Development of sustainable building standards: Next steps towards climate-friendly buildings in the City of Graz

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Abstract. To make efforts for climate protection in the City of Graz (Austria) as effective as possible, the city has established a climate protection fund, from which the KNB (Klimafreundliche und Nachhaltige Baustandards) project emerged. In the KNB project, a new approach was developed on how the city can already request and implement sustainability criteria for its public buildings in architectural competitions. This paper presents the methodology for evaluating the climate friendliness of building concepts based on the developed form "sustainability and climate protection". Moreover, an evaluation algorithm for assessing the competition works and ranking the building concepts is presented. To demonstrate the applicability and validate the form and the evaluation algorithm, we applied the procedure to a real architectural competition. The results show that all participants were able to consider the required aspects and that the external experts for sustainability assessment were able to evaluate the competition works using the developed evaluation algorithm. The City of Graz set the goal to apply this methodology in all further architectural competition and thereby take a further step towards sustainable procurement of buildings.

Keywords: building/constructed asset, sustainability assessment, case study, architectural competition, buildings standards, sustainable construction

1. Introduction

Cities and communities play a key role in global sustainable development [1]. Currently, about 55% of the world's population lives in cities. As a result of ongoing urbanization, this is expected to increase to 70% by 2050. This subsequently means that about 60% of the necessary housing and settlements have to be built first [2]. The observable trends in the settlement development of Graz (Austria) correspond to those of many European medium-sized cities. The historically developed core city model is based on a centralization of most utilities and a general separation of functions, i.e., working, living and leisure [3]. The predicted population in the City of Graz will also increase by approximately 20% until the year 2040. In this context, Graz has resembled a giant construction site in recent years, at least in certain parts of the city. Each day, about 10m² of surfaces are paved every hour [4].

As a result of these increased construction activities, more greenhouse gas (GHG) emissions will also be emitted in the coming years. Looking at the construction industry in Europe, this sector accounts for about 39% of energy consumption and about 36% of GHG emissions, making it the single largest contributor to energy use and GHG emissions [5]. A further increase in GHG emissions massively
endangers compliance with the necessary climate target paths as well as the fulfilment of the Agenda 2030 goals [6,7].

The consequence of climate change is a global warming of the earth's atmosphere. Since 2001, an increase in average air temperature of 1.4°C has been measured in Graz. Extreme weather events such as heavy rain or dry periods occur more frequently and are more intense. To combat these developments and to make the efforts for climate protection in Graz as effective as possible, the city has launched the "Graz Declaration on Climate Protection" [8].

Due to the commitments within the declaration, there is a need for continued developments and improvements that will contribute to the reduction of GHG emission in the construction sector. Specific principles, including practical measures, e.g., implementing life cycle assessment (LCA) in the procurement process of public buildings, must be established for a transition of the construction industry to a net-zero carbon built environment [9,10]. In this context, governments and the public sector play a crucial role in setting and enforcing long-term principles, values and priorities by providing guidance and additional incentives.

In the construction of buildings, the scope for action and the possible sphere of influence on energy efficiency, sustainability and climate protection as well as on life cycle cost are highest in the project development and competition phase. Many of the decisions made during the competition and early design phase set the building performance for the later building [11].

One of the earliest project phases within the procurement process of buildings is the architectural competition. Architectural competitions in Austria are conducted as open, restricted or invited competitions and are subject to the requirements of the Federal Public Procurement Act, the Competition Regulations for Architecture (WOA 2010) and the Performance Specification for Architectural Competitions (WSA 2010) [12–14]. The WSA 2010 is not legally binding for clients but is used voluntarily as a basis for many architectural competitions. In such cases, the WSA 2010 is binding for both the client and the participants. In public sector building projects, competitions are an indispensable instrument for ensuring quality and transparency in planning and constructing. Architectural competitions are thus award procedures that serve to provide the client with a first draft of a plan in the fields of spatial planning, urban planning, architecture, construction and engineering [15]. An architectural competition is useful because it offers a large number of comparable solutions at a reasonable cost, among which the most suitable project can be identified in a fair and transparent manner. As a quality-oriented, project-based procedure, an architectural competition is more effective and transparent than any other procedure under consideration for architectural services [16].

