EVALUATION CRITERIA OF SUSTAINABLE SOLUTIONS IN BUILDINGS BASED ON THE THREE PILLARS OF SUSTAINABILITY

Kateřina Eklová*[1], Josef Kupec[1], Renáta Schneiderová Heralová[1], Petr Dlask[1], Zita Prostějovská[1]

[1]Czech Technical University in Prague, Faculty of Civil Engineering, Praque, Czech Republic, katerina.eklova@fsv.cvut.cz

Abstract

Sustainability of buildings is a complex term which incorporates many individual factors, solutions, and technologies that are implemented in the building. This paper provides mapping research and investigates the evaluation criteria of individual sustainable solutions and technologies. A list of criteria was selected representing each of the three pillars of sustainability: environmental, economic, and social. The importance of the criteria was then evaluated by a panel of real estate experts from the Czech Republic: project managers, sustainability managers, property managers. The analysis determines the most important evaluation criteria for the selection of a sustainable solution which brings the biggest perceived benefit to the investor and owner of the building. In addition, the analysis shows how the experts perceive importance of each of the three pillars of sustainability.

Keywords

Buildings; economic sustainability; environmental sustainability; evaluation criteria; social sustainability

JEL Classification

Q56 Sustainability
D83 Search

DOI: https://doi.org/10.14311/bit.2021.02.01

Editorial information: journal Business & IT, ISSN 2570-7434, CreativeCommons license published by CTU in Prague, 2021, http://bit.fsv.cvut.cz/

Introduction

Sustainability of buildings is a complex term which incorporates many individual factors, solutions, and technologies that are implemented in the building. However, the word “sustainability” does not have a definition which would be universally understood, and each expert imagines a different concept. [1] The same applies to a “sustainable building” or a “sustainable solution”, as there is no generally accepted definition.

There are many different Green Building Rating Systems (GBRS) which assess the sustainability of buildings. [2] All of them include many different criteria of sustainability from all areas of sustainability: environmental, economic, and social. These areas are often referred to as the three pillars of sustainability. [1] These GBRS assess the whole building but the building itself consists of hundreds of different technical and architectural solutions. Therefore, it is also necessary to look at the individual solutions and to measure their individual impact on the building’s sustainability.

The aim of this paper is to provide mapping research among which evaluates criteria of individual sustainable solutions and technologies. The qualitative analysis among real estate experts determines the most important evaluation criteria for the selection of a sustainable solution which brings the biggest perceived benefit to the investor and owner of the building. In addition, the analysis shows how the experts perceive importance of each of the three pillars of sustainability.

Methodology

First, a list of criteria was selected representing each of the three pillars of sustainability: environmental, economic, and social. The criteria were selected based on a scientific article [3] which collected criteria from many relevant sources such as Sustainable Development Goals by United Nations [4], Level(s) by EU [5], Green Building Rating Systems: LEED [6], BREEAM [7], DGNB [8], SbToolCZ [9], WELL [10], and other sources. The example of criteria from the GBRS system is illustrated in Figure 1.

Management	Health and wellbeing	Water	Materials
— Project brief and design — Life cycle cost and service life planning — Responsible construction practices — Commissioning and handover — Aftercare	— Visual comfort — Indoor air quality — Safe containment in laboratories — Thermal comfort — Acoustic performance — Accessibility — Hazards — Private space — Water quality	— Water consumption — Water monitoring — Water leak detection — Water efficient equipment	— Life cycle impacts — Hard landscaping and boundary protection — Responsible sourcing of materials — Insulation — Designing for durability and resilience — Material efficiency
Energy	**Transport**	**Waste**	**Land use and ecology**
— Reduction of energy use and carbon emissions — Energy monitoring — External lighting — Low carbon design — Energy efficient cold storage — Energy efficient transport systems — Energy efficient laboratory systems — Energy efficient equipment — Drying space	— Public transport accessibility — Proximity to amenities — Alternative modes of transport — Maximum car parking capacity — Travel plan	— Construction waste management — Recycled aggregates — Operational waste — Speculative floor and ceiling finishes — Adaptation to climate change — Functional adaptability	— Site selection — Ecological value of site and protection of ecological features — Minimising impact on existing site ecology — Enhancing site ecology — Long term impact on biodiversity
		Pollution	**Innovation**
		— Impact of refrigerants — NO_x emissions — Surface water run-off — Reduction of night time light pollution — Reduction of noise pollution	— Innovation

Figure 1: example of sustainability criteria for buildings in GBRS - BREEAM New Construction 2016 (source: breeam.com)

In the list of criteria for this survey there were selected 25 criteria in total: 10 environmental criteria, 10 economic criteria, and 5 social criteria.

