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A process-oriented decision model for determining the permitability of construction projects

DISSERTATION

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submitted by

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Foreword of the supervisor

In many countries, the building permit process is a critical and often nerve-wracking affair. Investors want to invest in their property on a large scale to make it fit for the future or just to fulfill their own individual wishes. It is not uncommon for the free expression of a large or bold building idea to be opposed by relevant regulations that our state has imposed on itself in the form of building laws and ordinances. These regulations serve several purposes, such as the maintenance of security and order and mutual consideration in a society oriented towards peaceful and prosperous coexistence.

The building permit process includes everything that has to do with ensuring that state supervision is aware of the planned building project and has the opportunity to consult and also accept it before a developer makes a large and not easily reversible investment by starting his building project. As a rule, the responsibility for assessing and approving building projects lies with the lower building supervisory authorities. Building authorities can be organized differently depending on the district, even if they ultimately have to meet the same basic standard.

In her dissertation, Ms. Fauth has set herself the goal of illustrating the diversity of these complex processes within building authorities, and mapping them in a flexible overall scheme. The purpose of this diagram is to provide the authorities themselves with a flow chart in which they can find and locate their individual process structures. It also serves the purpose of creating a basis for future automated processes within a standardized general flow chart that is made available digitally.

Finally, on the basis of numerous interviews and subsequent thorough evaluation of her research, Ms. Fauth has demonstrated in which areas not only objectively verifiable facts are to be assessed, but where special evaluations remain necessary, which are to be made by the respective building official and within the framework of equitable discretion. Decisions made on the basis of such evaluations should be recorded transparently in the future and made accessible as professional decision references on a supra-regional basis.

I wish all readers of this work an enjoyable and instructive reading. In particular, I wish for Ms. Fauth and her research colleagues that this work will contribute to the further consistent improvement of building permit processes in research and practice, and thus establish the digitization of building permit processes on a solid foundation.

Hans-Joachim Bargstädt Weimar in July 2021

Acknowledgements

In the summer of 2016, I began to explore the idea of submitting a BIM model equivalent to a building application. Since then, this approach has been accompanied by ups and downs, such as the lack of data, which eventually led to new insights. Above all, my research has affected many people, to whom I would like to express my gratitude at this point.

First and foremost, I would like to express my sincere thanks to my doctoral supervisor Prof. Dr.-Ing. Hans-Joachim Bargstädt for his comprehensive supervision of my work during my time as a research assistant at the Chair of Construction Engineering and Management, and beyond. My inspiring discussions with him have contributed greatly to the success of this doctoral thesis.

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From September 2017 to March 2018, I was able to complete a research stay at the University of Southern California in Los Angeles (USA) as part of a Fulbright doctoral scholarship. This not only gave me the opportunity to expand my research internationally, but also to develop personally. Therefore, I would like to express my special thanks to Prof. Lucio Soibelman, Ph.D. and the German-American Fulbright Commission.

My dissertation is based on a large number of interviews that helped shape this work. At this point, I would like to thank all interview participants for their cooperation. I would also like to thank the (former) students of the Bauhaus-Universität Weimar who helped with the interviews or who contributed new inspirations to my work through their projects and theses.

I would like to thank my former colleagues at the Chair of Construction Engineering and Management for our fruitful discussions and small experiments, and for their words of motivation. I further thank Mr. Sven Rothe for his help in implementing the web application. In particular, I would like to thank my husband for his encouragement and unwavering support.

Bolzano, July 2021

Abstract

In recent years, the discussion of digitalization has arrived in the media, at conferences, and in committees of the construction and real estate industry. While some areas are producing innovations and some contributors can be described as pioneers, other topics still show deficits with regard to digital transformation. The building permit process can also be counted in this category. Regardless of how architects and engineers in planning offices rely on innovative methods, building documents have so far remained in paper form in too many cases, or are printed out after electronic submission to the authority. Existing resources – for example in the form of a building information model, which could provide support in the building permit process – are not being taken advantage of. In order to use digital tools to support decision-making by the building permit authorities, it is necessary to understand the current situation and to question conditions before pursuing the overall automation of internal authority processes as the sole solution.

With a substantive-organizational consideration of the relevant areas that influence building permit determination, an improvement of the building permit procedure within authorities is proposed. Complex areas – such as legal situations, the use of technology, as well as the subjective alternative action – are determined and structured. With the development of a model for the determination of building permitability, both an understanding of influencing factors is conveyed and an increase in transparency for all parties involved is created.

In addition to an international literature review, an empirical study served as the research method. The empirical study was conducted in the form of qualitative expert interviews in order to determine the current state in the field of building permit procedures. The collected data material was processed and subsequently subjected to a software-supported content analysis. The results were processed, in combination with findings from the literature review, in various analyses to form the basis for a proposed model.

The result of the study is a decision model that closes the gap between the current processes within the building authorities and an overall automation of the building permit review process. The model offers support to examiners and applicants in determining building permit eligibility, through its process-oriented structuring of decision-relevant facts. The theoretical model could be transferred into practice in the form of a web application.

Kurzfassung (in German)

Die Auseinandersetzung mit der Digitalisierung ist in den letzten Jahren in den Medien, auf Konferenzen und in Ausschüssen der Bau- und Immobilienbranche angekommen. Während manche Bereiche Neuerungen hervorbringen und einige Akteure als Pioniere zu bezeichnen sind, weisen andere Themen noch Defizite hinsichtlich der digitalen Transformation auf. Zu dieser Kategorie kann auch das Baugenehmigungsverfahren gezählt werden. Unabhängig davon, wie Architekten und Ingenieure in den Planungsbüros auf innovative Methoden setzen, bleiben die Bauvorlagen bisher zuhauf in Papierform oder werden nach der elektronischen Einreichung in der Behörde ausgedruckt. Vorhandene Ressourcen, beispielsweise in Form eines Bauwerksinformationsmodells, die Unterstützung bei der Baugenehmigungsfeststellung bieten können, werden nicht ausgeschöpft. Um mit digitalen Werkzeugen eine Entscheidungshilfe für die Baugenehmigungsbehörden zu erarbeiten, ist es notwendig, den Ist-Zustand zu verstehen und Gegebenheiten zu hinterfragen, bevor eine Gesamtautomatisierung der innerbehördlichen Vorgänge als alleinige Lösung zu verfolgen ist.

Mit einer inhaltlich-organisatorischen Betrachtung der relevanten Bereiche, die Einfluss auf die Baugenehmigungsfeststellung nehmen, wird eine Optimierung des Baugenehmigungsverfahrens in den Behörden angestrebt. Es werden die komplexen Bereiche, wie die Gesetzeslage, der Einsatz von Technologie aber auch die subjektiven Handlungsalternativen, ermittelt und strukturiert. Mit der Entwicklung eines Modells zur Feststellung der Baugenehmigungsfähigkeit wird sowohl ein Verständnis für Einflussfaktoren vermittelt als auch eine Transparenzsteigerung für alle Beteiligten geschaffen.

Neben einer internationalen Literaturrecherche diente eine empirische Studie als Untersuchungsmethode. Die empirische Studie wurde in Form von qualitativen Experteninterviews durchgeführt, um den Ist-Zustand im Bereich der Baugenehmigungsverfahren festzustellen. Das erhobene Datenmaterial wurde aufbereitet und anschließend einer softwaregestützten Inhaltsanalyse unterzogen. Die Ergebnisse wurden in Kombination mit den Erkenntnissen der Literaturrecherche in verschiedenen Analysen als Modellgrundlage aufgearbeitet.

Ergebnis der Untersuchung stellt ein Entscheidungsmodell dar, welches eine Lücke zwischen den gegenwärtigen Abläufen in den Baubehörden und einer Gesamtautomatisierung der Baugenehmigungsprüfung schließt. Die prozessorientierte Strukturierung entscheidungsrelevanter Sachverhalte im Modell ermöglicht eine Unterstützung bei der Baugenehmigungsfeststellung für

Prüfer und Antragsteller. Das theoretische Modell konnte in Form einer Webanwendung in die Praxis übertragen werden.

Table of contents

List of figures

List of tables

List of abbreviations

ACCC	Automated Code Compliance Checking
AIA	American Institute of Architects
BauGB	Building Code (in German: *Baugesetzbuch*)
BauNVO	Land Utilization Ordinance (in German: *Baunutzungsverordnung*)
BauVerfV	Building Procedure Ordinance (in German: *Bauverfahrensverordnung*)
BBSR	Federal Institute for Research on Building, Urban Affairs and Spatial Development (in German: *Bundesinstitut für Bau-, Stadt- und Raumforschung*)
BCA	Building and Construction Authority Singapore
BCF	BIM Collaboration Format
BIM	Building Information Modeling
BIMiD	BIM in Germany Consortium (in German: *BIM in Deutschland Konsortium*)
BMVI	Federal Ministry for Digital and Transport (in German: *Bundesministerium für Digitales und Verkehr*)
B-Plan	Development Plan (in German: *Bebauungsplan*)
BPMN	Business Process and Model Notaton
cm	Centimeter
DIBt	Deutsches Institut für Bautechnik
DIN	Deutsches Institut für Normung e. V.
eBG	Elektronisches Bau- und Genehmigungsverfahren
EGovG	EGovernment Act (in German: EGovernment-Gesetz)
EN	European Norm
EnEV	Energy Saving Ordinance (in German: Energieeinsparverordnung)
EUnet4DBP	European Network for Digital Building Permit
FK	Form of communication (in German: *Form der Kommunikation*)
GG	German Basic Law (in German: *Grundgesetz*)
GIS	Geoinformation System
HOAI	Fee structure for Architects and Engineers (in German: *Honorarordnung für Architekten und Ingenieure*)
ICC	International Code Council
IDM	Information Delivery Manual
IEC	International Electrotechnical Commission
IFC	Industry Foundation Classes
IS-Argebau	Information System of the Conference of Construction Ministers (in German: *Informationssystem der Bauministerkonferenz*)
ISO	International Organization for Standardization
IT	Information Technology
LOB	State Building Code (in German: *Landesbauordnung)*
LOD	Level of Development
m	Meter

MA	Employees (in German: *Mitarbeiter*)
MBauVorlV	Model Construction Documents Ordinance (in German: *Musterbauvorlagenverordnung*)
MBeVO	Model Ordinance on Places of Accommodation (in German: *Muster-Beherbergungsstättenverordnung*)
MBO	Model Building Code (in German: *Musterbauordnung*)
M-PPVO	Model Ordinance on Inspection Engineers and Inspection Experts (in German: *Muster-Verordnung über die Prüfingenieure und Prüfsachverständigen*)
MVD	Model View Definition
MVStättVO	Model Ordinance on Places of Assembly (in German: *Muster-Versammlungsstättenverordnung*)
n	Variable for a natural number
NIBS	National Institute of Building Sciences
NKB	Nordic Committee on Building Regulations
OZG	Act to Improve Online Access to Administrative Services (in German: *Gesetz zur Verbesserung des Onlinezugangs zu Verwaltungsleistungen*)
PPVO	Ordinance on Inspection Engineers and Inspection Experts (in German: *Verordnung über die Prüfingenieure und Prüfsachverständigen*)
SP	Parking space (in German: *Stellplatz*)
ThürBO	Thuringian Building Code (in German: *Thüringer Bauordnung*)
TMBLM	Thuringian Ministry for Construction, State Development and Media (in German: *Thüringer Ministerium für Bau, Landesentwicklung und Medien*)
TMBV	Thuringian Ministry of Construction and Transport (in German: *Thüringer Ministerium für Bau und Verkehr*)
TöB	Agencies of public interest (in German: *Träger öffentlicher Belange*)
VDI	Society of German Engineers (in German: *Verein Deutscher Ingenieure*)
VfdB	German Fire Protection Association (in German: *Vereinigung zur Förderung des Deutschen Brandschutzes e. V*.)
VwVfG	Administrative Procedure Act (in German: *Verwaltungsverfahrensgesetz*)
WE	Housing unit (in German: *Wohneinheit*)
XML	Extensible Markup Language
ZS	Timestamp (in German: *Zeitstempel*)
3D	Three-dimensional

1 Introduction

1.1 Initial situation and motivation

Building regulations exist all over the world; whether in the historic city center of Weimar (Germany) or in the mid-century modern style of Palm Springs, California (USA). What seems so supposedly simple and coherent is in reality a complex construct of interdisciplinary content and systems.