In current architectural competitions, however, specific sustainability requirements, e.g., information on embodied and operational GHG emissions, are not sufficiently requested. The goal of the City of Graz has thus been to develop the form so that it will address sustainability and climate protection in a manner that can be applied in future architectural competitions.

2. Materials and methods

2.1. Case study

The following described case study represents an architectural competition where the developed assessment methodology has been applied on a pilot basis. Due to the confidentiality obligation, detailed project information cannot be disclosed. The project to be designed in the competition is located on an approx. 6,000m² property in the City of Graz, which was tendered by the public sector (City of Graz – Building Construction Department). The architectural competition was conducted as an invited competition. The invited architectural competition is an exceptional procedure for smaller projects. The awarding authority invites a limited number of participants to submit a competition entry [16]. In the course of the competition, six participants submitted a competition work, which was finally evaluated and ranked by the competition jury. A special feature of the competition was that there were specific requirements on the topic of sustainability and climate protection using the new developed “sustainability and climate protection” form. After the submission of the competition works, they were
evaluated by the individual external experts. In addition to the experts for sustainability assessment, experts for energy and cost were also separately involved in the evaluation of the competition works. After evaluating the criteria of the individual competition works required in the form, three project clusters were defined by applying the evaluation algorithm (detailed description see section 2.3). After the competition works were classified into these clusters, the ranking was passed on to the competition jury to be considered in determining the winner of the architectural competition.

2.2. Development of the "sustainability and climate protection" form.

To comply with the principles of a fair and equitable competition, a special form was developed in advance. The form served to ensure the comparability of the competition works with regard to the required sustainability and climate protection measures. Overall, the form consists of two main parts (i) construction and (ii) climate protection. Part I asked for specific measures to optimize the OI3 eco-index and the EI index for strategically important components of the building [17,18].

The OI3 eco-index evaluates the environmental quality of materials based on the environmental indicators of global warming potential (GWP), acidification potential (AP) and the demand for non-renewable primary energy (PENRN). The OI3 eco-index can be calculated for building materials and entire buildings. As a single number, the indicator makes a quantitative statement for global warming, environmental acidification and consumption of non-renewable energy resources potentials. The disposal indicator (germ. EI index) is used to the uniform assessment of the disposal properties of constructions and materials at building level. In a semi-quantitative procedure, the current disposal route of a building component or the recycling potential that would be possible from an economic and technical perspective if the framework conditions were improved by the assumed disposal date of the building product is evaluated. The higher the effort for deconstruction and recycling and the more negative the impact of disposal on the environment, the worse the classification at the building material level.

Specific information in the form of a textual description had to be provided by the participants for following building components:

- roof
- exterior walls
- load-bearing interior walls
- insulation material
- facade
- windows
- doors
- non-load-bearing interior walls
- ceiling
- floor construction
- floor covering.

In addition, a strategic weighting factor (from 1 less important to 3 very important) was assigned to the distinct components, which was then used in the internal evaluation by the external sustainability assessment experts.

The second part of the form requested textual descriptions of the measures contributing to the following criteria:

- Measures for the reduction of embodied GHG emissions.
- Measures for the reduction of operational GHG emissions.
- Measures for the planned photovoltaic concept.
- Measures in the context of the micro and city climate.
• Measures for rainwater management
• Measures in sustainability terms for the heating and cooling context
• Measures in sustainability terms for the extreme weather events context
• Measures in sustainability terms for the microclimate context until 2050.

Figure 1 illustrates the individual process steps of the architectural competition as a flow chart. Furthermore, the implementation of the form within this standardised process, the internal evaluation and the inclusion in the jury competition are shown.

![Flowchart](image)

**Figure 1.** Flowchart for the implementation of the "sustainability and climate protection" form for architectural competitions.

