50 publications, with each edition dealing with a different theme, including timber housing [72] or low-energy housing [73]. The publication consisted of a detailed overview of housing developments and a presentation of key data and conclusions. The projects were documented in detail using photographs, plans, descriptions, and costs, and compared using the SEL system. The evaluation criteria, with their breakdown into factors, are shown in Table 5, and their analysis is shown in Figure 6.

Table 5. Quality evaluation criteria—Système D'évaluation De Logements (SEL).

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
1	Place of living	Residential offer	S	4%
2		Supporting services	S	4%
3		Mobility and transport	P	4%
4		Spatial impact	P	4%
5		Open space	P	4%
6		Participation	S	4%
7	Housing estate	Free traffic zone	P	4%
8		Outdoor integration space	P	4%
9		Individual transport	P	4%
10		Entrance area of houses and flats	A	4%
11		Common room	A	4%
12		Community premises	A	4%
13		Laundries and drying rooms	A	4%
14		Additional premises	A	4%
15	Housing unit	Real living area	A	4%
16		Room size and additional space	A	4%
17		Versatile arrangement	A	4%
18		Flexible rooms	A	4%
19		Kitchen and dining room	A	4%
20		Sanitary facilities	A	4%
21		Storage space	A	4%
22		Adaptability of private space	A	4%
23		Private outdoor spaces	A	4%
24		Space between the home and the outdoor area	A	4%
25		Private storage space outside the flat	A	4%

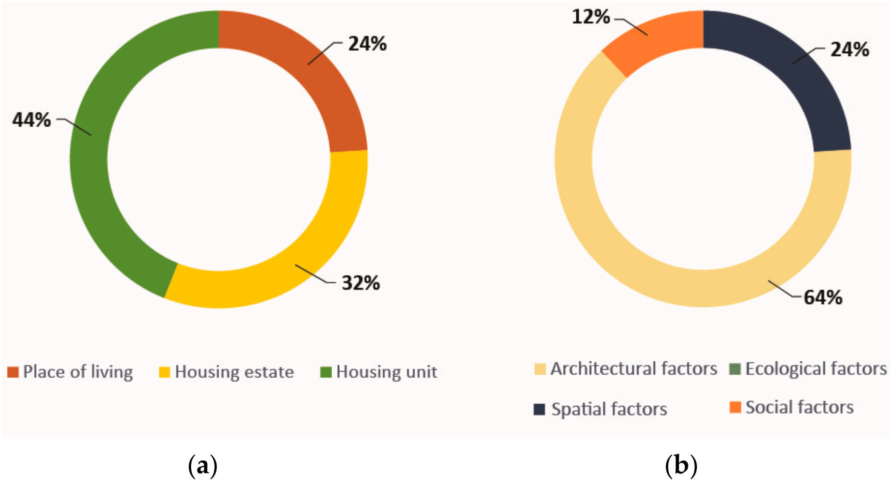


Figure 6. (**a**) % share of categories when evaluating quality. (**b**) System % share by type of factor: spatial (P), architectural (A), ecological (E), and social (S).

3.5. NF Habitat—NF Habitat HQE

NF Habitat-NF Habitat HQE is an independent certification system for evaluating the quality of sustainable housing environments. The system was developed by the French association QUALITEL, which has been researching housing quality for over 46 years [70].

The beginnings of the association's research date to 1974 when a method of measuring the quality of dwellings was created under the name Qualitel. The system was supposed to make an objective evaluation of individual apartments, thanks to which both investors and inhabitants would have complete information about the property. The quality certificate, which is issued by an objective association, was especially useful for people who decided to buy or sell a property. On its basis, it was possible to verify the rental or sale price. In its original version, the Qualitel system operated until 1988. The current version of the system was published in 2015 and is issued by CERQUAL Qualitel Certification, the certification unit of the QUALITEL Association. The unit is only involved in the certification of planned residential buildings. Developers can apply for the "NF Habitat" and its extension to the "NF Habitat HQE" certification, enriched with indicators for sustainable housing. The high level of certification and objectivity of the evaluation is confirmed by the cooperation with the French National Institute of Standardization (Association française de normalisation—AFNOR) [74]. The measurement indicators cover the entire life cycle of a building—through design, construction, use, renovation, and deconstruction. NF Habitat also offers indicators relating to the various contemporary housing challenges (including thermal comfort, acoustic comfort, safety, and ecology). According to the Qualitel association, NF Habitat certification is founded on four basic pillars: (1) quality of life; (2) respect for the environment; and (3) economic result [75]. The evaluation criteria, with their breakdown into factors, are shown in Table 6, and their analysis is shown in Figure 7.