In Germany, seemingly everything is regulated and prescribed by legalities. Especially in public service institutions, this is taken for granted. It is more astonishing that the processes of review procedures for building permitability[1] in building supervisory authorities[2] are not subject to any legal regulation. The review procedure is thus solely dependent on the organization and structure of the respective authority. These are given a certain amount of discretional action. Looking at the operational level of the building permit authority, there is also a discretion or scope for decision-making in the individual examination of building projects. Undoubtedly, all these decisions are within the framework of the applicable law of the Federal Republic of Germany, written down in legal texts or resulting from court rulings. It is precisely this individuality that distinguishes construction projects from serial production in the automotive industry, for example, and makes standardization difficult.

In addition to the fundamental right of freedom of ownership under Article 14 of the German Basic Law (GG)[3], there is a general prohibition to build in Germany with the reservation of a permit and the associated observance of the various regulations. Permissions are obtained by means of a building permit. Obtaining a building permit is therefore essential for the implementation of a building project[4].

In 2019, 222,678 building permits were issued for buildings and construction projects in building construction in Germany. Of these, approximately 66% were issued for the construction of new buildings, while approximately 34% of construction projects are attributable to an existing building.[5]

[1] Definition of building permitability: **Building permitability** refers to conformity of a building project in accordance to legal requirements. It describes the ability to obtain a building permit. It serves to ensure a legal condition in the building environment.
The **determination of the building permitability** (also building permit determination) is the examination and assessment of the documents submitted to the building permit authority by authority employees as decision-makers.

[2] Definition of building permit authority: Building supervisory authorities and synonymous, state-specific designations are referred as **building permit authorities**. This is where the building permitability is determined.

[3] GG (2019), Art. 14

[4] Wirth and Schneeweiß (2016), p. 2

[5] Destatis (2020)

Despite this high workload for the building permit authorities, the process turns out to be conventional and fraught with lengthy interactions[6]. The value of efficient permitting would be of great importance to all parties involved[7].

Due to deregulation and staff shortages in the public sector, the importance of automated processes is steadily increasing. In the course of the current and worldwide digitalization of industry and economy, a consideration in this direction is obvious. However, the construction and real estate industry is still at the beginning.[8] Nevertheless, the introduction of the Building Information Modeling (BIM) methodology in particular will have an impact on the processes of building permit authorities in the future[9], and thus opens up potential for research approaches in this area.

A special feature of the consideration of the official point of view, in contrast to the optimization intentions of a private enterprise, is that there are **no monetary incentives regarding the gaining of a profit**. At the very least, the reviewing building officials[10, 11] have no economic advantage or disadvantage as a result of their decision. Only the enforcement of objectives in the **interest of society** and public interest forms the basis for decisions.

The research topic pursues an **interdisciplinary approach**. It combines aspects of architecture and civil engineering (in particular construction management and construction informatics), as well as law and public administrative sciences.

1.2 Problem statement

The development of **property prices** increases the pressure on builders and project developers to exploit building law. This leads to increased uncertainty in building permit authorities. In turn, decisions become more difficult. This is accompanied by high workload and increase in processing and decision-making time. This problem is exacerbated by a **high number of building applications**.

[6] Ponnewitz (2019), p. 234 ff.
[7] Schulte (1996), p. 212
[8] BBSR (2019), p. 96 ff.
[9] Green (2016), p. 233
[10] Definition of building official: When the term **building official** is used, this includes all members within building permit authorities (e.g., heads of office), unless this is more specifically indicated.
[11] It should be noted at this point that, for reasons of readability, the feminine or masculine spelling is used. It is representative for both terms. (This note mainly refers to the German original text.)

In construction project management, the building permit phase is usually an **obscure component** that is difficult to assess in terms of time, and thus also in terms of the financial planning and coordination of a construction project.[12] **Delays** begin, for example, with an incomplete application form.[13] The lack of cohesion in aspects of building permit law leads to a loss of transparency, and delays.[14]

The German building permit process has long been fraught with **difficulties.**[15] To counteract these, there have been various amendments made to building regulations in recent years. In the state of Thuringia (Germany), statistical data was collected in 2006 and 2009 on the experiences of the 28 Lower Building Supervisory Authorities (in German: *Untere Bauaufsichtsbehörden*) there, as well as on the state administrative office, as the upper building supervisory and opposition authority. Further authorities were given the opportunity to comment.[16] The objectives of the amendment included concentration of official activities on essential core areas, reduction of sovereign inspection, and reduction of monitoring activities; strengthening of personal responsibility of building owners and other parties involved in construction projects; and simplification and acceleration of building permit procedures. However, the user-friendliness of the legal text was also a concern with the amendments. Building permits should no longer serve as a clearance certificate for all laws under public law, but should confirm conformity of the project to regulations.[17]

The survey identified various **problems in practice**. For example, building owners and planners lack a sense of responsibility for compliance with requirements. This was stated by 88% of research respondents in 2006 and 68% in 2009.[18] In addition, many respondents complain about the inadequate qualifications of many architects (79% in 2006, 36% in 2009).[19] Additional demands are made in 50% of building applications[20]. Other problems include quality of planning, assessment of building classes, classification of special buildings, and assignment of the correct type of procedure.[21] Although it can be assumed, regarding aspects relevant to building permits, that an increase in familiarity and wealth of experience have been developed as years go by; the examination of building documents remains, for the time being, a challenging and time-consuming activity.

[12] Müller et al. (2017), p. 15
[13] IT-Planungsrat (2016), p. 61
[14] Icks and Richter (2001), p. 34
[15] Schulte (1996), p. 206 f.
[16] TMBLM (2009); TMBV (2006)
[17] TMBLM (2009), p. 3 f.; Hannewahr (2011), p. 9
[18] TMBV (2006), p. 7; TMBLM (2009), p.6 f.
[19] TMBV (2006), P. 7; TMBLM (2009), P. 7.
[20] TMBLM (2009), P. 30
[21] TMBLM (2009), p.12 ff.

Reduction in staff and **shortage of skilled workers** is another major problem for building permit authorities.[22] An increased need for streamlined building permit processes also exists at the international level. A study conducted in 2014 by the International Code Council (ICC) and the National Institute of Building Sciences (NIBS) found that 30 percent of staff in U.S. building permit authorities will reach retirement status in the following two years, and over 80 percent by 2029.[23] Recruiting professionally adequate replacements is a major problem internationally.

Collaboration with the approving authority is a special aspect of the planning process compared to other service phases, as it involves coordination with non-contractually-bound partners. This poses problems, particularly with regard to **digitalization.** Currently, interactions with authorities in this context only take place in individual cases. This contradicts the idea of integrative and information loss-free data exchange with BIM.[24]

There are currently many discussions in the press about who is responsible for the insufficient building activity, and thus for the **prevailing housing shortage**. Building permit authorities an building regulations are also being targeted.[25,26]

These assumptions are due to the fact that **building regulations are** becoming more **extensive and complex,** and thus necessitate constantly expanding, expert knowledge.[27] The **multiplicity** of building regulations increases the difficulty in dealing with them. For example, it is almost impossible for a foreign planner (without the help of local colleagues) to handle a project efficiently with the aim of obtaining building permits.[28] To some extent, this is also true when working in different states or provinces.

Another aspect that contributes to the unrecognized complexity of the issue is **decision-making scope**. For example, **subjectivity arises repeatedly** in determining one's ability to obtain a building permit. Often, builders view obtaining a building permit as an act of grace. For example, Hauth writes, "only

[22] TMBLM (2009), p. 11 ff.; Pezzei (2019), p. 10 f.; Etscheid (2018), p. 126.
[23] NIBS (2014), P. 2.
[24] Ponnewitz (2019), p. 237 ff.
[25] Definition of building regulations: The term **building regulations** serves as a collective term for all kinds of regulations related to buildings (laws, ordinances, statutes, etc.).
[26] Anlegen in Immobilien (2019)
[27] Nawari and Alsaffar (2015), p. 167
[28] Icks and Richter (2001), p. 34

those who are fortunate enough to encounter a good-humored and benevolent building official will get the building permit they desire"[29].

1.3 Objective

Up to now, relatively little importance has been attached to analysis of building permit phase in project management. This concerns project developers in terms of achieving the right to build. Especially in the building permit authorities themselves, there is need for action[30]. Thus, the work presented here begins with a substantive-organizational consideration of building permit procedures. In doing so, it addresses the concern not only of advancing digitalization and integrating automation, but also of improving the entire procedure[31].

The aim is to present a model of the **interaction of processes and review contents** relevant to building permits that is efficiently tailored to the modern possibilities of digital representation and communication. The aim is not to provide an exhaustive list of all building regulations and the criteria contained therein, but rather to support the determination of approvability. The model can be described in the form of a **process-oriented decision model.** It thus represents an image of **complex, cross-regulatory issues**. Not every decision can be determined in advance, but its **transparency** can be improved by a supporting model. A model also creates an awareness of issues, which feeds into decisions. This can strengthen **intersubjectivity**[32] within stakeholders, which in turn increases satisfaction with decisions.

The model addresses organizational structures as well as technical aspects. Among other things, the identification of legislative objectives[33] and the handling of subjectivity play a role. The model also considers the integration of digital building models in the sense of BIM. The proposed approach does not look for a solution in the adaptation of building regulations, but rather in the handling of processes. Primarily, the model should provide assistance to the authorities themselves. A standardized model ensures uniform and consistent processing, and thus offers potential for process optimization.

[29] Hauth (2019), p.21 (translated from the original German)
[30] Schulte (1996), p. 91 ff.
[31] Pezzei (2019), p. 10 f.
[32] Definition of intersubjectivity: **Intersubjectivity** refers to an agreement between different parties, so that a complex fact is understood and comprehended equally by several parties. Nevertheless, it does not express a general, indisputable and formally provable statement.
[33] Definition of legislative objectives: The term **legislative objectives** represents the objectives of all building regulations.

1.4 Description of research needs

The research to date on building-permit-relevant, system-oriented project management is not sufficient. Research approaches primarily consider overall automation, although fundamental approaches have not yet been sufficiently scientifically investigated.