2.3. **Development of the evaluation algorithm**
In order to evaluate and compare the competition works after submission, a special evaluation algorithm was developed. The special feature of the evaluation algorithm is that it calculates clusters based on the evaluation of the external sustainability assessment experts, into which the submitted projects are classified. At the start of the evaluation algorithm, the sustainability assessment experts evaluated the participant's information stated in the form on a scale of 1 to 3. 1 in this regard indicates that the stated
measures largely contribute to the respective criterion, 2 indicates that the measures partially contribute to the criterion and 3 that the measures do not contribute to the respective criterion. In addition, a score of n was assigned if the described measures could not be evaluated in the course of the formal review process (due to unclear or missing information). This results in the aggregated evaluation scores for each criterion. The evaluation algorithm consists of four steps. At the beginning, the aggregated evaluation scores, i.e., for the OI3 eco-index and for the EI index, are determined on the basis of the weighted evaluation of the strategic building components. For the calculation of the evaluation scores, the minimum and maximum evaluation of all submitted competition works are used. This results in three individual project-specific evaluation scores for the OI3 eco-index and for the EI index. Three evaluation scores, i.e., 1, 2 and 3, are assigned depending on the clusters in which the competition works perform. Cluster 1 ranges from C_MIN to C_1,LIM, Cluster 2 from C_1,LIM, to C_2,LIM, and Cluster 3 from C_2,LIM, to C_MAX.

\[
C_{MIN} = \sum_{p=1}^{n} E_{crit/min,n} \\
C_{1,LIM} = \sum_{crit=1}^{n} \frac{E_{crit,MAX}-E_{crit,MIN}}{3} + E_{crit,MIN} \\
C_{2,LIM} = \sum_{crit=1}^{n} \frac{E_{crit,MAX} E_{crit,MIN}}{3} + 2 x E_{crit,MIN} \\
C_{MAX} = \sum_{crit=1}^{n} E_{crit,MAX}
\]

where:
E_{crit,MIN} = minimum evaluation for criterion n from all submitted competition works
E_{crit,MAX} = maximum evaluation for criterion n from all submitted competition works

In a second step, the mean values of the two evaluation scores from the "construction" part are calculated on the one hand, and the mean values from the evaluations of the eight criteria from the "climate protection" part are calculated on the other hand. In the third step, these two values are combined and classified into 3 final clusters resulting in an initial ranking of the building concepts. The final clustering ranges from the best score, i.e., 2, to the worst score, i.e., 6, and is shown in Figure 2.

![Initial ranking and considering non-assessable criteria](image)

**Figure 2.** Generating initial ranking and considering non-assessable criteria within the clusters.
In the last step, the measures that cannot be assessed, i.e., all criteria assessed with n, are included in the evaluation. Thereby, the cluster of the building concepts deteriorates by one cluster for every two non-assessable criteria.

3. Results

3.1. “Sustainability and climate protection” form – Part I construction
In this part, as already mentioned in the method section, textual descriptions of measures to optimize the OI3 eco-index based on klimaaktiv criterion C.4.1-Ecoindex OI3 in addition to textual descriptions of measures to optimize the EI index based on klimaaktiv criterion C.4.2-Disposal indicator are required. As shown in Figure 3 (fourth column), the participants had to provide specific information on the strategically important components in terms of the two required indexes in textual format, i.e., OI3 eco-index and EI index. However, this information is not allowed to be published due to the principle of confidentiality.

![Figure 3. Evaluation of the "sustainability and climate protection" form - Part I Construction - validation by using a case study.](image)

3.2. “Sustainability and climate protection" form - Part II climate protection
In part II, an additional eight criteria needed to be described, in which the textual description of project-specific measures in relation to climate protection was requested by the participants. The assessment criteria were defined in several stakeholder workshops together with the City of Graz (A10 Stadtbaudirektion) and the sustainability assessment experts. Some criteria were adapted from the national building certification system klimaaktiv [19]. First, textual descriptions of general measures to reduce embodied and operational GHG emissions are required. Followed by required descriptions regarding the photovoltaic concept, measures addressing the micro and city climate and description
regarding the rainwater management. The last three criteria inquire about long-term measures, i.e., up to the year 2050, for climate protection. These include measures to improve sustainability in relation to heating and cooling, in relation to extreme weather events, and in relation to the microclimate and urban climate.

3.3. **Practical application and validation using a case study**

Figure 3 and Figure 4 show the evaluations carried out by the external sustainability assessment experts on the basis of one submitted competition work. First, the building-related measures were evaluated based on the scale of 1 to 3, additionally with the factor ‘n’ if the criteria could not be evaluated. Then, for the construction part, the minimum and maximum values of all submitted competition works were identified and the individual project-specific evaluation score for the OI3 eco-index and the EI index was derived. A project-specific score of 2 was evaluated for both the OI3 eco-index and the EI index for the specific submission under consideration, taking into account the equation presented above (see Figure 4 - construction part).