The use of the certification system in France is significant, QUALITEL estimates that the association has issued more than 2.5 million certificates since its creation in 1974. The association responds to the expectations of the inhabitants, in a study carried out in 2015, up to 78% of French people who were surveyed would like to have a single national reference system for housing quality, which would allow and make easier their choice of place for living. Since then, the organization has been developing research towards the creation of a leading building certification system in France, and currently offers ten evaluation systems for multi-family housing, individual housing, or retrofitted residential buildings. In the year 2019 alone, 150,000 housing certificates were released [76].

Table 6. Quality evaluation criteria—NF Habitat-NF Habitat HQE system.

No.	Category	Factor	Type of Factor: Spatial (P), Architectural (A), Ecological (E), Social (S)	% Proportion of Final Score
1	Quality of life	Safety	S	4.5%
2		Indoor air quality	A	4.5%
3		Water quality	A	4.5%
4		Impact of building on climate change	E	4.5%
5		Comfort of living	A	4.5%
6		Building thermal comfort	A	4.5%
7		Acoustics	A	4.5%
8		Natural lighting	A	4.5%
9		Services and transport	P	4.5%
10		Smart building	A	4.5%
11	Respect for the environment	Energy performance	E	4.5%
12		Reduction in water consumption	E	4.5%
13		Land development (site retention)	E	4.5%
14		Building materials	E	4.5%
15		Waste (life cycle and construction waste)	E	4.5%
16		Climate change (minimizing greenhouse gas emissions)	E	4.5%
17		Biodiversity	E	4.5%
18	Economic result	Building renovation costs	S	4.5%
19		Building exploitation costs	S	4.5%
20		General costs	S	4.5%
21		Deconstruction costs	S	4.5%
22		Use of local resources	E	4.5%

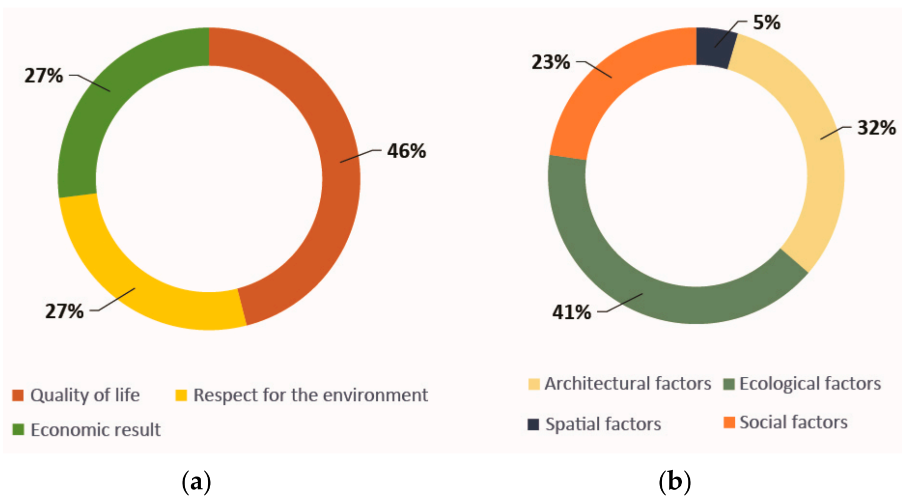
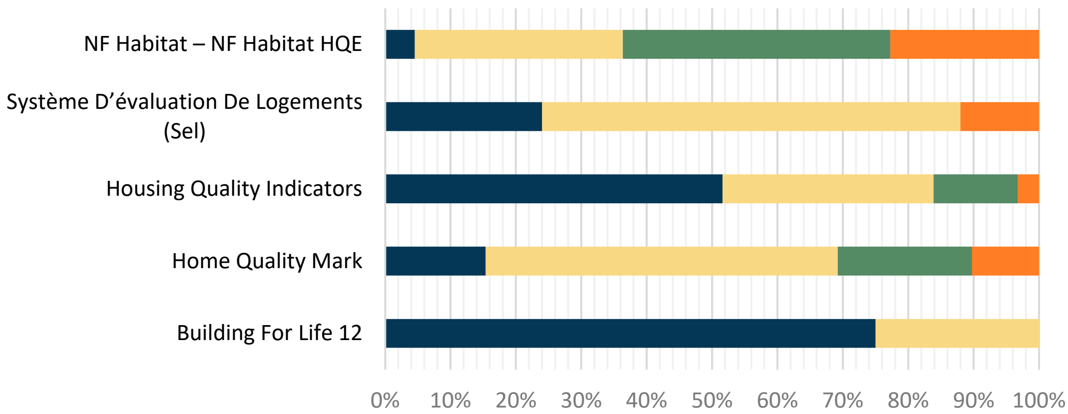


Figure 7. (**a**) % share of categories when evaluating quality evaluation. (**b**) System % share by type of factor: spatial (P), architectural (A), ecological (E), and social (S).