Of scientific relevance is the **determination of fundamentals,** as well as the analysis of symbiotic compatibility of legal, constructional, and administrative aspects. In the form of an empirical study, data is to be collected and evaluated for this purpose, whereby the actual state as well as all influences can be determined and delimited. The consideration of procedural, structural, as well as subjective aspects in the determination of building permitability represents a particular challenge. The aspects projection into a decision model is at the core of this investigation. The evaluation of BIM conformity in internal processing of building applications by authorities is another pillar of this research.

In order to achieve the desired objectives on a scientific level, the following research questions are outlined:

1. How can the determination of building permitability be **described in general terms**?
    a. What methodology can serve as basis for a description to determine building permitability?
    b. What are the detailed processes for determining ability for building permits?
    c. What aspects influence the processes for determining ability for building permits?
    d. How can digital methods impact the determination of building permitability?
2. How can a **decision-making scope** be integrated into this description?
    a. In what form do subjective aspects exist in building permit determination?
    b. How can subjective aspects in the building permit process be interpreted and presented?

1.5 Delimitation

The present work is a **substantive-organizational consideration** in the sense of construction management. Although it is characterized by legal and informatics influences; computer science, law, and public administrative sciences are not the focus.

Particularly relevant to achievement of objectives is examination of the **building permit procedure** in **building permit authorities**. Other activities such as building design, building inspections, preliminary inquiries or archiving are not considered. The perspective of building officials in building permit authorities is authoritative. It is natural, however, for an applicant to try to anticipate the possible decision-making processes of the building permit authorities throughout the course of permit planning. Thus, the results also represent a significant advantage for designing architects.

Although international tangents are also included, the **current legal conditions in Germany** form the basis of the study. In this context, public building law is decisive. In the case of planning law, this is specified by the planning code (BauGB) and, in part, by the building utilization ordinance (BauNVO); while in the case of building law, the model building code (MBO) is used. In a few cases, state-specific building regulations are used – predominantly the Thuringian building code (ThürBO).

Building and construction projects and **new building projects** form the core of the work**.** Furthermore, the focus is on construction projects that require a **comprehensive building permit procedure**; such as multi-story residential construction or special buildings of various kinds. For better illustration, an example project is used. **General statements are fundamentally made, which can be adapted** to any type of building or building project. In this context, both substantive and formal law are considered; with the focus on substantive law. Building permit determinations **outside regular cases** are the focus. Fees and time limits in building permit procedures are not included in this work. Other legal aspects such as urban land use planning, regional planning law, and ancillary building law are not considered in the context of the work.

Furthermore, there is a restriction on the involvement of numerous **agencies of public interest** (TöB). These are only touched upon and mentioned by way of example as relevant contributors in the building permit procedure. These also include inspection engineers and inspection experts, or neighbors.

In addressing BIM, only the principles and research approaches relevant to determining building permitability are considered. In this context, Automated Code Compliance Checking (ACCC) is worth

mentioning. However, a full analysis of the problem in connection with computer-interpretable legal texts is not the subject of this work.

1.6 Methodology

Figure 1schematically demonstrates the structure and organization of this work. An introduction in **Chapter 1** is followed by an examination of interdisciplinary theories and foundations in **Chapter 2**. The basis of the thesis is formed by system and model development, as well as project and process management and decision theory. Under the focus on subjectivity and quality, informatics and legal perspectives are incorporated in addition to commentary on terminology. These range from fuzzy logic to methods of legal norm interpretation.

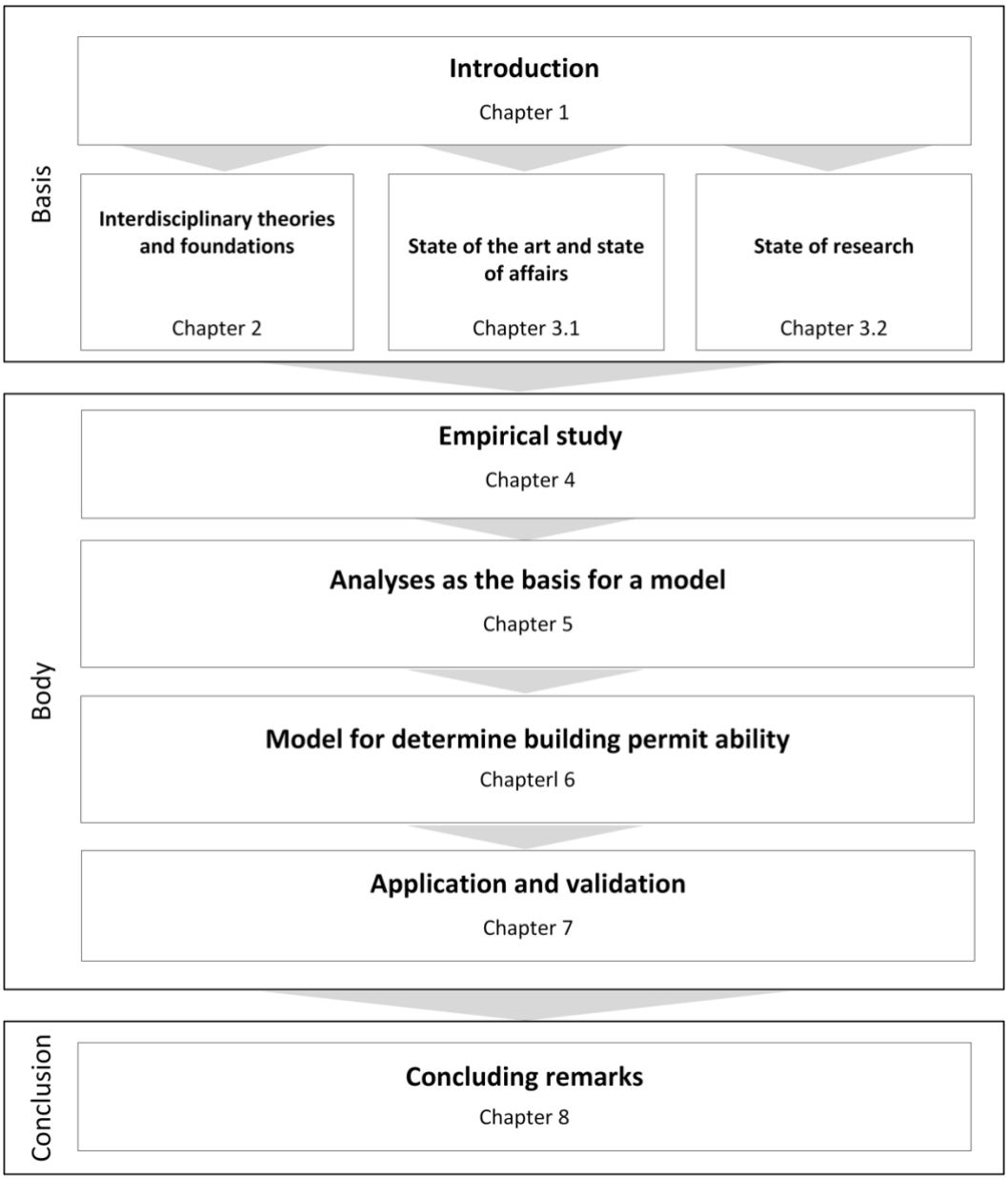

Figure 1 - Schematic overview of the dissertation[34]

Integration of digitalization is essential to the topic. Thus, the state of the art is given in **Chapter 3**. First, essential aspects of BIM are presented, followed by an introduction to the building permit legal environment. In state-of-the-art research, a combination of the two aforementioned topics - the BIM-oriented[35] building permit – is sought after. Based on an internationally oriented literature study, relevant research approaches in this regard are presented.

[34] Own illustration

[35] Definition of the term BIM-oriented: **BIM-oriented** is understood as something that is based on the BIM method, or uses a BIM model as well as aspects that are under the influence of the BIM method. The orientation can only be supportive, and is not to be equated with automation.

The empirical study in **Chapter 4** on building permit processes is justified by the need to identify the actual processes within building permit authorities. On the one hand, documentation of qualitative factors in the form of field research is necessary; on the other hand, the data must be interpreted and transferred into a scientific context. As a result, processes and structures are visualized. Furthermore, the empirical study provides information about sensitivities, concerns, and potential for improvement.

Chapter 5 presents findings in areas of official structures, building permit processes, building regulations, and objectives; as well as subjective aspects. Additionally, facts relevant to building permits are transferred to the BIM application profile; thus laying the foundation for the model to be developed.

Chapter 6 contains a description of the model. An explanation of the structure and desired intentions is followed by the actual model development. Product, target, actor, and action system are described theoretically. Influences such as external factors, subjectivity and legislative objectives expand the model. Finally, synergies and interactions within the model are discussed.

Chapter 7 shows how the model can be validated and transferred into practice. A web application is presented for this purpose. A building permit determination is simulated and evaluated using a demonstration.

Chapter 8 provides a summary of the results. In addition, an outlook of the remaining research needs is given, so that future approaches in science and industry can build on this work.

2 Interdisciplinary theories and foundations

2.1 System and model development

Issues in civil engineering are complex constructs. A multitude of problems and their connections to each other and to surrounding aspects make a simple representation impossible. Systems theory approach deals with the representation of such constructs. In doing so, the issues are described as systems (and represented as models). Descriptions take into account all interrelationships, but only as far as necessary (and not as possible). The aim is to understand a comprehensive problem and not an individually considered, separated subarea. Thus, a certain abstraction is made. This results in abstract systems that are problem-oriented and refer to a concrete issue or solution approach.[36]

There are various approaches to describe systems theory. Zangemeister captures in 1971 as follows: "Systems theory, together with systems research which complements it, is concerned with the task of explaining the behavior of phenomenal systems on the basis of different models by developing mathematically accessible models of ideal system types. All the knowledge gained in this process should serve to explain the structure, behavior and influencing parameters of systems in order to be able to control systems and to plan and introduce better systems for the future."[37]

The structure of systems basically always follows the same pattern. A system consists of elements (also entities or objects), the relationships between them (also relations), and attributes. The elements have properties that are described by qualitative or quantitative parameters, by means of the attributes.[38] Relations between elements give a system order, as can be seen schematically in Figure 2The sum of all elements and relationships is called structure. Often a system consists of several systems, called subsystems. Furthermore, a subdivision of system hierarchy into several levels is possible. The set of all elements and relationships outside the system is called environment. Elements outside the system can have an influence on it.[39]

[36] Kochendörfer et al. (2018), p.13 ff.
[37] Patzak (1982), p. 11 after Zangemeister (1971) (translated from the original German)
[38] Schneeweiß (1991a), p. 18
[39] Kochendörfer et al. (2018), p. 13 ff.