In the next step, the evaluation scores of the two parts were combined, i.e., the mean values for the two parts were calculated, rounded up or down and aggregated. For the specific submission, this resulted in the evaluation scores shown in Figure 4.
in an average rating of 2 for the construction part and 1 for the climate protection part. For example, the topics of bioclimate or passive design strategies, i.e., site orientation, building form, compactness, are considered on the one hand under the criterion "General measures for GHG emission reduction embodied" and on the other hand under the criterion "General measures for GHG emission reduction operational". The evaluation of the impact on the mentioned topics is carried out by the sustainability assessment experts. These are evaluated on the basis of the submitted competition works, i.e., on the basis of plans (floor plans, sections and site plans) and 3D renderings. In addition, the textual descriptions of the participants regarding the two criteria are also considered in the evaluation.

In total, this resulted in an overall rating of 3 (sum of 1 and 2) for the building concept of the competition work. Based on the defined cluster classification in Figure 2, the case study with the rating of 3 therefore falls into cluster 1 with a rating of 3. Since all information has been provided, there are no non-assessable criteria and the cluster is not downgraded.

As an example, Figure 5 shows the winning project of the architectural competition, which was selected by the competition jury taking its sustainability criteria into consideration as obtained from the "sustainability and climate protection" form together with the energy efficiency and cost criteria.

![Figure 5. 3D rendering of the winning project – Created by Architekturbüro Zepp.](image)

4. Discussion
The results of the study indicate that the developed form "sustainability and climate protection" can already be implemented in the architectural competition. It has been shown that the participants address the required criteria and thus enable an initial evaluation of the building performance in terms of sustainability and climate protection. The developed evaluation algorithm supports the definition of project-specific clusters, i.e., individual clusters for each architectural competition, which enables the comparability of the submitted competition works.

The OI3 eco-index together with the EI index were used in the form context for the construction evaluation, in addition to other criteria.

The OI3 eco-index can be used to determine descriptive values for the environmental optimization of buildings with a reasonable amount of effort and is based on scientific findings from life cycle assessment. While the assessment of GWP is certainly in the foreground at present, resource efficiency can be mapped with PENRT and local impacts on air quality, soils and water bodies with AP. These three indicators available from LCAs are still among the most robust, leading to directionally stable calculation results at both component and building level. It is not the aim of this article to analyse or evaluate the tripod of LCA, for example by examining the methods to be applied, databases and the system boundaries, but rather to show that a request for the environmental performance of buildings is
already possible and also useful in the architectural competition. Analogously, the focus is also not to discuss the choice of EI index.

The textual descriptions provided by the participants showed that the majority of the measures indicated were assessable on a scale of 1 to 3. Only a few exceptions were rated as not assessable (n) by the external sustainability assessment experts. With the help of the individual evaluation algorithm, the results from the evaluation of the competition submissions show that a comprehensible ranking of the submitted building concepts is possible. The situation that emerged, especially in the case study presented, was that all six competition works submitted a similar concept, i.e., a single-story wooden building with a flat roof. By applying the evaluation algorithm, however, it was still possible to generate different clusters, for evaluating the very similar building concepts and providing a differentiated decision-making basis for the jury.

The results provide a new insight into the relationship between the early design stage of buildings and the implementation of sustainability requirements. It must also be mentioned at this point, however, that the advantage of this early implementation also brings disadvantages in practice. The remuneration for architectural competitions is low in comparison to the effort expended. The additional request for detailed information on sustainability measures further increases this effort while the remuneration still remains the same. In many architectural competitions, i.e., also in the case study example, only the first three ranked contributions received compensation for participation in the competition. In a conducted survey on the procedure as well as on the form "sustainability and climate protection" and its contents among the participating architectural offices, we asked the question about the required additional time for providing the data for the requested information in the form. Even though some of the participating architectural offices criticized the increased effort, all participants provided the requested information. Nevertheless, the City of Graz has voluntarily set itself the goal of demanding these sustainability requirements in all architectural competitions and by that pushing the implementation of more sustainable buildings and thus contribute to climate protection and sustainability. Regardless of additional remuneration, the architectural offices must provide this data in the future if they intend to participate in an architectural competition of the City of Graz. Furthermore, it is also conceivable that even more detailed information will be requested at this early stage, such as an LCA, when developing an adapted compensation model. In this context, we are currently working on a so-called GHG emission bonus/malus system, in which environmentally optimized projects with a lower GHG emission potential will be awarded the contract and the winner will receive a bonus (as for example in a case where the GHG emission potential is low but the project price is higher) or penalized by a malus (when the GHG emission potential is high but the price is the lowest).

