BIM checking software requirements in the scope of the Vienna building authority

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Abstract
The use of Building Information Modeling (BIM) is evolving rapidly, with methods designed to accelerate building construction processes by optimizing different phases. Numerous vendors offer BIM checking applications with the objective of ensuring that planning and execution are as error-free as possible, primarily benefiting private sector contractors. However, public building authorities should also be able to use the advantages of BIM, e.g. for their digital building permission process. The central issue in digital building submission is automatic BIM checking and the associated checking software. Together with the City of Vienna, criteria for checking software were therefore determined. Particularly important next to the checking scope was maintainability, availability, and expandability of checking applications. This leads to a discussion, enabling Vienna's building authority to plan future automated building code checks effectively.

1. Introduction
The advent of digital technology in the construction sector is accelerating. Building Information Modeling (BIM) has now become an indispensable component of both the design and construction phase. This method is designed to represent comprehensive building data in one or more three-dimensional models. The objective is to ensure that all relevant parties have access to this data at any time. Whyte and Hartmann (2017) assert that BIM is a driving force for change in the construction industry. However, the benefits of BIM extend beyond planning and construction. One significant beneficiary of these discussions is often overlooked: building authorities. Building authorities as public entities are responsible for overseeing compliance with building codes and regulations. These tasks can also greatly benefit from the use of BIM. One of the main benefits is the

automation of code checking during the building permission process. This can increase efficiency and reduce costs (Beach et al., 2020). The building authority of Vienna has expressed a strong interest in the advancement of automated building code checking by initiating the BRISE-Vienna project (Stadt Wien, 2024a). This project was started with the objective of creating a digital building permission process based on openBIM. In addition to accelerating and optimizing official procedures, the project's primary focus is on the automated verification of BIM models for compliance with building regulations. Several vendors have developed BIM checking applications, each offering their own iteration of BIM checking tools. These tools are designed to automatically recognise and subsequently communicate errors in the domain models during the planning phase and execution planning (Eichler et al., 2024). Errors are recognised at an early stage and reduce time-consuming and cost-intensive changes in the execution and operating phase. However, these applications must be highly customizable, as the building authorities of different countries and even cities have to check regulations that can vary significantly. Therefore, off-the-shelf BIM checking applications may not fully satisfy their needs.
The project partners of BRISE-Vienna already had long term experience regarding automated checks. Based on their advice Solibri (2024) was chosen as BIM checking application. The primary objectives are to maximize automation, reduce the workload of building authority, and enhance the efficiency and speed of the process. During the research project, it was repeatedly found that authority-specific requirements had then not been the focus in the development of Solibri. As an alternative to existing software solutions, software companies can either be commissioned directly to develop individual products or developers may be directly employed by the authorities. Estonia and Dubai have made significant progress in the area of digital building permission process (Ismail et al., 2024; Lavikka, R & Kallinen, A., 2024). In both cases, appropriate software companies have been commissioned to create customized applications. Geneva implemented a platform for the digital submission of BIM models in the IFC format (République et canton de Genève, 2023). For that, Geneva has employed its own developers who can respond to individual wishes and requirements directly.
Consequently, there's a need for building authorities to establish specific criteria and requirements for evaluating BIM checking applications to determine the suitability of off-the-shelf applications. A broad definition of general classifications of BIM model checking have been proposed by Succar (2009) and Hjelseth (2016). Jos (2023) categorizes BIM model checking methods into three categories: Clash detection, model content checking and, code checking. These criteria can be used to compare different applications. However, they only refer to the checking-process itself in a superficial manner. The building authority has further requirements for the applications that go beyond the checking scope in the planning phase. With the aim to fill this gap, the authority-specific requirements for the checking software were determined. The determination was carried out on the basis of expert interviews and workshops with the authorities of the City of Vienna. The result is a comprehensive list of requirement criteria, including a prioritisation of the criteria, whereby certain criteria were defined as non-negotiable (K.O. criteria). This research shows the results of the evaluation and outlines other solutions such as proprietary development. The paper starts with the method used to define the checking criteria. This is followed by describing each criteria and their requirements in the context of building authorities. Finally, the authors outline the results, describe possible ways for building authorities to adept the found criteria and discuss potential next steps for the building authority of Vienna.