The increased interest in the NF Habitat and NF Habitat HQE systems is evident in the number of issued certificates. It shows that in 2018, there was an increase of 21%, mainly to the expanded application in multifamily housing. This is due to the attention to the topic of improving the quality of housing and its environmental impact by city authorities. The QUALITEL association signs partnership agreements with cities in order to implement their certification system in newly designed residential buildings—both private and social ones. An example of this is the city of Metz in northeastern France, which on 24 January 2019 concluded an agreement committing to NF Habitat HQE certification for all new housing built in Zones D'aménagement Concerté (ZAC) [76].

4. Results

The systems that have been studied for analyzing and evaluating housing environments demonstrate real effectiveness in the designs (or modernizations) of housing projects in which they have been used. However, for the systems to achieve their purpose, it is crucial that the investor and designer work together to receive the best possible result in the evaluation system they have used. All the systems are different, with some focusing more on spatial factors and others expanding more on the architectural factors of the housing environment, as shown in Figure 8. This is due to the different goals that the authors wanted to achieve by introducing the new system. For example, the authors [58] of the BFL 12 system were looking to design user-friendly spaces, whereas the authors of the HQI system wanted to improve living conditions in social buildings.



	Building For Life 12	Home Quality Mark	Housing Quality Indicators	Système D'évaluation De Logements (Sel)	NF Habitat – NF Habitat HQE
Spatial factors	75%	15%	52%	24%	5%
Architectural factors	25%	54%	32%	64%	32%
Ecological factors	0%	21%	13%	0%	41%
Social factors	0%	10%	3%	12%	23%

Figure 8. % share of the factor.

The common point of the analyzed systems is the method of assessment by means of indicators, which contain specific guidelines, catalogues of "good practices" influencing the improvement of living conditions for the inhabitants. Due to this, it is possible to objectively evaluate the housing environment, and also use a comparative method to analyze different housing environments. This method is a very useful tool that allows both monitoring of its effectiveness and the analysis of results. By using appropriately defined indicators, the importance of factors that are currently problematic in housing environments can be highlighted. Measures to prevent the problem during the planning stage can also be included. The final assessment of the housing environment allows for a detailed analysis and comparison with the value applied by the system. Appropriately defined indicators could also play an educational and awareness-raising role for the public, e.g., to raise awareness of the importance of combating climate change. The use of a coherent and objective evaluation instrument would make it possible to compare housing buildings and, in the final analysis, to reward outstanding properties.

A common conclusion that can be made from research about the ways in which systems are used to evaluate the quality of residential environments is that the systems are most effective at the pre-design and design stages. This is due to the ability to apply quality factors in the early stages that later make up the final assessment. All the systems discussed provide a tool in discussions with the developer through which architects can implement good design solutions in housing developments.

Based on the analysis of the assessment systems, 13 main categories of quality factors are presented in Appendix A.

5. Discussion

The quality of housing environments consists of specific factors that can be identified and characterized. The analysis of the research problem and the identification of factors that improve the quality of the housing environment were the main and most difficult tasks of the conducted research. Characterization of these factors fulfils the identified research objectives of systematizing the state of knowledge affecting high-quality housing environments. The path to quality in residential architecture begins with working on a well-designed housing environment—a value that is difficult to evaluate [77–79]. The problem of presenting quality as an "added value" is common to all architectural projects. Owing to contemporary research, it can be stated that good design corresponds with long-term economic benefits [80]. This issue has been studied by a few researchers [81,82] dealing with quality in residential architecture, however, such work is relatively rare. The lack of extensive and systematic research in this specialization may be due to the belief that housing is one of the common investments of lesser importance for society. The analysis in the development of systems for measuring the quality of housing environments (result) has updated existing knowledge on the issue of housing quality.

The quality factors in the analysis (see Appendix A) define the elements which, if considered in the design of today's housing environment, can allow one to realize a high-quality living space. The main categories have been grouped into quality types: spatial [83], architectural [68], environmental [84], and social [85]. With such a wide range of quality types, it is possible to satisfy the highest probability of future inhabitants' needs. Moreover, quality factors can be divided into (i) material and (ii) non-material. Material factors can be measured in an objective way with the use of indicators. In the case of non-material factors, evaluation is subjective and depends on, e.g., the knowledge, experience, views, and preferences of the evaluator. The equal interaction of material and non-material factors can allow for an accurate assessment of the quality of the housing environment [86]. Therefore, the impossibility of objectively assessing non-material factors, which mainly affects the final assessment of the housing project, determines the difficulty of the assessment. A qualitative factor that cannot be translated into concrete values is, in the opinion of some stakeholders, an unreliable factor. This also coincides with the common opinion that good design is an "additional" value to investment. This opinion has been debunked by recent research, in which high-quality architecture brings a range of social, economic, and cultural benefits [87,88].