The generalizability of the results is limited by the Austrian context. The procedure of architectural competition might be different in other countries. Also, the developed form "sustainability and climate protection" contains a first selection of criteria, which can be also adapted in the future. For example, the OI3 eco-index and EI index criteria of the klimaaktiv building certification system are included in the current version of the form. However, there are several other similar indicators that can describe and evaluate the environmental performance of a building.

In addition, it must be mentioned that a holistic sustainability assessment includes the three fields of environmental quality, economic quality and social quality as well as technical and functional qualities [20]. Considering that a detailed request for information on aspects of sustainability and climate protection in the course of architectural competitions is uncharted territory, the aim of this first step was the detailed request for information on aspects of environmental performance. From a holistic sustainability assessment perspective, this constitutes a limitation of this study. Future studies should take into account how to include these additional efforts, for example conducting a full LCA, in the architectural competition process.

Finally, the current digital developments in the building sector, such as the application of building information modeling, will support this early assessment of building performance and thus drive the sustainable procurement of buildings.
5. Conclusion
The alarming development of climate change, which is progressing due to the increasing GHG emissions, is leading to ever more undesirable changes on our planet, such as storms, floods or droughts. In order to counteract these devastating changes, all countries are required to make their greatest possible contribution to the reduction of GHG emissions. Especially in the building sector, there is huge potential for these efforts due to the enormous material and energy flows.

In the course of a building's life cycle, the greatest possibility for influencing building performance is the early design phase. Due to this background and the motivation to drive the sustainable development of buildings and thus to optimize the building performance, specific sustainability aspects were already requested in the course of architectural competitions.

With the support of the City of Graz, which is responsible for the awarding of public buildings, a form for "sustainability and climate protection" was developed. This form consists of two sections, these being "construction” and “climate protection”, which are represented by 10 distinct criteria that must be addressed by all participants during the course of each architectural competition. In the “construction” section, the OI3 eco-index and the EI Index were used to evaluate the building concepts in the context of both their environmental performance and their ultimate deconstructability and recyclability. The criteria in the "climate protection" section target topics such as reduction of GHG emissions, photovoltaic and rainwater management concepts, and micro and urban climate.

The form as developed and described has already been applied in three announced architectural competitions. In this article, a specific submission of one architectural competition and its evaluation by external sustainability assessment experts is presented. Six participants were invited to submit solutions for this architecture competition. It emerged in the final assessments that each of the participants had addressed the required criteria of the form extensively. Using a project-specific evaluation algorithm, the six competition works submitted were divided into clusters and ranked according to their contribution to the criteria. The evaluation was finally taken into account in the award process. With this effort, a further important step for the implementation of sustainable buildings has been taken at this early project stage and the project has been carefully steered towards the achievement of a net zero carbon-built environment.

By using the form that has been developed in combination with the accompanying process workflow, an important contribution has been made to the development of sustainable building standards. Furthermore, the City of Graz has voluntarily agreed to use the form in all of its architectural competitions in the future, thus taking on a pioneering role in the sustainable procurement of buildings in Austria. The next steps in our research include (i) the comparison of the developed standards for sustainable buildings with similar developments from other European countries, e.g., the System for Sustainability Requirements in Planning Competitions (SNAP), (ii) the identification of barriers to the implementation of LCA in building procurement processes, and (iii) the development of a framework for the mandatory integration of LCA in tendering and awarding procedures and thus to reduce GHG emissions, with the aim of contributing to the EU Climate Action Plan 2030 and ensuring carbon neutrality by 2050.

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