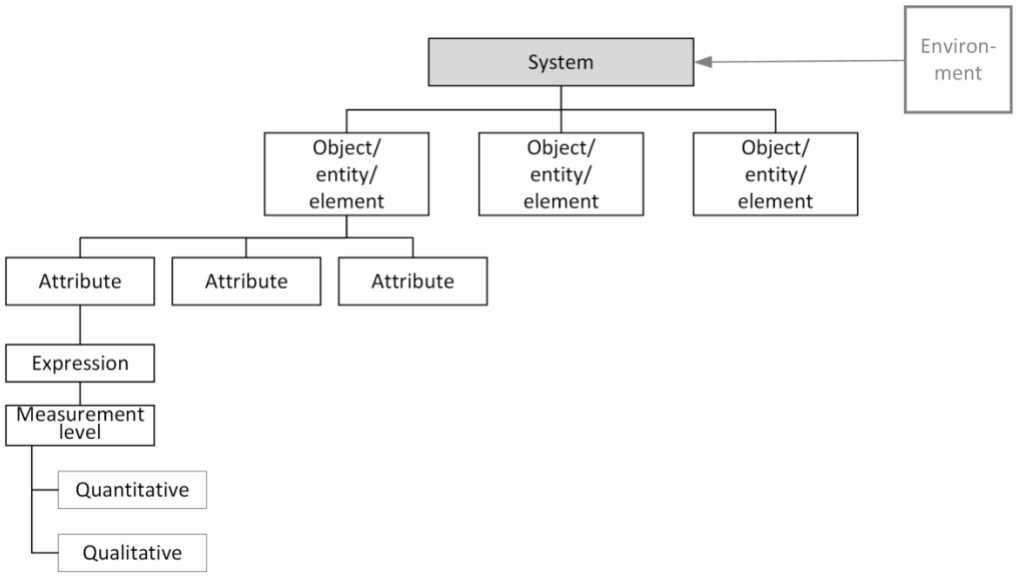

Figure 2 - Schematic overview of a system structure[40]

The delineation between system contents and system environment is a lengthy process, as the system description may need to be adjusted several times.[41] A system is determined by its problem definition and its purpose. The depth of consideration of the system is also related to the purpose of the system. The properties of the system serve its description, but are never complete.[42] In order to clearly represent the necessary facts of a complex construct, the methods of decomposition, hierarchization, or operationalization are suitable. As consequence, subsystems are developed as subsystems of an upper system.[43] Figure 3shows a schematic representation of this method. In this process, subdivisions are made until sufficient knowledge and experience are available for the specific purpose.[44]

In system development, it is often necessary to proceed operationally.[45] According to Brandenberger and Ruosch, three components must be considered in the approach: (1) One should proceed from the rough to the detailed. Notably, all general targets are set up first before being concretized step by step. (2) Structuring in phases should be considered, where a division into different stages aids clarity. (3) The **problem-solving cycle** describes the approach to solving problems, which consists of the steps of situation analysis, target formulation, synthesis and analysis, evaluation, and selection/decision.[46]

[40] Own illustration based on Schneeweiß (1991a), p. 18 ff.
[41] Patzak (1982), p. 25 f.; Aggteleky (1989), p. 97; Kaestner (2003), p. 97
[42] Dangelmaier (2003), p. 6 f.
[43] Patzak (1982), p. 42 ff.; Schneeweiß (1991b), p. 62
[44] Dangelmaier (2003), p. 11 ff.
[45] Schneeweiß (1991a), p. 28 ff.
[46] Brandenberger and Ruosch (1996), p. 13 ff.

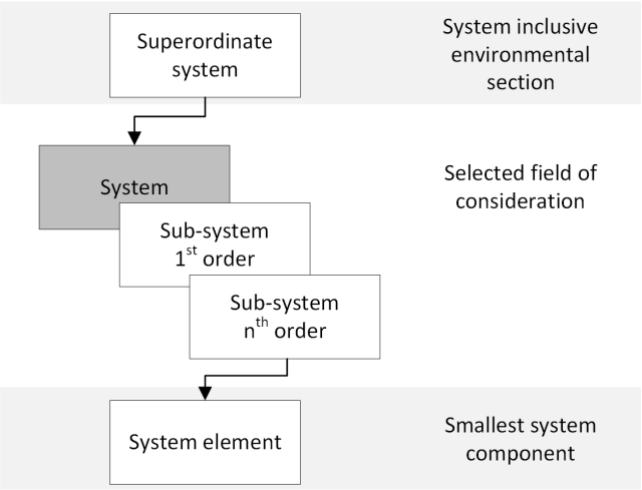

Figure 3 - Methodology for the decomposition of a system[47]

Furthermore, for a graphical representation, a distinction is made between the two structure types, namely the structure system and the flow system. The **structure system** represents the factual connections between the relevant points in a hierarchical structure, whereas the **flow system** describes the logical and temporal connection to the target achievement on a procedural level.[48]

With regard to problem solving, a system can essentially be divided into four system typologies: the target system, the action system, the actor system, and the product system.[49] Table 1presents these system typologies with explanations. The different system typologies can be integrated as subsystems into an overall system. Figure 4an example of a system for construction projects along with its subsystems. The consideration of a system under the consideration of problem-solving processes – and thus a practical approach – is called system engineering.[50]

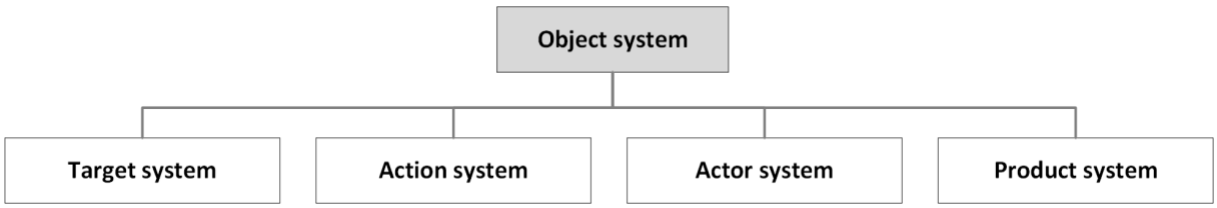

Figure 4 - Schematic overview of an object system[51]

[47] Own illustration based on Patzak (1982), p. 43
[48] Schneeweiß (1991a), p. 24; Kochendörfer et al. (2018), p. 16
[49] Kochendörfer et al. (2018), p. 16 f.
[50] Ropohl (2012), p. 34
[51] Kochendörfer et al. (2018), p. 18

Table 1- Overview of system types[52]

System types	Explanations	Appearance Examples	Structural form
Target system (Needs)	Summary of states to be aimed at, result of action as the planned final state	Requirements specification, requirements description	Structure
Action system (Tasks)	Summary of the actions required to achieve the targets	Project, program, process	Flow
Actor system (Organizations)	Supporter of the activities, executing unit of the action system for achieving the targets	Organization, agent, instrument, material resources	Structure
Product system (Structural plant)	Impact object	Work object, result, object	Structure

In general, a **target system** can be described as a collection or outline of pursued targets.[53] As a rule, decisions are made to achieve targets. However, the knowledge of targets can open up new alternatives for action.[54] Targets are preferably mapped in hierarchies[55] in a vertical or horizontal order. In the vertical target order, the overall targets are ordered into operational, preferably qualitative and quantitative subtargets and individual targets. This creates a means–purpose relationship as an interaction between targets of different hierarchies. Subtargets are thus means for the next higher targets, which in turn are means for their respective higher targets up to the highest overall target. In horizontal target ordering, the targets are at the same level of the hierarchy. The relationships between the targets at one level exhibit greater completeness and freedom from overlap (disjunction).[56]

Models serve to illustrate complex facts and to improve the clarity and communication of systems. In scientific terms, a model is an object or a structure that depicts or (schematically) illustrates (and simplifies or idealizes) the inner relationships and functions of something.[57] Figure 5illustrates the principle that a model is a representation of a system.[58] Since it is not possible to capture all aspects in a model faithfully, models are abstracted.[59] Therefore, they represent reality in a simplified manner and follow the principle of abstraction.[60]

[52] Adapted from Kochendörfer et al. (2018), p. 17; Patzak (1982), p. 30 f.; Patzak (1989), p. 36.
[53] Dangelmaier (1999), p. 472
[54] Eisenführ and Weber (2003), p. 53
[55] Patzak (1982), p. 169 ff.; Eisenführ and Weber (2003), p. 62 f.
[56] Patzak (1982), p. 169
[57] Duden Online (2019), search term: model
[58] Schneeweiß (1991a), p. 53
[59] Laux et al. (2012), p. 26 f.
[60] Gadatsch (2017), p. 79; Kaestner (2003), p. 89

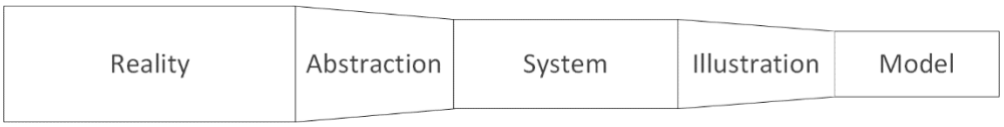

Figure 5 - Schematic representation of reality illustration[61]

2.2 Project management and process management

Already in 1996, Schulte described possibilities for accelerating construction projects within building permit authorities as well as their administrative organization. The use of project management is advisable for accelerating procedures. The professional competence as well as the rights and powers of individual project managers are decisive factors. The balancing of internal experience and expertise with external project management approaches is cited as key to accelerating procedures.[62]

Systems thinking is a suitable basis for **project management**. Complex issues and their relationships can be simplified and understood using a system. Project management can lead a target-oriented project through the systemic approach.[63]

Various definitions of project management exist. DIN ISO 21500 describes project management as the application of methods, tools, techniques, and competencies in a project. It continues as follows: "Project management is implemented through processes. The processes selected for a specific project should be coordinated from a systemic point of view. [...]."[64]

In addition to the variety of project management approaches that exist, the system-oriented project management approach is addressed in particular in the context of this work. This approach refers to the system-theoretical view of management with regard to an overall system along with its specific environment. The task of management consists of planning and controlling for the optimized achievement of system targets and the individual targets derived from them. To develop a system, a comprehensive overall picture of the situation and its environment is indispensable. According to Patzak and Rattay, due to the complexity and interdisciplinarity of project management, only the system-oriented approach does justice to this task.[65]

[61] Own illustration based on Schneeweiß (1991a), p. 53
[62] Schulte (1996), p. 99 f., p. 208
[63] Kaestner (2003), p. 103 ff.
[64] DIN ISO 21500 (2016), p. 10 (translated from the original German)
[65] Patzak and Rattay (2004), p. 33 f.

In terms of the BIM methodology, procedural thinking is an essential component of business processes. For the ideal use of BIM technologies, dealing with the actual processes is necessary for identifying and enabling implementation approaches.[66]

A **process** is a set of activities or functions. Processes serve to fulfill a task, which represents a service. This refers to incoming and outgoing data transformations. Connections between the processes can be made through various connectors.[67]

In a company, processes are operational tasks that denote a service for that company. Here, business processes are referred to. Such processes can be related to public institutions, which are also companies or enterprises in the broader sense. In public authorities, administrative tasks are thus completed, which result in a service for the respective authority or citizen.