The analysis of systems for measuring the quality of housing environments shows that evaluation systems should strive for the synergy (interaction) of spatial, architectural, environmental, and social factors [89]. This is due to the fact that only by such a multisystem action is it possible to provide a completely high-quality living environment. Measuring only selected material factors, in the worst case, can result in the implementation of an investment, in which pressure related to costs and reduced construction time leads to a loss of functionality and an unattractive building [90]. It is therefore important that quality evaluation tools focus on a synergy of factors, without prioritizing the material factors over the non-material ones. Only with such an approach are we able to not lose the value of the project, which is something that should be emphasized by the evaluation system. An example of the complexity of using the measurement of some physical parameters of a building [91] is, e.g., the level of light intensity in a room. This can be measured using an illuminance meter, with a precise lux value being obtained. However, the inhabitant's perception may be more perceptual or subjective, and may not confirm that the room has the right level of light.

The application of a building certification system at the design stage allows a high-quality building to be designed. The implementation of a building that meets the necessary functional, technical, and social quality standards is especially important for residential buildings. At the design stage, designers using the assessment system can make fundamental decisions that will be accepted by the investor in the development project. Implementing solutions such as sustainability at this stage allows them to be economically implemented, unlike in the case of retrofitting an existing building stock, where the work and financial effort is much higher and more difficult to implement. Therefore, the authors of all certification schemes explain that it is crucial to apply the systems' solutions at the conceptual design stage.

In the search for elements that influence the quality of housing environments [92], researchers indicate that the most important evaluation indicators should be the needs of inhabitants and the measurement in the building after their occupation [93]. In housing, it is difficult—if not impossible—to know the opinions of future inhabitants. Apart from a few cases where designers have known the requirements of future occupants, some assessment systems also implement workshops with representatives of local organizations or the neighborhood community [94]. In this way, it is possible to get to know different perspectives and opinions on investments. Such pre-design workshops, carried out to understand the needs of all parties in the construction process, aim to identify common goals and priorities. This method is often decisive, since it is the user's input that is innovative and contributes to the quality of the designed building. The lack of research in residential architecture, conducted after occupants have moved into the building, is limiting the designers' knowledge of how to implement potential improvements to housing designs, as well as how to adapt these improvements to the needs of people in today's time [95].

Improperly designed housing environments [96] impose increased (hidden) costs on municipalities, which ultimately cover these expenses through taxes. The main reason why hidden costs are not considered is that they are not incurred by decision makers, but instead by society as a general community [97]. An incorrect project location, a lack of infrastructure, and a lack of jobs are examples of the increased "hidden" costs that will be imposed on future occupants, neighbors, and society. In economic science, this type of hidden cost is called a negative externality—it happens when someone, through their actions, does something that generates costs for others [88]. Examples of such negative external effects could be environmental pollution, noise, or overcrowding. Every new development involves certain costs which can certainly be counted as negative effects, e.g., consumption of natural resources, space, or green areas. However, the new development can generate compensation in terms of value and utility that will benefit the local community, as well as future inhabitants [98,99]. The issue of negative externalities is extremely important when trying to explain why the cost of a bad project is not always considered during the planning of a development. By transferring such costs to others, the initiators of these costs often insulate themselves from the negative consequences that are ultimately paid by the public.

Multi-criteria evaluation systems are becoming increasingly popular in developed countries, and are especially used in office [100], administration [101], and retail buildings [102], as well as in housing projects [19,53,75]. Clearly, this is a result of the implementation of sustainability policies in international corporations, and also the need to reduce expenditure. Rating systems such as BREEAM and LEED can reduce the environmental impact of a designed building by scoring quality measures [90], e.g., to reduce the use of fossil fuel resources, reducing carbon emissions and already visible climate change. Another argument to support green certification of buildings is the need to reduce expenditure in the energy sector [103]. The unstable situation on the energy market, rising energy prices, and difficulties in providing adequate amounts of fuel will mean that the solutions included in the certification systems will grow in popularity. An element that should also be pointed out in favor of using certification systems is the quality of a building's construction, which reduces the costs of its maintenance and servicing [104,105].