2. Methods

The aim of the BRISE-Vienna project was to develop an openBIM submission process. According to Urban et al. (2021), the Industry Foundation Classes (IFC) file format is a prerequisite for the entire process. IFC is an open data format whose data schema is standardised in ISO 16739-1. In Austria, the building authorities can only require open standards in order to ensure transparency and accessibility. Open standards promote interoperability between different software solutions, which facilitate data exchange and create competitive advantages. Based on this, BIM models shall be checked on compliance with building codes and regulations. This encompasses the building code of Vienna (Stadt Wien, 2024b), the garage act of Vienna (Stadt Wien, 2020), and the OIB guidlines (Austrian Institute of Construction Engineering, 2024).
Urban et al. (2024) describe the checking system as a two step-process. The system differentiates between pre-check and the openBIM submission. The major difference regards the checking scope and the phase. In the pre-check phase, planers can anonymously test their models with fully automated LOI checks, plausibility checks, normative checks, and technical specification checks. Therefore, only fully automated checking rules are included. The openBIM submission phase contains all available checks, including semi-automated checks. These may need additional interpretation from building authority officers or simply give visual support to speed up the checking process. Based on the project-experience, expert interviews were conducted with the Vienna building authority to define the fundamental criteria for a BIM checking application. Each criterion consists of one or more requirements. After developing detailed requirements, a discussion was held to evaluate each criterion and their requirements. Together with the building authority of Vienna two distinct types of criteria were determined as essential:

- **Knockout Criteria** define basic requirements for the software. Failure to meet these criteria leads to immediate exclusion from further consideration.
- **Evaluable Criteria** include general requirements, specific performance features of the application, and costs/licensing, which together determine the overall functionality and quality of a software. These also enable a ranking.

Following up on the interviews and the discussion, a workshop was conducted to determine the relevancy of each requirement and through averaging, for every criterion. In this workshop, two building authority officers were asked to evaluate every requirement based on a Lickert scale where 1 equals very relevant and 5 irrelevant in their role for the submission process.
These various steps can be generalized to the process shown in Fig. 1. The figure also includes the next steps for an authority. Off-the-shelf BIM Checking applications have to be evaluated and ranked based on the criteria. To conclude the process, the building authority has to compare the best application with the options of commissioning a software company and in-house programming in order to determine the next steps.

3. Results

This research resulted in a detailed list of criteria and requirements regarding the needs of the building authority of Vienna for an openBIM submission process. The individual requirements are described below and explained in the context of this process.

3.1. Knockout Criteria

The knockout criteria, shown in Fig. 2, define rudimentary requirements for BIM checking applications. The first knockout criterion is compatibility with IFC and BCF. As an

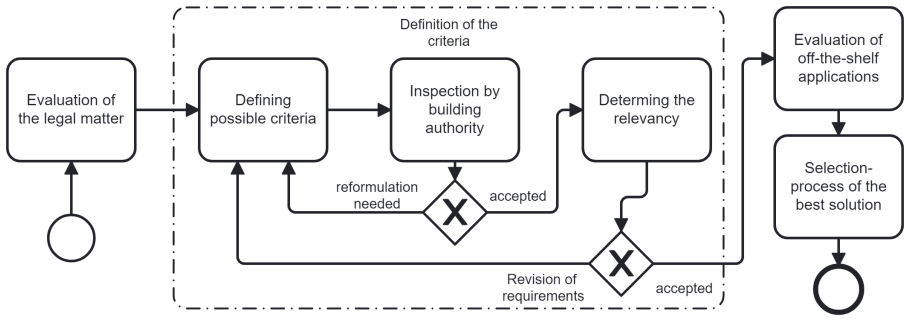

Figure 1: Process to define and evaluate BIM checking software criteria

Knockout Criteria	Requirements	Relevancy (1-5)
Open data formats	Is the software IFC and BCF compatible?	1
Data privacy	Who has access to the data?	1
	Where is the data stored?	1
		Score: 1,0

Figure 2: Knockout Criteria

authority, it must not demand proprietary file formats, as this would give preference to one software manufacturer. The checking application used must therefore be able to both import and export these open standards. The second knockout criterion relates to data protection. Essentially, it covers the questions of who has access to the submission documents and where they are stored. In accordance with the General Data Protection Regulation (GDPR), it is not permitted to transfer submitted project data to third parties. Consequently, only local-based software or hosted in-house server solutions are viable options. Cloud services that run via third-party servers are therefore not permitted. Typically, existing openBIM checking applications meet those requirements (e.g Solibri).

3.2. Evaluable Criteria

The evaluable criteria are divided into three areas: general criteria, checking criteria, and cost and licensing criteria.