The BIM methodology and business processes in terms of an optimized value chain correlate with each other. Thus, BIM process modeling describes BIM-related tasks and tools, the individuals responsible for executing them, and their sequence. This involves a full-scale reorganization and a BIM-based mindset, not just structuring of the data exchange.[68]

When considering processes, one must take the level of detail into account. Processes can be considered on different levels or in subprocesses (also partly processes). Thus, a process can be broken down into further processes, which creates process hierarchies.[69]

The identification of processes and subsequently of process structures is an essential part of **process management**. It is a complex undertaking, often requiring a great deal of effort or study. One reason is that individual employees are only aware of their own and surrounding processes, but these by no means represent completeness. If necessary, the view from the external side is target-oriented. The hierarchies described above should also be considered, as processes of different levels flowing together should be avoided.[70] The consideration of the different types of processes complicates this task even further. The structuring degree, knowledge and data intensity, repetition frequency, scope

[66] König (2015), p. 58 f.
[67] Allweyer (2005), p. 44 ff., p. 51 f.
[68] König (2015), p. 58 f.
[69] Allweyer (2005), p. 55
[70] Allweyer (2005), p. 59 ff.

and duration, as well as routine and exception processes are the most crucial criteria when distinguishing processes.[71]

Developing universally valid processes is difficult. Standardizing aspects such as people, targets, and technical components distorts the process structures, and therefore, it is useless for optimizing value creation in institutions.[72] In conclusion, processes must be developed individually.

In contrast to a process, a **workflow** describes a fully or partially automated process. Whereas the business process describes "what (is to be done)," the workflow depicts "how (it is to be executed)." Accordingly, an essential distinction is the level of detail.[73]

Process modeling is used to represent complex tasks with the help of processes and subprocesses.[74] Several different process representation models exist for this purpose. Business Process and Model Notation (BPMN) is an example of a control flow-oriented modeling method.[75]

In the present thesis, the **BPMN method** is focused on since it is widely used in the BIM area, and it is also particularly suitable for the representation of complex process structures.[76] In addition, the BPMN method is considered a normalized standard by ISO/IEC 19510, which is why uniformity in its application and understanding can be guaranteed. Above all, the target of process modeling with the help of BPMN is to ensure the traceability and transparency of the processes for optimized coordination and a trouble-free exchange of data and information.[77] A selection of symbols is presented in Figure 6For a clearer illustration, especially with long process chains, a vertical representation is partially used in this work.

[71] Allweyer (2005), p. 65
[72] König (2015), p. 72
[73] Gadatsch (2017), p. 12 f.
[74] König (2015), p. 59
[75] Gadatsch (2017), p. 81 ff.
[76] König (2015), p. 59, p. 63; Sacks et al. (2018), p. 99
[77] König (2015), p. 72

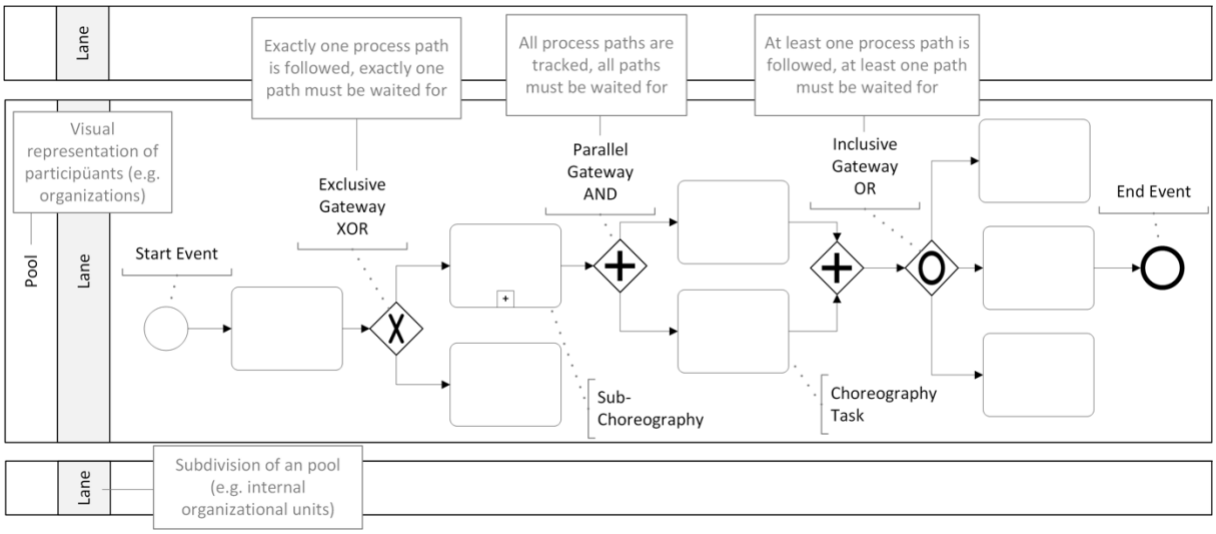

Figure 6 - Illustration of a selection of BPMN symbols[78]

2.3 Decision-making theory

Determining the ability to obtain a building permit involves a variety of decisions. A decision is a process of choosing between various alternative courses of action.[79] Decision-making theory does not dictate the decision-maker's choice, but rather provides assistance in "transforming one's own objectives into a system of objectives that is free of contradictions and then making a decision that is consistent with that system of objectives."[80] A decision alternative exists when at least two options exist and their outcome approximately satisfies the objective.[81]

Every decision is based on a decision field, which consists of the components of action alternatives, results, and environmental conditions. Environmental conditions represent all influences that affect the decision but cannot be influenced by the decision-maker. Action alternatives describe the possibilities from which decision-makers can choose. The outcome is the combined effect of action alternatives and environmental influences. Decision-makers are always guided by the targets and preferences for target fulfillment when determining the outcome.[82] A decision rule is a function that best meets the decision-maker's objectives. Figure 7presents a schematic representation of the basic elements of a decision model and clarifies the relationships between the components.

[78] Own illustration based on ISO/IEC 19510 (2013)

[79] Laux et al. (2012), p. 3; Goldbach et al. (2014), p. 39

[80] Laux et al. (2012), p. 5 (translated from the original German)

[81] Ibid.

[82] Eisenführ and Weber (2003), p. 9 f.; Laux et al. (2012), p. 29 ff.

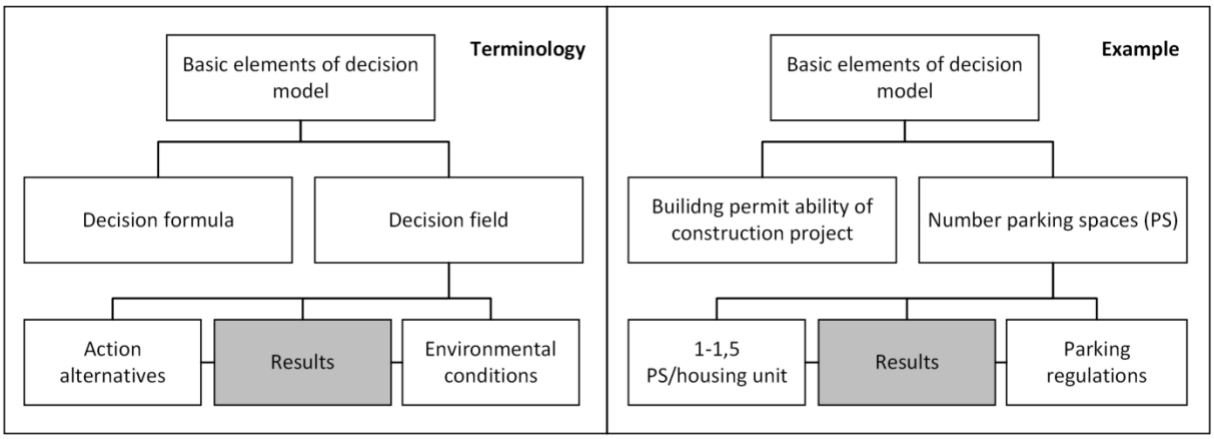

Figure 7 - Decision field – terms and example[83]

Decision models do not prescribe a decision, but rather they are aids in making the decision and serve as a preparation for it.[84] Decision models can appear in semantic, graphical, or mathematical form.

Decision models are divided into general and concrete decision models. General decision models refer to superordinate facts and are primarily described in a typified manner. By contrast, concrete decision models consider specified aspects and contain parameters belonging to the individual case. The general model forms the framework for a later specification.[85] Even if the decision-maker deviates from the proposed decision model, a preference for this over no decision model is nevertheless a given, since the process is made transparent and conscious simply by dealing with it. It then no longer comes to a purely intuitive decision.[86]

When setting up a decision model, the principle of simplification always applies. As much as necessary and as little as possible should be presented so that the specific facts can be analyzed and evaluated.[87] The decomposition of decision problems plays an essential role here.[88]

In decision-making theory, the **decision-making process** plays a critical role. Figure 8presents a summary of the decision-making process. These steps should be viewed as an overall process and not considered individually. Compliance with the sequence is not mandatory.[89]

[83] Own illustration based on Laux et al. (2012), p. 30
[84] Laux et al. (2012), p. 53 f.
[85] Laux et al. (2012), p. 19 f.
[86] Laux et al. (2012), p. 54
[87] Laux et al. (2012), p. 537 ff.
[88] Eisenführ and Weber (2003), p. 9
[89] Laux et al. (2012), p. 12 ff.

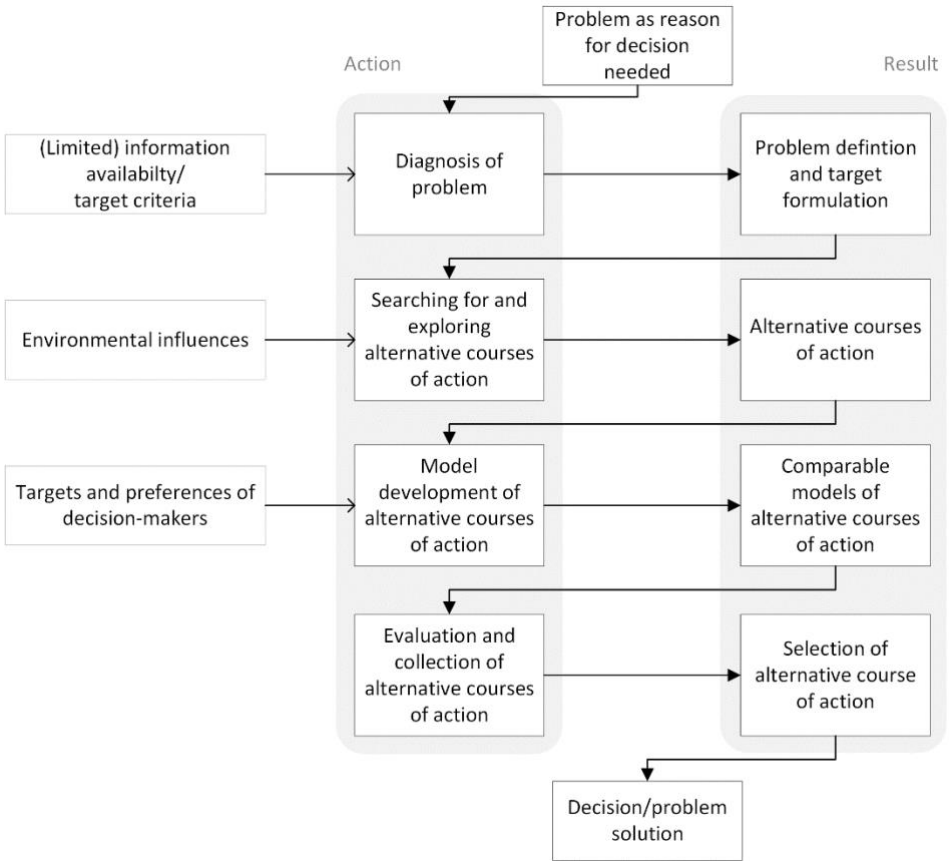

Figure 8 - Decision-making process[90]

A decision-making process begins with a problem as the reason for the decision. A deviation between the target state and the actual state is determined.[91] After the problem has been diagnosed, the target is formulated and the target state defined.[92] In this step, different levels of specification are possible.[93] According to Laux et al. the exploration of possible alternative actions is divided into the following three substeps:

1. Identify the restrictions on possible alternatives;
2. Search for alternatives; and
3. Forecast of the results of the alternatives.

