BIM in Early Design Phase: Workflow for Preliminary Assessment with SBToolCZ

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Abstract. Early design phase provides the highest potential for saving emissions and energy. Building Information Modeling (BIM) in cooperation with environmental assessment can be efficient tools for various kinds of analysis. This paper shows a possible workflow of using data from BIM in an online form for an early building assessment. Different methods of data export are also described. Czech national methodology, SBToolCZ was used for this study. However, the described principles are applicable for any other commonly used method. Results show approximately 60% of precision compared to the full SBToolCZ assessment (depends on the building typology). As an outcome of the study, a free online tool for architects and public usage is being developed.

1. Introduction
Buildings within their life cycle contain the significant potential for energy and carbon emission savings [1]. The highest potential for efficient buildings of any kind (embodied and operational emissions and energy, materials, water, land use, etc.) is during the early design phase, when only limited information about the building is available. Therefore, Building Information Modeling (BIM) is capable to help in the process of building optimization [2], [3]. It contains various relevant information that can be imported to the building assessment tool (e.g., area, volume, materials). How the recent international survey shows [4], Life-cycle assessment (LCA) method also became adopted in developed markets. Integrating BIM and LCA workflow is currently a highly developed research topic [5], [6]. Especially, the early design stage is still under fast development [5], [7]–[9]. This study shows an approach of using a model for simplified building assessment.

The aim of this research project is to present a workflow that combines early design BIM models with a simplified building assessment SBToolCZ methodology [10]. The main purpose is to create a free, publicly available tool that allows architects and designers to optimize building projects in the early design phase. Presented models were developed in the software Autodesk Revit 2021.

Universal definition of the early design stage is a complex task due to different national regulations, norms, and habits. In terms of BIM, there are two main types of models: (1) Conceptual and (2) Element based.

(1) Conceptual models (also named “shoe-box models” [11]) contain only basic geometry and they include building mass, conceptual structures with their areas, and gross floor areas. Those models are beneficial in urban studies or if the environmental database with aggregated data is available. However, the SBToolCZ methodology calculates the building’s impact based on a
real (not aggregated) Bill of Quantities (BoQ). For the purposes of this study, those models were considered as too simple. (2) Element based models are not necessarily detailed. However, they contain elements with their approximate location and dimensions and volume. The common way for model description in terms of their development is Level of Development (LOD) [12], which was described by the BIM forum organization. The optimal LOD for this study is 200-300. This model development corresponds to concept design and it can be still considered as an early design phase. Both model types are shown in the following Figure 1.

![Figure 1: Comparison of conceptual and element-based models](image)

In the Czech Republic, a green building certification methodology SBoolCZ [10] was developed. Currently, it is established as a relevant tool in the public as well as in the private sector. The original methodology is complex, and it needs around 500 inputs which are not available in the early design phase. Therefore, a simplified tool called preSBToolCZ was also developed almost 10 years ago. The focus was to estimate building quality as early as possible. This research project has an aim to update the original preSBToolCZ version according the current release of SBToolCZ with two key aspects: (a) transfer the original Excel spreadsheet into the free online application and (b) allow to use the potential of BIM.

2. Methods

2.1. SBToolCZ Analysis
The SBToolCZ methodology is divided into four different building typologies: Office Buildings, Apartment Houses, Family Houses and School Buildings and each typology consists of four categories: Environmental, Social, Economics and Management and Location. Every of the 53 criteria describes the impact of the building on the surroundings with the focus on sustainability. Every criteria has its own weight. Exact values for all criteria are explained in detail in a publication for each building typology [13]–[16]. The importance of each category slightly varies according to the typology as it is shown in Table 1.

Many criteria are the same throughout the building typology, but their assessment can vary. It concludes with a complex task to cover all typologies. The differences are caused by the different usage of the building and due to the chronological development of SBToolCZ.

There are five different data sources in the full version of the methodology: BIM, GIS, Documents, Processes and Other sources. In preSBToolCZ, only 2 data sources are considered:

(a) An online form,
(b) Data from the BIM (BoQ).
The rest of the data sources are not available in the early design phase and therefore, they are not considered. The list of criteria selected in the updated preSBToolCZ assessment tool are shown in chapter 3.