3.2.1. General Criteria

The general criteria deal with topics that are not directly related to the checking process. They are shown in Fig. 3. For the building authority of Vienna, the main focus is on the maintainability of the software. Dependency on the software manufacturer must be precisely defined in the contract. If the product is based on other closed source products, the dependencies must also be precisely defined. Furthermore, it must be possible to independently reproduce checking results from older software versions at any time. The reason for this lies in the legal situation in Vienna. Court proceedings and appeals must be able to be processed even years later. This requires a versioning system to be able to verify and confirm old checking reports and the checking system itself, even after software updates. In addition to the issue of the reproducibility, it must also be possible to map future changes to the legal material. If these changes regarding the checking are to be processed directly by the building authority officers, the checking system must be maintainable or adaptable by non-programmers. In this context, the guaranteed long-term functionality and support of the selected software was a key focus of the workshops with the building authority officers of the city of Vienna. Over

Evaluable Criteria		
General Criteria	**Requirements**	**Relevancy (1-5)**
Maintainabilitly	Is there a dependency on an external vendor?	1
	Can results be reproduced at any time? (versioning)	1
	Can changes to the law be adapted directly?	1
	Can a non-programmer maintain it?	1
	How long can the functionality be guaranteed? (Assessment)	1
	How long can access to the checkingroutine be guaranteed?	1
		Criterion score: 1,0
Expandability	Can the basic application be extended? If so, what options are available?	1
	Is user interface customization possible? (Flexibility)	2
		Criterion score: 1,5
Availability	Where can the software be operated (on-prem, cloud, PC) Is it a web service?	1
	Is the service limited to a certain number of users?	2
	Is it possible to assign tasks and roles?	1
		Criterion score: 1,3
Ease of Use	Are training documents available and publicly accessible?	2
	Are tooltips available that describe functions directly in the software?	2
	Is an interactive tutorial available for first-time users?	3
	Is a contact person available for questions or problems (first-level support)?	2
	Are there any training courses?	3
		Criterion score: 2,4

Figure 3: General Criteria

2000 checking routines were developed in the BRISE-Vienna project. Each software has its own unique characteristics, which means that the checking rules must be recreated when the software is changed. The conversion of processes, the creation of new rules, and the training of employees all require time, money, and personnel resources that are currently tied up in operational activities. A public authority is designed for stability and is not structured as an agile start-up. A changeover of this kind represents a significant challenge for the authority, particularly in terms of resources. A change in application every five years, for instance, is not a viable option for the building authority. In light of long-term functionality, access to the checking routine itself must also be considered.. During the BRISE-Vienna project, it became apparent that software updates can change settings with regard to the checks. Suitable measures must be taken to prevent this.
The next area covers the expandability and adaptability of the software. In addition to typical basic checks, such as an LOI check, checking the entire relevant legal matter requires more extensive checks, e.g. escape route analysis (Fischer et al. (2023)) or verification of fire compartments (Pfeiffer (2024)). Accordingly, the software must have expansion options in order to automatically check those mostly national-specific regulations. Ideally, it should be possible to program new checks without involving the developer of the software. Solibri provides this capability through the use of an API. Only through such expansion options is it possible to automatically check complicated national-specific regulations. The adaptation of the user interface is also important for the building authority of Vienna. The checking application will become the central tool for the building authority in the future and will replace the classic approach with paper plans. This represents a significant change in working methods. To facilitate this changeover as easily as possible, the software solution must be highly usable. For

user acceptance (building authority officers), the user interface of the application should therefore be adaptable to the respective needs. On the one hand, this means adopting the output style of the authority. On the other hand, it also means being able to customize the structure and layout of the software in order to influence the click stream.
The next criterion is the availability of the product. In this context, availability describes how and whether the software is available to an officer. The first aspect that needs to be clarified is where the software is installed on. A distinction is usually made between on-premises, cloud-hosted and local based. The building authority of Vienna and others have already transitioned to a Virtual Desktop Infrastructure system (VDI) and have encountered challenges in maintaining and integrating desktop-only applications. In this instance, web services could be a valuable solution, provided that they can be hosted on the City of Vienna's own servers (=on premises) in accordance with the knockout criterion. Regardless of whether it is a web service or local-based software, it must be taken into account that several instructors will always be conducting examinations at the same time. Therefore, either an unlimited number of users must be able to use the software simultaneously or sufficient licenses must be available for local-based software. It is also crucial that different tasks and roles can be assigned via the platform. The officers should have access to the check, while the checking-rule developers require access to the rule development. A submitter should only see the part that is necessary for uploading their projects. To achieve this, system administrators must be able to assign roles quickly and easily and supervisors may assign tasks to various roles to achieve efficiency. In addition to these three criteria, the City of Vienna's building authority officers also consider user-friendliness to be a key factor. When switching from the current process to an openBIM submission process, many officers need to be trained. It is therefore particularly important to ensure that training documents/courses are accessible and that first-level support (e.g. Helpdesk) is available. Furthermore, the application should have tutorials and tool-tips implemented directly into the application.