An action alternative can always be to refrain from action. In this step, it is crucial to find suitable and realistic action alternatives. Furthermore, the evaluation and selection of an alternative action occur before the decision comes into effect in the realization phase.[94]

[90] Own illustration based on Laux et al. (2012), p. 12 ff.; Eisenführ and Weber (2003), p. 4 ff.; Goldbach et al. (2014), p. 39, p. 43

[91] Fauth (2017), p. 21

[92] Ibid.

[93] Laux et al. (2012), p.13

[94] Laux et al. (2012), p. 12 f.

Decision-making theory is divided into two main forms, namely descriptive and prescriptive. **Descriptive decision-making theory** examines the prevailing decisions and how people decide. Aspects such as the target formation of decision-makers and the effect on the process play a role. Descriptive theories are established through empirical research. Thus, real connections and variables can be identified.[95] By contrast, **prescriptive decision-making theory** provides recommendations on how to act or decide. This theory is derived through deduction (inference).[96]

The difficulty in setting up a decision model lies in the exploration of the decision-makers' target system and in assessing the relevance of the specific decision problem. The performance of a task is often intuitive without the ability to name a concrete target. Once this is known, the decision problem can be addressed.[97] Through normative foundations, a decision problem can be analyzed rationally and transparently.[98]

2.4 Subjectivity and quality

Subjectivity is omnipresent – in decisions, in systems, and in processes. For centuries, several disciplines have been concerned with the concept of the subject. Among them are theology, philosophy, jurisprudence, and sociology.[99]

2.4.1 Definitions

Subjective refers to something that is determined by personal feelings, interests, or prejudices. Subjective often also means biased, unobjective, or partisan.[100] Another definition describes a subjective action as one that emanates from a subject, or a decision-maker.[101] A person as a subject can never be entirely unbiased, as their presuppositions are always individual. Subjectivity is understood as the self-perception of a subject,[102] which must not be violated.[103]

[95] Schneeweiß (1991a), p. 85; Laux et al. (2012), p. 16 f.
[96] Schneeweiß (1991a), p. 85 f.; Laux et al. (2012), p. 16 ff.
[97] Laux et al. (2012), p. 18 f.
[98] Fauth (2017), p. 17
[99] Zima (2017), p. IX
[100] Duden Online (2019), search term: subjective
[101] Dangelmaier (2003), p. 5 ff.
[102] Frank (2012), p. 29, p. 353
[103] Ritter (1980), p. 11

Quality is formulated as the totality of the characteristic properties (of a thing).[104] However, in the context of a determination, this is always to be equated with a quality assessment.[105] DIN EN ISO 9000 describes the concept of quality as the conformity of services with claims.[106] Moreover, quality can be interpreted subjectively and objectively.[107]

A system and how it is handled will always be shaped by subjective decisions. "This subjectivity cannot and should not be eliminated, but merely made transparent."[108] Thus, decisions and decision models are influenced by a variety of **subjective factors.** Decision-makers as subjects vary in targets, experiences, levels of information, and skills, which all influence a decision. Thus, a decision model can never be completely objective.[109] A decision model should not exclude subjective aspects, but rather transfer them into a transparent value system, so that all participants are aware of the objectives and discourse is stimulated.[110,111]

Schneeweiß described and categorized subjectivity according to the degree of definiteness. Indeterminacy is subdivided into a lack of information and a lack of conceptual acuity. In this context, the degree of information, vagueness, and types of empirical facts are considered.[112] Vague facts, in the sense of fuzzy attributes (or even elements), are vital components of a system along with hard and solid facts and must not be neglected.[113]

With regard to the determination of the ability to obtain a building permit, both subjective and qualitative facts can be spoken of. The term subjective is used when facts with direct human influence are involved. The term qualitative is used when an assessment is not based on factual values and therefore does not have a quantitative character. Consequently, for example, qualitative content triggers a subjective decision.

[104] Duden-Online (2019), search term: quality
[105] Jura-Forum (2019)
[106] DIN ISO 9000 (2015)
[107] Gabler Business Dictionary (2019)
[108] Dangelmaier (2003), p. 5 ff. (translated from the original German)
[109] Laux et al. (2012), p. 54 ff.
[110] Fauth (2017), p. 19
[111] Eisenführ and Weber (2003), p. 10 f.
[112] Schneeweiß (1991a), p. 34 ff.
[113] Schneeweiß (1991a), p. 40 ff.

2.4.2 Uncertainty and fuzziness

In mathematics, the term uncertainty is often used. Hartmann and Lehner distinguished ambiguous facts into objective uncertainty and subjective uncertainty, as seen in Table 2.[114] This makes the variability and range associated with these terms clear.

Table 2 - Classification of uncertainties[115]

	Subjective uncertainty	Objective uncertainty
Characteristic features	The sensory processes of people are not standardized	Measurement errors and numerical inaccuracies
	Conceptual and linguistic uncertainties	Statistical statements
	Subjective perception and the resulting probabilities	Ignorance of parameters and general relationships

Something is called **fuzzy** if it cannot be unambiguously assigned (to an attribute). By contrast, in a binary system or in formal logic, all attributes can be assigned 0 or 1 and true or false. In the case of fuzziness, these would be, for example, "more," "a little," or "less." Uncertainty is thus also caused by unclear concept formation (e.g., in the case of attribute expression).[116]

Fuzziness can be argued and described through operationalization. This is referred to as **fuzzy logic** or fuzzy theory. Depending on the application, however, this is limited since subjective aspects always flow in. To be able to guarantee the target of mathematical assignment, a membership function is assigned to fuzzy objects in fuzzy logic. The membership function indicates how strongly an object belongs to the set of objects and which particular characteristic the object has. A set of fuzzy elements is called a fuzzy set, which has fuzzy, fluid boundaries, unlike a mathematical set. Furthermore, the characterization of simple relations with fuzzy conditional statements ("If A, then B") is used to describe them. [117]Vagueness and fuzziness can be used to describe the formalization of objects and processes through the use of fuzzy set theory to view them in an automated manner. [118]

For clarity, the following example is provided: According to the binary system, a construction project may or may not affect the surrounding development with noise. A boundary within a radius of 100 m is assumed. This is not plausible since only a few centimeters can make a difference. In terms of fuzzy logic, the surrounding development within a radius of 80 m could be classified as slightly impaired with a belongingness index of 0.2, and that within a radius of 20 m could be classified as severely impaired

[114] Styczynski et al. (2017), p. 78 after Hartmann and Lehner (1990)
[115] Ibid. (translated from the original German)
[116] Schneeweiß (1991a), p. 37 ff., Zimmermann and Gutsche (1991), p. 240 ff., Grauel (1995), p. 2 ff.
[117] Grauel (1995), p. 2 ff.; Zimmermann and Gutsche (1991), p. 240 ff.; Schneeweiß (1991a), p. 37 ff.; Styczynski et al. (2017), p. 89
[118] Styczynski et al. (2017), p. 87

with a belongingness index of 0.8. The situation is similar, for example, for the perception of temperature or colors. Figure 9presents the difference between fuzzy and non-fuzzy values.

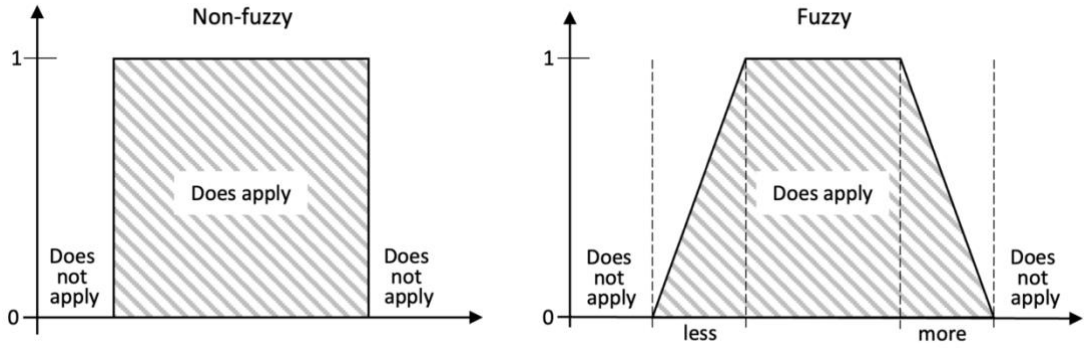

Figure 9 - Graphical example of fuzzy logic[119]

Fuzzy logic and other **expert systems** essentially deal with the content-considering knowledge processing of humans and its connection with computers. Accordingly, fuzzy logic emulates decision-making and human reasoning, with the aim of making linguistic statements computer-interpretable.

Procedural engagement with fuzziness can be understood in a variety of ways, such as in terms of fuzzy connections, fuzzy attribution, or fuzzy process levels. A concept can be described by considering fuzzy information (content expansion) using specific labeling.[120]

2.4.3 Legal scope and instruments

Leeway within the scope of the law extends to discretion, undefined legal terms, and the scope for assessment. These represent instruments of administrative action. In Germany, in contrast to various other countries, they are anchored in the building regulations. In terms of content, a distinction must be made between facts and legal consequences. This often results from the linguistic formulation of a legal text.[121] Basically, building regulations can be described as if-then rules; that is, "if the legal consequence is to occur, then the offence must be met."[122] Thus, the facts indicate the conditions that are decisive for the legal consequence to occur.[123] Figure 10classifies the legal scope and instruments with regard to the elements of offence and legal consequence.

[119] Own illustration based on Grauel (1995), p. 4
[120] Hüsselmann (2003), p. 199 ff.
[121] Brühl (2019), p. 19 ff. (translated from the original German)
[122] Müller (2010), p. 3 according to Zippelius (1999), § 5 p. 29
[123] Müller (2010), p. 3

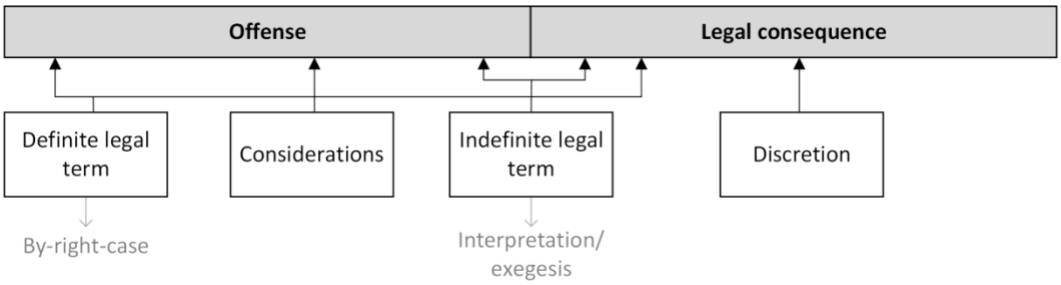

Figure 10 - Classification of legal scope and instruments[124]

Indefinite legal terms are words that are abstract, undefined, and ambiguous. They are also open to interpretation. They come into play on the factual side as well as on the legal consequence side. Their use by the legislator is aimed at achieving the objectives of the legislation. Decisions based on indeterminate legal concepts must be subject to judicial review.[125] The purpose of indefinite legal terms is not to grant a scope of discretion.[126]

Independently of indeterminate legal terms, **considerations** take place, and they are always found on the factual side.[127] Moreover, they are always applied on the basis of the individual case decision.