Table 1: Weight of the main categories of SBToolCZ methodology

| Category                      | Office Buildings | Apartment Houses | Family Houses | School Buildings |
|-------------------------------|------------------|------------------|---------------|------------------|
| Environmental                 | 50%              | 50%              | 50%           | 35%              |
| Social                        | 35%              | 35%              | 35%           | 50%              |
| Economics and Management      | 15%              | 15%              | 15%           | 50%              |
| Location                      | 0%               | 0%               | 0%            | 0%               |

2.2. Data export

The next task was to analyze a different method of data export and investigate which fit the most for this study.

2.2.1. Schedule Export. The most common way of data export from BIM is through the schedule. This method is valid for the most common use cases if BoQ is needed externally. The problem is that the user is always limited only to what a software the developer allows. There are more advanced options which include wider export possibilities and automation of this process through a parametric design (*Autodesk Dynamo*). However, the possibilities of exported data are still limited. Another limitation is that schedules are not standardized, which is problematic for the possible automation.

2.2.2. gbXML Export. More advanced way of data export is Green Building eXtensible Markup Language, an open schema developed for data exchange with focus on energy, HVAC systems, etc. This format is standardized which simplifies possible automation. For this study, only BoQ from the model is needed. Therefore, it is not the right solution.

2.2.3. IFC Export. The most complex way of data export is with Industry Foundation Classes (IFC) format which is developed by the international organization buildingSMART. This format is ISO standardized [17] and it has high potential to be the most common format for BIM data exchange [18]. IFC offers the widest possibilities of storing geometrical and nongraphical data with a different schema [19]. Negative aspect of its complexity is the lower understandability of this format.

2.2.4. BIM Authoring Tool Plugin. Opposite approach of data export is to develop own plugins for software. Every main BIM authoring tool offers an Application Programming Interface (API) which allows to develop any custom tool which the user needs. Therefore, this approach is the best for repetitive export tasks in large scale. This solution also offers the highest potential for automatization. Since all software is still developing, the negative effect is a constant demand for software developers. Which includes that the presented approach can work in a big corporation only.

When all described solutions were investigated with their pros and cons, the simplest approach: Schedule export was selected for this study. The exported schedule can be incorporated into the online web application which is now being developed.
3. Results

As an outcome of the analysis mentioned in the previous chapter, a list of criteria which can be accessed in the early design stage was created. Only two main data sources are considered in the early design phase: (a) an online form, which describes the building standards and calculation inputs and (b) BIM model in LOD 200-300. According to the analysis, 21 criteria (from total 53) were selected. Those criteria are available in the early design phase. All selected criteria with their weights are shown in Table 2. All mentioned criteria cover around 60% of the results for the full assessment. The exact number is different according the building typology.

| Table 2: Criteria selected in the preliminary assessment with their weight |
|-------------------------------------------------|
| ![Table Image](image_url) |

Even-although *Location* category has a weight of “0”, it is still important to consider these criteria in the early assessment, because they can be beneficial for the users of the building in the future.
4. Discussion
Proposed overview was presented with a focus to connect the early design stage BIM model with the SBToolCZ methodology. The connection with this methodology can be considered as a limitation of the study. However, the principles are transferable to any other green building methodology, such as Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), Deutche Gesellshaft für Nachhaltiges Bauen (DGNB) or any other. Comparison of the mentioned methodologies and their relation to BIM and LCA was already described [20].

Previous version of preSBToolCZ methodology was taken as the input of this research project and analyzed. According to this analysis, the workflow of assessing buildings in the early design stage was developed. The workflow is divided into two parts: (a) a form in which the user defines another input relevant for the building assessment (structural system, heating system, etc.) and (b) BIM model which allows exporting the relevant information in the early design phase. When all inputs are set, the preliminary building assessment can be processed. SBToolCZ methodology was also reviewed and updated according to the current trend of BIM usage.

5. Conclusion
As an outcome of this research project, a free web-based application is now being developed. In the future, building projects can be optimized in terms of the building’s shape, orientation, and materials. A designed building project can also be precertified. There are the following possible use cases that can be performed with the presented workflow:
1. Building shape optimization – only the building shape in the BIM model is gradually changed in iterative steps; building materials and equipment are consistent.
2. Building material and equipment optimization – only inputs in the online form are being changed, the building shape is consistent.
3. Combination – building shape as well as materials and equipment are changed in iterative steps.
Thanks to the presented workflow, architects and designers will be able to estimate the building’s negative impact (embodied and operational) in the early design phase with a solid amount of certainty and have enough time to optimize the building design.

6. Acknowledgments
This research project was supported by an internal student’s grant at the Czech Technical University in Prague, project nr. 161 - 1612059A124.

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