The importance of the criteria was then evaluated by a panel of real estate experts from the Czech Republic: project managers, sustainability managers, property and facility managers, and other professionals in real estate who make decisions about the selection of sustainable solutions which will be implemented in the building. The qualitative survey was distributed electronically. There were 24 respondents from 7 different real estate development companies based in the Czech Republic.

The structure of the questions was based scientific articles which investigated relation of the respondents to sustainability. [11] [12]

In the beginning of the survey, the experts answered an open question “What do you consider a sustainable solution in a building?”, to ensure that the answers are comparable. The second open question was “Which are the criteria you use to decide which sustainable solution to implement?”, to find out the most important criteria which are spontaneously named by the experts. This question also gave the expert an option to name a criterion which might not be included in the survey. Only after they answered the open questions of the survey, the respondents could see the next part.

In the second part of the survey, there was a list of the 25 criteria. Each criterion had to be evaluated on a scale from 0 to 5 points, with 5 points being the most important. The order of the criteria changed randomly for each respondent to avoid bias. It was also not clear to the respondents to which pillar the criteria belonged to. Therefore, it is possible to evaluate the importance of each of the pillars for the real estate experts.

The survey also included a set of demographic questions (gender, age) and the questions about the specific field of real estate (family housing, multifamily housing, office, retail, industrial) and their position.

The responses from the survey were then analyzed and the most important criteria were selected.

Results

Respondents

There were 24 respondents who answered the survey. All of them work in the Czech Republic in real estate development companies. Employees of 7 different real estate companies participated in the survey. There were professionals with different positions in the company: 11 project managers, 4 property managers, 4 senior managers, 3 sustainability managers, 1 leasing manager, and 1 cost manager. Their field of real estate development was mainly residential development of multifamily housing (18 respondents) and office development (11 respondents). There were also developers of single-family housing (4 respondents), public buildings (2 respondents), and retail commercial centers (1 respondent). The participants could select more fields of real estate development in this question.

18 respondents were male, 5 respondents were female, and 1 respondent did not indicate gender. The average age of the respondents was 38 years, with 24 being the youngest participant and 57 being the oldest participant.

Sustainable solutions

All the respondents claim that they implement sustainable solutions in their buildings.

The experts answered an open question “What do you consider a sustainable solution in a building?” and the topics in Table 1 were spontaneously named the most often (5 or more mentions). It is notable that the energy savings is by far the most mentioned concept. Water savings are also important for some of the experts. On the other hand, carbon savings were only mentioned 4 times, so it is not a topic that comes to the mind of most experts spontaneously.

There are a few technologies which are associated the most as sustainable solutions: rainwater retention and use, grey water use, heat recovery from air, photovoltaic panels, and green roofs. Economic efficiency was only mentioned twice, and social factors such as community or building users were mentioned 3 times. This shows that most of the experts associate the phrase “sustainable solutions” with environmental aspects only.

Table 1: Solutions which are considered a sustainable solution by the respondents (source: authors)

Solutions	Number of mentions	% of respondents
Energy savings	14	58%
Sustainable materials	8	33%
Rainwater retention and use	8	33%
Renewable resources	7	29%
Grey water use	6	25%
Heat recovery from air	6	25%
Photovoltaic panels	6	25%
Water savings	5	21%
Green roofs	5	21%

Criteria – open question

In the survey there was a following open question "Which are the criteria you use to decide which sustainable solution to implement?". The criteria In Table 2 were spontaneously named the most often (5 or more mentions).

Table 2: Criteria for evaluation of sustainable solutions which are considered the most important by the respondents (source: authors)

Criteria	Number of mentions	% of respondents
Investment cost	13	54%
Payback period of the solution	6	25%
Added value for clients	5	21%

The investment cost of the solution is by far the most important decision factor for most of the experts. Some of the experts also consider the payback period during the solution life cycle, however, the investment cost is a more important criterion as a spontaneous answer. The experts also mentioned one social criterion: the orientation towards their clients and the benefits it might bring to them. However, environmental criteria were not mentioned at all. This would suggest that the experts evaluate the sustainable solutions primarily based on economic and social criteria.