3.2.2. Checking Criteria

In addition to general criteria, requirements for the checking process were also defined. The focus is primarily on the scope of the checking. These criteria are shown in Fig. 4. In order to meet the requirements of the building authority of Vienna, a range of check types must be possible. In line with Eichler et al. (2024), these are divided into formal checking criteria, quality checking criteria, and regulatory checking criteria. The formal checking criteria focus primarily on the fulfillment of the IFC data structure and the existence of alphanumeric information content of elements. This includes checks for the data structure and properties.
The quality checking criteria contain checking of the geometric relationships such as collision and distance between components. In contrast, the regulatory checking criteria use alphanumeric as well as geometric information in order to check legal or normative requirements, e.g. building code (Austrian Institute of Construction Engineering, 2024). This requires more complex checking such as working with mathematical formulas, checks containing information of numerous models, and integrating interpretations by building authority officers. To ensure this, Urban et al. (2024) demonstrate that it is beneficial to the openBIM building permission process to categorize the checking rules into three types: automated rule, semi-automated rule, and graphical assistance rule. An automated rule (e.g proof of light exposure) displays the finished result, where as a semi-automated rule (e.g escape route analysis) has some parts that run automated but needs additional decisions from an officer to create a result. Graphical assistance rules assist the officers in their decision. For example, it may highlight load bearing elements

Evaluable Criteria **Checking Criteria**	**Requirements**	**Relevancy (1-5)**
Checkingscope	Are formal checking criteria included? e.g. data structure (duplicate GUIDs), property checks	1
	Are quality checking criteria included? e.g: Collision check, Distance check	1
	Are regulatory checking criteria included? e.g: Objectrelations Geometry checks Checks via mathematical formulas Comparison with external documents Checks against specially created surfaces and volume elements Checks with several models	1
	Is IDS possible?	1
		Criterion score: 1,0
Structure	Is the software designed for rule-based checks? (Adaptation to laws and guidelines)	1
	How are checking rules structured? (template, visual scripting, waterfall,...)	1
	Is it possible to customize the checking rules? If yes, which type? (template level, component level,...)	1
	Is it possible to manage the checking rules centrally (independent of the models)?	1
	What options are available for displaying results?	1
	Can user-defined filters be created to highlight certain elements?	2
	Can results be reused elsewhere?	1
	Which export formats are possible?	1
	Is direct communication possible? (Collaboration platforms)	3
		Criterion score: 1,3
Performance and Scalability	Can very large BIM models also be checked efficiently? (System requirements)	1
	Can a large number of checking procedures be carried out simultaneously?	2
		Criterion score: 1,5
Pre-check	Can the pre-check be carried out anonymously?	1
	Can the checking process be automated?	1
	Is the user automatically notified on completion?	2
		Criterion score: 1,3

Figure 4: Checking Criteria

for the structural analysis. The types are shown in Fig. 5.
Since the building authority of Vienna provides Exchange Information Requirements (EIR) for the submission process, they would like to define them via Information Delivery Specification (IDS). In order to utilise this standard, the application must be capable of importing and working with IDS. For an efficient checking process, paragraphs of the legal matter must be checked in a comprehensible manner. It is essential to define which checking element corresponds to which paragraph in order to verify them manually, if necessary. This clear assignment can be summarized as rule-based checking, whereby a rule is always assigned to previously determined paragraphs. Checking elements consist of rule-templates and components. A rule template is a predefined format that can be used to create different specific rules. It provides a framework for defining the conditions and parameters to depict different paragraphs of the legal matter. A component, however, performs individual subtasks, such as filtering element or mathematical oper-