Leeway for assessment (in German: *Beurteilungsspielraum*) represents a special form in the sense of indeterminate legal concepts for which there must be a statutory basis for authorization and is subject to only limited judicial review.[128] Leeway for assessment is a special concept that must not be confused with general decision-making scope. Since it is an exception in jurisprudence, it is not considered further in the course of the present work.

In legal science, one method for dealing with and reasoning about indeterminate legal concepts is the **theory of legal norm interpretation.** This can also be understood as exegesis. In the literature, the canons of legal norm interpretation according to Friedrich Carl von Savigny (1779–1861) are mentioned as the origin of this method. The following four (modified) original and most important methods are applied according to today's jurisprudence[129]:

- Wording interpretation (grammatical interpretation);
- Teleological interpretation (meaning and purpose of the provision);
- Systemic interpretation; and

[124] Own illustration
[125] Hufen (2010), p. 606 ff.
[126] Hofmann et al. (2016), p. 135
[127] Ipsen (2001), p. 153
[128] Hofmann et al. (2016), p. 135 f.; Maurer (2006), p. 145 f.; Hufen (2010), p. 606 ff.
[129] Rüthers et al. (2018), p. 441; Reimer (2016), p. 136; Hildebrand (2017), p. 65; Lagodny (2013), p. 37

- Historical interpretation.

This method is neither laid down by law nor binding. Nevertheless, it is perceived by almost all legal practitioners as a guiding principle.[130] Other methods of interpretation include interpretation in conformity with the constitution and interpretation in conformity with directives.[131] The central objective of interpretation is always the purpose of the norm (teleological interpretation). The other kinds of interpretation are to be understood as a means of identifying the purpose of the norm.[132]

In the context of building law, different views arise in the interpretation. An objective interpretation is not possible. Even a supposedly objective interpretation corresponds only to the individual subjective regulatory ideas of the decision-maker.[133] This suggests a concretization; however, arming the already complex legal texts with such concretizations would lead to overload as well as increased confusion. Notably, the standard to be met would fall short of the technical possibilities. At the interface between technology and law in particular, the legislator is reliant on indeterminate legal terms.[134]

According to § 40 of the Administrative Procedure Act (VwVfG), **discretion** is incumbent on the building officials in the authority.[135] The limits of discretion range between the principle of equal treatment[136] and the principle of proportionality.[137,138] Decision-makers are not entitled to free choice or arbitrariness. Decision-makers must act in accordance with the purpose of the discretionary entitlement and comply with the legal limits.[139,140]

Discretion is divided into two forms: the discretion to decide whether to apply discretion and, if so, the discretion to choose how to apply it. Discretion is exercised solely on the legal consequences side. The purpose of discretion is based on the justice of the individual case and the optimization of the purpose. It is necessary to find appropriate and relevant solutions in the individual case or to differentiate the norm's purpose with regard to the individual case. Discretion is expressly granted in the norm. This can be achieved linguistically through terms such as "can," "may," or "is empowered," or it can be

[130] Rüthers et al. (2018), p. 441
[131] Reimer (2016), p. 119; Hildebrand (2017), p. 65
[132] Rüthers et al. (2018), p. 452
[133] Rüthers et al. (2018), p. 449
[134] Schulte (1996), p. 161 f.
[135] VwVfG (2019), § 40
[136] GG (2019), Art. 3 para. 1
[137] GG (2019), Art. 20 para. 3
[138] Hofmann et al. (2016), p. 139
[139] VwVfG (2019), § 40
[140] Hofmann et al. (2016), p. 142; Maurer (2006), p. 140; Storr and Schröder (2010), p. 96

understood from the context. A deviation can only be considered in exceptional cases with justification. A discretion is always within the statutory framework and its legality is subject to judicial review.[141] If discretion can be applied, then decision-makers are obliged to do so or to weigh up.[142] Errors of discretion and their legal consequences as well as similar aspects are not considered further in this work.

Other forms of leeway, such as political decision-making and design leeway due, for example, to economic intentions, are not discretion in the aforementioned sense[143] and thus are not considered. The legal scope and instruments embody an essential aspect in the determination of building permits and are summarized as **decision-making scope** hereinafter.

2.5 Summary of the basic theories

Complex issues can be described by systems and represented with the help of models. The structuring of information of various kinds in a model and the implementation of processes are just as possible as their interconnection. A decision model can never be completely objective, but it can use systems theory to lay a basis that is as objective as possible for the decision, thus striving towards the target of intersubjectivity. A qualitative decision by a human decision-maker will always be subject to its subjective influence. The consideration of subjective decisions is thus indispensable for the determination of the ability to obtain a building permit.

The **individuality** of each building project, based on the uniqueness of the combination of land and building, makes formulating a completely general model a particular challenge, since a general model does not occur in practice. The significance of individual case justice in the sense of building law thus gains importance. In dealing with individuality, system-oriented project management offers a well-founded basis as well as the potential for dealing with the scope for decision-making.

[141] Hufen (2010), p. 603 ff.; Brühl (2019), p. 27 ff.; Hofmann et al. (2016), p. 138 f.; Maurer (2006), p. 135 f.
[142] Grüner (2016), p. 230 f.
[143] Reimer (2016), p. 237

3 State of the art and research

3.1 State of the art

In this section, the main aspects of the topics of BIM (Section 3.1.1) and building permits (Section 3.1.2) are described. The aspects explained are relevant for understanding the following sections and approaches.

3.1.1 Building information modeling

3.1.1.1 Methodology and definition

"BIM refers to a collaborative **working methodology** by which, based on digital models of a building, the information and data relevant to its life cycle are consistently captured, managed and exchanged in transparent communication between stakeholders or handed over for further processing."[144] Consequently, the integration of the BIM methodology into building permit processes is a logical consequence and necessary for the value creation of digital models throughout the building life cycle.[145] The level of digitalization in the German construction sector generally still has considerable potential for optimization.[146] The "*Stufenplan Digitales Planen und Bauen*" (step plan digital planning and building) sees a need in Germany to develop and provide software-neutral checking rules.[147]

The BIM methodology must be distinguished from the actual **BIM model** or building information model. The BIM model is a data model that provides the geometric and semantic information of the building. A model enriched with relevant information will contribute to improved decision-making.[148]

3.1.1.2 Technical background

The **Industry Foundation Classes** (**IFC**) standard developed by BuildingSMART International is an open standard for the exchange of BIM data. IFC are standardized in ISO 16739:2017[149] and supported by common BIM software vendors. The current IFC version IFC 4 was released in 2013.[150] IFC follow an

[144] BMVI (2015), p. 4 (translated from the original German)
[145] Ponnewitz (2019), p. 236 f.
[146] Westphal and Hermann (2015), p. 3
[147] BMVI (2015), p. 13
[148] Hausknecht and Liebich (2016), p. 50 f.; NIBS (2019)
[149] ISO 16739 (2017)
[150] BuildingSMART (2013)

IFC schema. Interoperability, such as that between software packages or different lifecycle phases of a building, is a main advantage of the IFC standard.

IFC models are represented as entities, attributes, and relationships. An entity is a well-defined element described by attributes. The IFC standard supports objectified relationships that are represented as separate objects. An IFC model includes a semantic and a geometric description. IFC models can be exchanged using exchange formats, such as STEP or STEP-XML, both of which are standardized in ISO 10303.[151]

A **Model View Definition** (**MVD**) accesses a section of the IFC schema. It is a part of a data model, where the information from the IFC that is stored or passed on is precisely regulated. MVDs specify a model part for the solution of a certain requirement.[152] The data model or the **model view** can be viewed with the help of a model viewer (also called a BIM viewer). Depending on the software application, other options for evaluating the data model can also be used, such as inserting comments or taking measurements. In doing so, the data and functionality of the model are not changed.[153] MVDs are standardized and described in DIN EN ISO 29481.[154] BuildingSMART is also developing standards for exchanging MVDs through an IFC interface.[155]

In a model-based permit process, a critical aspect is the **Level of Development** (**LOD**). The LOD determines the required depth of information, which can be used to determine the uniformity of the model. The American Institute of Architects (AIA) and the American BIM Forum have defined LODs.[156] In general, the level of detail for permit content in Germany is assumed to be LOD 300.[157] This corresponds to the information level of permitting plans (as part of the application documents).

The Association of German Engineers (VDI) describes the **BIM Collaboration Format** (**BCF**) as a "vendor-neutral data format for the exchange of coordination messages in change management between different BIM software products." The BCF is not used to exchange models, but rather

[151] ISO 10303 (2014)
[152] VDI 2552 (2018), p. 6; Beetz et al. (2015), p. 130 ff.; Borrmann and König (2018), p. 1481
[153] VDI 2552 (2018), p. 4
[154] DIN EN ISO 29481 (2018)
[155] BuildingSMART (2020a)
[156] AIA (2013); BIM Forum (2019)
[157] Autodesk (2018), p. 15

information such as location, perspective, affected objects, or texts.[158] It can be considered equivalent to the two-dimensional revision cloud.[159]

Model checking describes an automated check of regulations based on a BIM model. Geometric, semantic, and linked information is compared according to its conformity with, for example, building regulations. The main challenge is to translate the regulations into a computer-interpretable language. A standardized and structured data model is an ideal basis for a uniform comparison. Due to numerous requirements on and pieces of information in the data model in the form of detailed component or element descriptions, high degrees of complexity and creation effort arise. A provision is nevertheless desirable because a uniform automated conformity check can then be conducted. The application possibilities of model checking are manifold. The verification of country-specific building regulations within the scope of the building permit is just one example.[160]

Eastman et al. described a rule checking system as the basis of **Automated Code Compliance Checking** (**ACCC**). This consists of four components: rule interpretation, model preparation, rule execution, and reporting, as depicted in Figure 11.[161] The components represent the requirements for a checking program.

Automated checks are performed using special software called **model checkers**. The information that model checkers can check is based on numeric or alphanumeric data. They are therefore primarily of a quantitative nature. Checks beyond this, for example with qualitative data, are not yet possible.[162]

[158] VDI 2552 (2018) (translated from the original German)
[159] Beetz et al. (2015), p. 143 f.
[160] Tulke (2015), p. 281
[161] Eastman et al (2009), p. 1013 ff.
[162] Nawari (2018), p.26 f., p. 126; Ponnewitz and Bargstädt (2019), p. 1562 f.