Concluding the undertaken research and its results described in the Discussion Section 5, it can be stated the issue of the quality of living environments and multi-criteria assessment systems is a difficult subject to characterize. The characteristics presented (Appendix A) fill a gap in scientific publications on this research issue. The 13 universal categories of quality factors can be used more widely by city planners and authorities as the basis for updating urban policies. Suggestions for the use of the publication for future research work should refer to the identification of a hierarchy of quality factors for housing environments. The identification of this hierarchy appears to be an important and difficult task that is faced by all the authors of the building certification and the discussed assessment systems.

6. Conclusions

In the presented review publication concerning multicriteria analysis for the assessment of energy-efficient residential environments, five systems were discussed in detail: (1) Building For Life 12, (2) Home Quality Mark, (3) Housing Quality Indicators, (4) Système D'évaluation De Logements (Sel), and (5) NF Habitat-NF Habitat HQE. The research aimed to show how assessment systems can improve the energy efficiency of residential buildings. The analysis of the research problem and the identification of factors that influence the improvement of residential environments was the most important and most difficult task of the investigation. By characterizing the factors, the research objective was completed, and 13 main categories of quality factors were identified. The preparation of universal categories of quality factors will allow these aspects to be used in the implementation stage of housing environments. Considering these factors is an important element in the development of housing projects when taking into account the needs of residents, the environment, and the developer.

In the literature analysis, five contemporary assessment systems for housing environments were analyzed. The analysis of these assessment systems was related to the research thesis, as these tools easily identify selected qualitative factors of housing environments and allow for their evaluation. The results of the analysis of the systems showed that:

1. Factors can be identified.
2. An objective system can be prepared.
3. Such systems can be used in practice, e.g., in the design industry, real estate, and public administration.

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Appendix A

Table A1. Summary of systems for evaluating housing environments.

Category	Factor	Rating System 1	2	3	4	5
1. Space	Access for residents to services and facilities located close to the dwelling	x		x		x
	Clear separation of public and private space with access to the area for neighborhood contacts	x	x	x	x	
2. Mobility and transport	Access to public transport	x	x	x	x	
	Access to sustainable mobility facilities such as city bikes, scooters, or a local car sharing system		x			
3. Economical availability	Full information about housing costs, including, e.g., the maintenance and exploitation of the building					x
4. Ecology and sustainability	Improving the energy efficiency of the building					x
	Biodiversity					x
	Identification of environmental risks and opportunities		x			
	Ecological changes and improvements		x			
5. Water	Reduction of water use during construction of the building and during future use		x			x
	Reduction in water consumption		x			
	Ensuring good quality water					x
	Management of rainwater and land retention		x			x
6. Building materials	The use of quality building materials		x			
7. Waste management	On-site waste management		x			
	Waste recycling (throughout the life cycle of the building)					x
	Designing appropriate outdoor spaces for waste storage	x				
8. Climate change	Minimizing greenhouse gas emissions					x
9. Safety	Designing safe housing environments, both the dwellings themselves and the developed area		x	x		x
10. Comfort and functionality of the dwelling	Indoor air quality					x
	Thermal comfort in the building		x			x
	Acoustics		x			x
	Natural lighting		x	x		x
	Smart building design		x			x
	Ventilation		x			
	Indoor pollutants		x			
	Noise pollution		x	x		
	Living space per inhabitant			x		
	Additional spaces/functions in the dwelling			x		
	Appropriate living area, rooms, and additional space depending on the function				x	
	Flexible living space design				x	
	Kitchen and dining room				x	
	Sanitary facilities			x	x	
	Storage space in the home and outside				x	
	A well-designed space between the living area and the outdoor area				x	

Table A1. *Cont.*

Category	Factor	Rating System				
		1	2	3	4	5
11. Building and facilities	Open and accessible places		x			
	Outdoor recreational space		x			
	Shared spaces for inhabitants			x		
	Integrating the building in the neighborhood	x				
	External storage space and facilities	x			x	
	External integration space				x	
	Entrance area of buildings and housing units				x	
	Community spaces				x	
	Laundry and drying rooms		x		x	
	Extra rooms				x	
12. Community	Participation of future inhabitants or the local community in the design of buildings				x	
	Guarantee for the proper use of the home, including: inspections, launching and testing of appliances, and installations		x			
	Complete package of information about the property, which is necessary to make a decision before buying or renting		x			
13. Energy factors	Analysis of the energy source and energy costs needed to construct the building and to exploit it		x			

Legend of evaluation systems: 1—Building For Life 12; 2—Home Quality Mark; 3—Housing Quality Indicators; 4—Système D'évaluation De Logements (Sel); and 5—NF Habitat–NF Habitat Hqe.

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