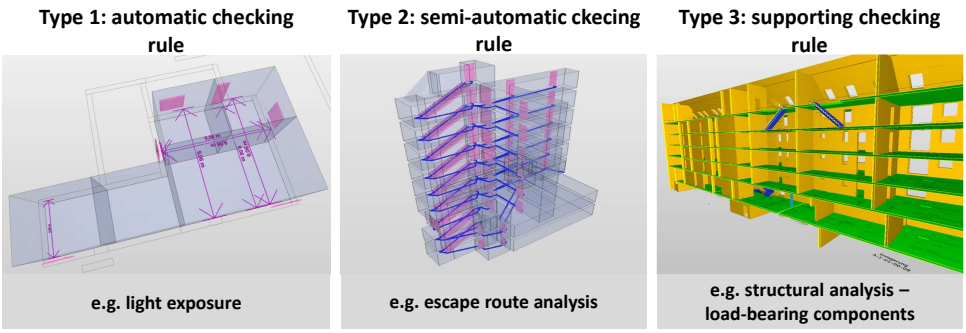

Figure 5: Types of checking rules

ations. In order to map paragraphs, it is necessary to combine various components and populate them with parameters. A further distinction is made with regard to the nesting of checking elements. Common types are the waterfall arrangement, in which various checking elements are executed one after the other based on gatekeeper conditions, and visual scripting, which enables more complex combinations. Simple user-defined adaptation of existing checking elements is also very important. This requirement relates both to the modification of the checking rules for maintenance purposes and to the creation of new ones in order to be able to automatically check further paragraphs of the legal matter. To achieve this, usage and editing of rules has to be centrally organized, restricted to selected roles and independent of the loaded models. Once the check has been completed, the next important point is the presentation of the results. In addition to a user-defined display, the building authority officers require various export formats such as pdf and xlsx. The program must include filter methods to highlight different results. This enables the authority to create different result reports according to the assigned role. Furthermore, the results should be accessible globally on the platform, allowing them to be utilized at any time in another checking process. Additionally, the ability to share the outcomes of the checking directly with different authority departments via an internal collaboration platform would be beneficial.
Performance and scalability are also key considerations when selecting an application, given that approximately 13,000 building projects are submitted to the building authority of Vienna each year (Krischmann et al., 2020). The software must be able to handle a large number of check procedures simultaneously. In addition, larger BIM models (>500 MB) must be displayed and checked efficiently. As discussed earlier, the building authority wants to provide an automated pre-check. In order to enable this service, fully automated parts of the checking process must automatically lead to a report after the building model has been uploaded. Furthermore, the upload must be anonymously (the building authority does not retain any information about these) and the submitter should be informed about the completion of an automated checking.
Checking applications are typically adept at the checkingscope. However, given the complexity of the building code in Vienna, existing solutions either cannot automatically check those regulations or require extensive programming knowledge to expand the basic program. Another point of criticism is the implementation of the anonymized and automated pre-check. With existing products, it can only be realized in a roundabout way .

3.2.3. Cost and Licensing Criteria

The final decision criteria relate to costs and licensing as shown in Fig. 6.
The authority includes both one-off payments and ongoing costs in the decision. Be-

Evaluable Criteria Cost and Licensing Criteria	Requirements	Relevancy (1-5)
Cost	Are there any one-off costs?	1
	Are there running costs? Per man, per checking, etc...	1
		Criterion score: 1,0
Licensing	Can the source code be made available upon commissioning?	1
	Is the software a closed source product?	1
		Criterion score: 1,0

Figure 6: Cost and Licensing Criteria

sides that, they would like to have insight into the source code on the finished product. Closed-source products are disadvantageous since a public authority has to guarantee transparency. At best, both the platform and the checking-rules should be publicly accessible. This will ensure transparency around the checking process and the required long-term support as the code is easily available even if the development team changes.

4. Discussion and Conclusion

Automated checking is being implemented in many authorities, and there are different approaches to how this can be done: off the shelf, commissioned, and in-house. All three have been used by different authorities, but none is the optimal solution. The conditions for authorities vary greatly from country to country, which makes it challenging to provide a single, universal recommendation for the optimal approach. This underscores the importance of this work. A key aspect that applies to all authorities is the evaluation of their specific needs. Based on this, the requirements for the software should be defined to identify the optimal solution for the respective authority. It is therefore essential to research the requirements for the checking software, as many building authorities are currently undergoing a process of digital transformation in this area.

The BRISE-Vienna research project enabled the development, implementation, and testing of an openBIM building permission process. Based on the experience gained, the research team was able to derive requirements for processes and application. The BIM checking application was the central element and the reason why the research team worked intensively on evaluating the requirements. The evaluation shows that the authority highly values the scope of the checking (score 1.0). In addition, the criteria costs and licensing, and maintainability are also significant (score 1.0). Vendors typically prioritize the checking scope and associated costs. However, for building authorities, the maintainability of the software is of equal importance, particularly in light of the need to archive the submitted models as well as the checking results. The second, neglected factor is the licensing. Closed-source licenses, which are commonly used by private providers, limit the needed transparency of building authorities.