Criteria - evaluation

After answering the open questions, the respondents were asked to evaluate a predefined list of sustainability criteria based on their perceived importance. Table 3 shows the list of criteria that was presented to the participants: there were 10 environmental, 10 economic, and 5 social criteria. The respondents ranked them on a scale from 0 (not important at all) to 5 (the most important). In Table 3 the criteria are ordered from the highest average score.

In the survey it was also not clear to the respondents that the criteria belong to three different pillars. Therefore, it is possible to evaluate the importance of each of the pillars for the real estate experts. Taking into account the results of the open question about criteria, it was expected that the economic and social pillars would be more important to the experts than the environmental ones. However, the survey showed a balanced result for all the three pillars. Out of the 10 most important criteria there are 3 environmental, 3 social, and 4 economic criteria.

There are 10 criteria with a rating 4,0 and higher up to 4,4. The results of the second part confirmed that the experts are concerned the most about the energy efficiency of their buildings as the results of

the open questions in the first part suggested. Other environmental criteria are water savings which were also mentioned in the open questions and more greenery.

The social criteria related to the users such as their comfort and well-being, the improvement of indoor environmental quality, and better functioning of the building are also perceived as very important by the experts.

There are several economic criteria which are perceived as very similar in importance: life cycle cost of the solution, investment cost, and payback period of the solution. It is notable that the investment cost, and life cycle cost and payback period are rated the same. However, in the first part of the survey 54% experts mentioned investment costs, but only 25% of the experts mentioned the payback period which is connected to life cycle costing. The experts perceived the life cycle cost and payback period as of the same importance, therefore there might be only one of these criteria as they express a very similar concept. Other important economic criteria are effective use of the building capacities and benefit for business success of the project.

Table 3: Criteria for evaluation of sustainable solutions rated by the respondents from 0 to 5 as the most important, order from the highest average rating (source: authors)

Criteria	Pillar	Average rating
Reduction of energy consumption	environmental	4,4
Improvement of comfort and well-being of users	social	4,2
Improvement of indoor environmental quality	social	4,2
Life cycle cost of the solution	economic	4,1
Reduction of water consumption	environmental	4,1
More greenery	environmental	4,1
Better functioning of the building for users	social	4,0
Investment costs of the solution	economic	4,0
More effective use of capacities of the building	economic	4,0
Benefit for business success of the project	economic	4,0
Payback period of the solution	economic	3,9
Higher safety of the users	social	3,8
Waste reduction	environmental	3,7
Marketing benefit for the company brand	economic	3,7
Better monitoring of building operations	economic	3,6
Carbon footprint reduction	environmental	3,6
Possibility for users to behave ecologically	environmental	3,6
Pollution prevention	environmental	3,5
Sustainable transport to the building	environmental	3,4
Better aesthetics of the building	social	3,3
Benefit for certifications (such as LEED, BREEAM, etc.)	economic	3,3
Biodiversity support	environmental	3,3
Use of recycled and recyclable materials	environmental	3,2
Benefit for evaluation according to EU Green Deal, EU Taxonomy etc.	economic	2,5
Better conditions of bank financing	economic	2,1

The graph in Figure 2 shows the distribution of rankings for each criterion. It is clear that for most of the top 10 criteria there is a consensus among the experts represented by the blue color (ratings 5 and 4). The neutral ratings of 2 and 3 are marked in gray. The red color (rating 1 or 0) suggests a different opinion on the importance of the criteria among the experts.

There are some polarizing criteria which are very important for some of the experts, but marginal to others. This results in a lower average score: higher safety of the users, waste reduction, pollution prevention, benefit for certifications, biodiversity support, use of recycled and recyclable materials, benefit for evaluation according to EU regulations, and better condition for bank financing. The reasons behind the low scores from some of the developers was not explained by the respondents and it might be examined in following research.

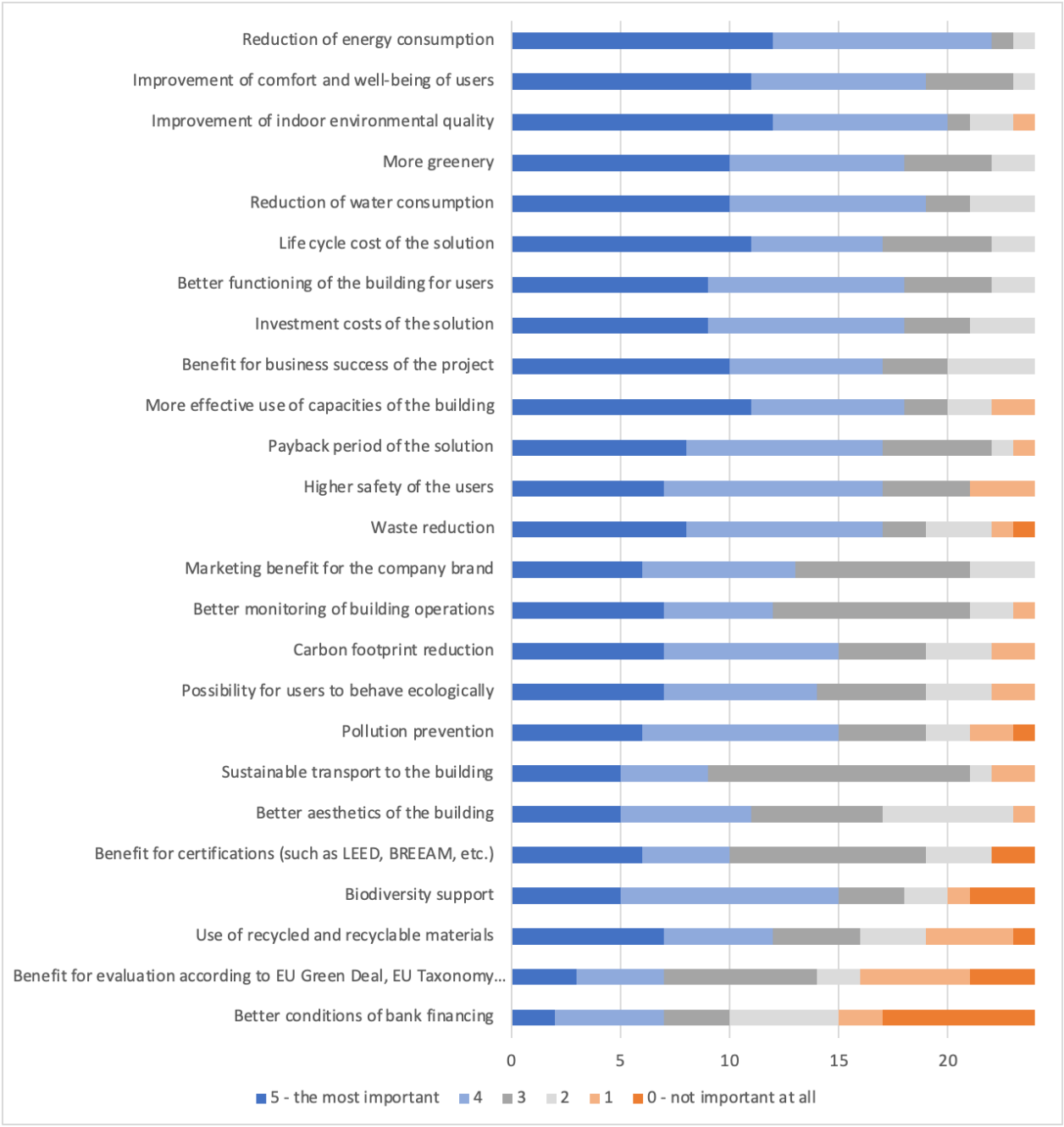

Figure 2: Distribution of ratings by the experts for each criterion (source: authors)

Conclusion and discussion

Conclusion

The results of the survey showed that criteria from all the three pillars of sustainability are important to the experts in real estate when evaluating sustainable solutions.

The most important environmental criteria are reduction of energy consumption, reduction of water consumption, and more greenery. The top social criteria are improvement of comfort and well-being of users, improvement of indoor environmental quality, and better functioning of the building for users. The top economic criteria are investment cost, life cycle cost, payback period, effective use of the building capacities and benefit for business success of the project.