Going forward, the next steps for the Vienna building authority include conducting extensive research into existing BIM checking applications. These will then be evaluated in regard to the identified requirements. Following this, the best solutions will be observed to determine whether they can fulfill the necessary requirements. If they cannot, the Vienna building authority will have to consider one of the alternative options.

References

Austrian Institute of Construction Engineering. (2024, May). OIB-Guidlines | OIB. Retrieved May 27, 2024, from https://www.oib.or.at/de/oib-richtlinien

Beach, T. H., Hippolyte, J.-L., & Rezgui, Y. (2020). Towards the adoption of automated regulatory compliance checking in the built environment. *Automation in Construction*, *118*, 103285. https://doi.org/10.1016/j.autcon.2020.103285

Eichler, C. C., Schranz, C., Krischmann, T., Urban, H., Hopferwieser, M., & Fischer, S. (2024, January). *BIMcert handbook: Basic knowledge openBIM. edition 2024*. Mironde-Verlag. https://doi.org/10.34726/5383

Fischer, S., Schranz, C., Urban, H., & Pfeiffer, D. (2023). Automation of escape route analysis for BIM-based building code checking. *Automation in Construction*, *156*. https://doi.org/10.1016/j.autcon.2023.105092

Hjelseth, E. (2016). Classification of BIM-based model checking concepts. *Journal of Information Technology in Construction (ITcon)*, *21*(23), 354–369. Retrieved May 7, 2024, from http://www.itcon.org/paper/2016/23

Ismail, A., Fahdah, I., & Almheiri, M. O. (2024, April). Transformative Journey: Dubai Municipality's BIM Adoption for Building Permitting and Regulatory Compliance. In *Digital Building Permit conference 2024 – Book of Abstracts*.

Jos, V. (2023, May). Model checking methods for BIM: The state-of-the-art analysis. Retrieved May 7, 2024, from https://tu-dresden.de/bu/bauingenieurwesen/cib/ressourcen/dateien/publikationen/Projekt-_Diplomarbeiten/Project-Work_Vladislav-Jos.pdf?lang=de

Krischmann, T., Urban, H., & Schranz, C. (2020). Entwicklung eines openBIM-Bewilligungsverfahrens. *Bauingenieur*, *95*, 335–344. https://doi.org/10.34726/2421

Lavikka, R & Kallinen, A. (2024, April). BIM-based building permit process: Finland's implementation path. In *Digital Building Permit conference 2024 – Book of Abstracts*.

Pfeiffer, D. (2024). Entwicklung von Prüfregeln zur (teil-)automatischen Bestimmung und überprüfung von Brandabschnitten. https://doi.org/10.34726/hss.2024.120480

République et canton de Genève. (2023, October). Je dépose ma demande d'autorisation de construire en BIM. Retrieved May 27, 2024, from https://www.ge.ch/node/33125

Solibri. (2024, May). Imagine. Reliable information on demand. Retrieved May 7, 2024, from https://www.solibri.com/

Stadt Wien. (2020). Landesrecht konsolidiert Wien: Gesamte Rechtsvorschrift für Wiener Garagengesetz 2008. Retrieved May 28, 2024, from https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000052&FassungVom=2020-10-13

Stadt Wien. (2024a). BRISE-Vienna – Smarte und innovative Verwaltung. Retrieved May 28, 2024, from https://digitales.wien.gv.at/projekt/brisevienna/

Stadt Wien. (2024b, May). Ris - Bauordnung für Wien - Landesrecht konsolidiert Wien. Retrieved May 28, 2024, from https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000006

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction*, *18*(3), 357–375. https://doi.org/10.1016/j.autcon.2008.10.003

Urban, H., Fischer, S., & Schranz, C. (2024). Adapting to an OpenBIM Building Permit Process: A Case Study Using the Example of the City of Vienna. *Buildings*, *14*(4), 1135. https://doi.org/10.3390/buildings14041135

Urban, H., Schranz, C., Krischmann, T., Asmera, H., & Pinter, B. (2021). Einsatz von openBIM und KI im Bewilligungsverfahren der Stadt Wien. *OIAZ*, *166*, 1–9.

Whyte, J. K., & Hartmann, T. (2017). How digitizing building information transforms the built environment. *Building Research & Information*, *45*(6), 591–595. https://doi.org/10.1080/09613218.2017.1324726