Discussion

There were a few findings that were unexpected, and the reasons behind them should be investigated more.

There was a general agreement among the experts about the importance of energy savings. The reasons behind might be the current energy crisis, or stricter legislation in the field of energy efficiency of the buildings.

54% of the experts mentioned the investment cost spontaneously, but only 25% mentioned payback period, and none of them mentioned lifecycle cost. This might mean that they are interested more in the initial costs in the construction phase, but the operational costs are less important to them because they will have sold the building to another owner by then. Therefore, they cannot directly benefit from the cost savings. However, when they evaluated each listed criterion in the second part, the rating was the same for all the three criteria of investment cost, payback period, and lifecycle cost. This difference should be investigated more.

The lowest rated criterion was the one of bank financing. Some possible reasons behind it are that most of the real estate companies have enough internal financial sources, or the banks do not take into account sustainability, or that the respondents were not the employees securing financing.

All these findings can be investigated in following research.

Following research

The top criteria can be used in following research which can create a decision-making model to help the experts to assess the value-benefit of the sustainable solutions. A methodology that calculates the overall sustainability of a solution should be established.

The reasons behind the results which were mentioned in the discussion can be researched deeper in qualitative interviews.

The list of the sustainability criteria included in the survey cannot be exhaustive, and there can always be another criterion. This was partially addressed by including open questions from which a new criterion arose: compliance with local legislation, which will be added to future research. The size of the panel was limited, and in further research the survey should be distributed to a wider audience to have the parameters of a quantitative research. The audience can also be expanded to other profession such as architects, and engineers. And it would be beneficial to widen the audience also to international experts to understand different priorities in the field of sustainability among different countries.

Acknowledgement details

This work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS21/011/OHK1/1T/11.

References

[1] PURVIS, B., MAO, Y., ROBINSON, D. Three pillars of sustainability: in search of conceptual origins. Sustain Sci 14, 2019, 681–695. https://doi.org/10.1007/s11625-018-0627-5

[2] SÁNCHEZ CORDERO, A., GÓMEZ MELGAR, S., ANDÚJAR, M. Green Building Rating Systems and the New Framework Level(s): A Critical Review of Sustainability Certification within Europe, Energies 2020, 13, 66.

[3] EKLOVA, K. Sustainability of buildings: environmental, economic and social pillars. Business & IT, Vol. X(2), 2020, pp. 2-11 DOI: https://doi.org/10.14311/bit.2020.03.01.

[4] UNITED NATIONS. Sustainable Development Goals, Res 71/313. Available online at: https://undocs.org/A/RES/71/313 (accessed 20 Dec 2021)

[5] DODD, N., Level(s) – A common EU framework of core sustainability indicators for office and residential buildings Available online at: https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/contentype/product_group_documents/1581681499/170816_Levels_EU_framework_of_building_indicators_Parts.pdf (accessed 20 Dec 2021)

[6] LEED. Available online at: https://www.usgbc.org/leed/v41 (accessed 20 Dec 2021)

[7] BREEAM. Available online at: https://www.breeam.com/BREEAMInt2016SchemeDocument/#resources/output/10_pdf/a4_pdf/nc_pdf_printing/sd233_nc_int_2016_print.pdf (accessed 20 Dec 2021)

[8] DGNB. Available online at: https://www.dgnb-system.de/en/buildings/new-construction/criteria/ (accessed 20 Dec 2021)

[9] VONKA, M. SBToolCZ Metodika. Available online at: https://www.sbtool.cz/ometodice/ (accessed 20 Dec 2021)

[10] WELL. Available online at: https://v2.wellcertified.com/v/en/concepts (accessed 20 Dec 2021)

[11] ELMUALIM, A., SHOCKLEY, D., VALLE, R., LUDLOW, G., SHAH, S. Barriers and commitment of facilities management profession to the sustainability agenda. Building and Environment, 45 (1), pp. 58-64, 2010. DOI: 10.1016/j.buildenv.2009.05.002

[12] WRIGHT, T.S.A., WILTON, H. Facilities management directors' conceptualizations of sustainability in higher education. *Journal of Cleaner Production*, 31, pp. 118-125, 2012. DOI: 10.1016/j.jclepro.2012.02.030