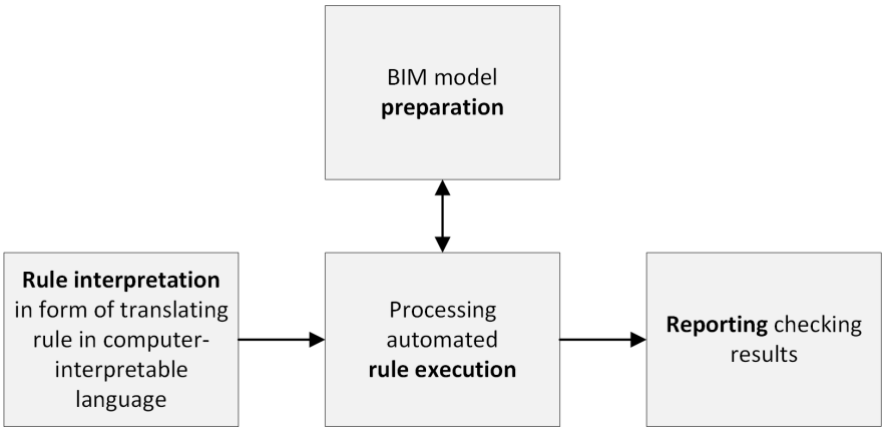

Figure 11 - Rule checking system[163]

In connection with model checking, it is necessary to explain **black-box** and **white-box methods**. A black box refers to a software application whose procedure is not visible. Accordingly, the user only sees input and output values. By contrast, the white-box method describes an application that makes all elements and processes that lie between the input and output values visible and comprehensible.[164]

3.1.1.3 Use cases

BIM use cases describe the extent to which BIM models are used in a project. They must be selected on a project-specific basis.[165] The quantity check and quality check of **BIM use cases** are defined with regard to the determination of the building permissibility.

The **quantity check** is conducted using ACCC in the sense of BIM. This is suitable for automated, quantitative queries. Specific activities include the operation of the model checker and the readout of the model checker's results by the check of another party.

The **quality check** involves the manual, BIM-supported inspection of building application documents and is used for qualitative queries. It requires actions such as filtering the required objects or viewing the stored visualizations and other building documents (i.e., views, sections, floor plans, details, and building description).

The quantity and quality checks can be applied in combination or independently of each other. However, a complete building permit determination is only possible through their combined usage.

3.1.2 Subjects relevant to building permitting

[163] Own illustration based on Eastman et al. (2009), p. 1016
[164] Preidel et al. (2015), p. 323 ff.
[165] Borrmann and König (2018), p. 1481 ff.; BMVI (2015), p. 3; Hausknecht and Liebich, p. 152 ff.

3.1.2.1 Legal framework in Germany

Aspects of building permit law are assigned to public building law. The **hierarchy of building permit authorities** in Germany is divided into supreme, upper, and lower building supervisory authorities,[166] which are responsible for ensuring compliance with building regulations. Essential tasks of the lower building supervisory authority are to examine building applications and to issue building permit notices. Lower building supervisory authorities are located in districts and independent cities.

Public building regulations are divided into planning law, building law, and ancillary building law. In Germany, they are regulated at the national, state, and municipal levels. At the federal level, the Planning Code (BauGB)[167] in conjunction with the Building Utilisation Ordinance (BauNVO)[168] onstitute the formative building regulation. This is where **planning law** is primarily determined. Due to the federal system, **building law** is subject to legislation by the federal states in the form of state building code (LBO). **Ancillary building law** is predominantly enforced by the agencies of public interest. At the municipal level, statutes of the individual municipalities also exist, which can affect both planning law and building law.[169] Figure 12presents a schematic overview of public building regulations in Germany.

Land use plans and development plans (B-plan) also represent applicable law within the framework of planning law. Both the graphic and textual parts are always decisive for a building project. Furthermore, different types of B-plans exist, for example, in the form of qualified or simple B-plans.[170]

[166] Wirth and Schneeweiß (2016), p. 11 f.
[167] BauGB (2020)
[168] BauNVO (2017)
[169] Wirth and Schneeweiß (2016), p. 5 ff.; Schmidt (2015), p. 1 ff.
[170] Wirth and Schneeweiß (2016), p. 17 ff.

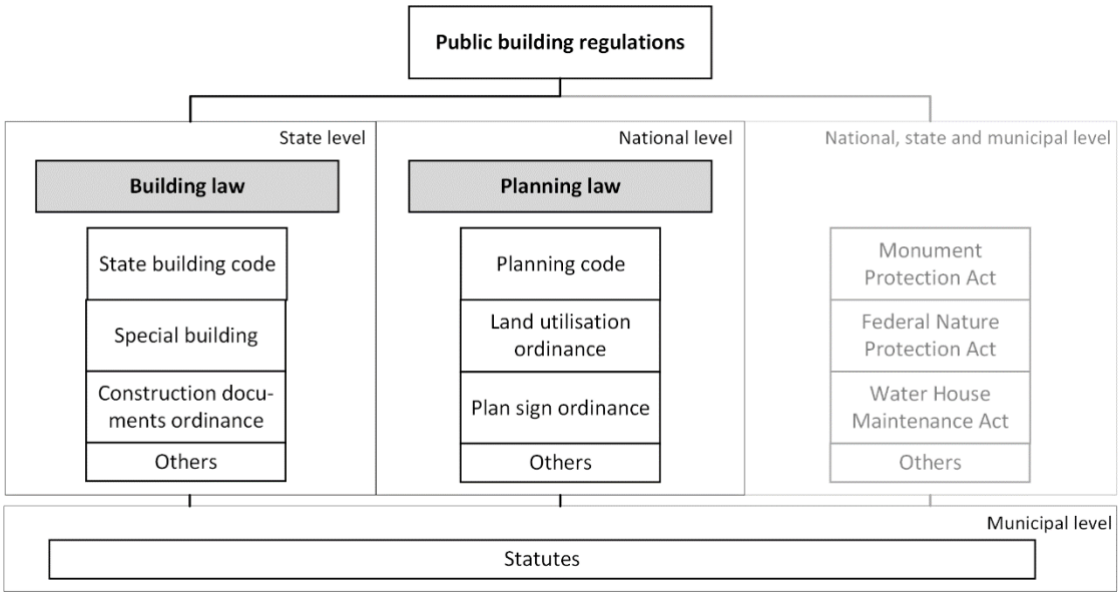

Figure 12 - Schematic overview of German public building regulations[171]

A further distinction is made between formal and substantive (or content-wise) law.[172] **Formal law** concerns rules that have no direct influence on the decision in the matter. These include rules on jurisdiction, procedure, or the form of the decision (e.g., oral, electronic, or written). Compliance with formal law means that the form of this administrative act must be observed. An **administrative act** refers to a sovereign official decision in an individual case.[173,174] With regard to the building permit, an administrative act is a decision or order on the commencement and implementation of a construction measure. With regard to compliance with the form, reference should be made to the building submission ordinances of the federal states as well as the model building submission ordinance (MBauVorlV).[175] Furthermore, certain procedural steps must be complied with for achieving formal legality. This concerns, for example, the consent of the municipality. In addition, the Ordinance on Inspection Engineers and Inspection Experts (PPVO)[176] must be observed.

Substantive law deals with the specific content of the building project, which must comply with the legal requirements. These include requirements for fire protection, distance areas, and building materials and products.

In Germany, the following four **types of procedures** exist with regard to building permits:

[171] Own illustration
[172] Hofmann et al. (2016), p. 78 f.; Wirth and Schneeweiß (2016), p. 96
[173] VwVfG (2019), § 35 (1)
[174] Schmidt-Eichstaedt et al. (2014), p. 19 ff.
[175] MBauVorlV (2007)
[176] M-PPVO (2012)

- Construction projects not subject to procedures
- Permit exemption
- Simplified building permit procedure
- "Comprehensive" building permit procedure

Building projects exempt from procedures are regulated in § 61 MBO and refer to structural installations that do not require a building permit. An exemption from permitting is possible if the building project is located in a B-Plan area and the requirements under the applicable law are met.[177] A simplified building permit procedure applies to building projects in building classes 1–3 that are not located in a B-Plan area.[178] All other building projects are subject to the comprehensive building permit procedure. Special buildings, defined according to § 64 MBO, are always – and thus independently of the existence of a B-plan – examined in a comprehensive procedure. The comprehensive building permit procedure is the subject of the present work. In principle, a building permit must be granted if the building project does not conflict with any public building law concerns.[179]

If a building project is a **special building**, special building regulations also apply, which describe project-specific regulations. For example, in the case of a hotel, the Accommodation Ordinance[180] applies, while in the case of a building with at least one assembly room, the Assembly Venue Ordinance[181] applies. In addition, special approval processes are used for special buildings. Here, inspection engineers are involved, who check the proof of stability and the fire protection concept on behalf of the building permit authority.

In Germany, jurisdiction plays a significant role in determining building permissibility. Court rulings, in addition to legal texts, can serve as guidance in decision-making. So-called *recognized solutions,* such as those developed and used in England and Wales to explain requirements, discuss underlying problems and describe strategies for compliance and do not exist in Germany.[182]

3.1.2.2 Processes relevant to building permits

The processes involved in obtaining building permits are complex and extend over various stages of a construction project. For example, achieving the right to build in the project development plays an

[177] MBO (2016), § 62
[178] MBO (2016), § 63
[179] MBO (2016), § 72
[180] Here, the example of the Model Accommodation Ordinance (MBeVO) is used.
[181] Here, the example of the Model Ordinance on Places of Assembly (MVStättVO) is used.
[182] Pedro et al. (2011), p. 7 f.; Schleich (2018), p. 24

essential role in the implementation and success of the project. Once construction is complete, the building permit authority may accept the property.

The sum of all processes relevant to building permitting is referred to as the **building permit phase,** which is illustrated in Figure 13. This phase includes building permit planning (from the perspective of designers and architects) as well as building permit procedures (from the perspective of the authority). In principle, the building permit phase starts with the project idea and ends with the building's inspection by the building permit authority. Furthermore, the end of the building permit procedure marks the beginning of execution planning and construction. Certain cases exist where these processes run parallel to building permit procedures. An example of this is partial building permits for individual construction phases.

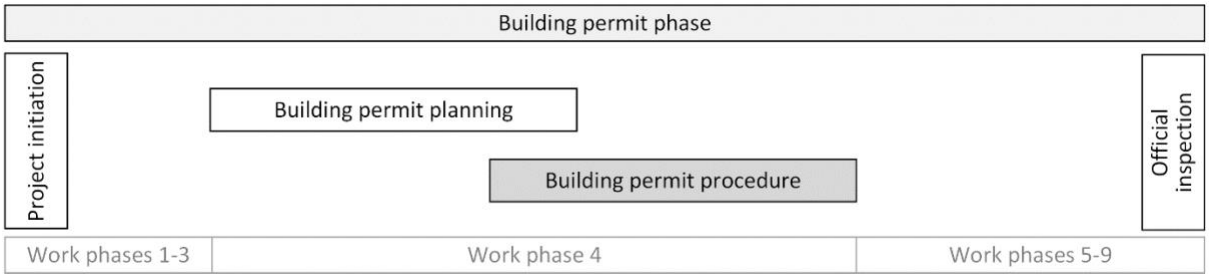

Figure 13 - Schematic overview of the building permit phase[183]

The activities of building permit authorities are varied and time-consuming. The advisory work alone vis-à-vis the building owners and applicants accounts for an average of 21% of the total work performed by these authorities.[184] The figure for construction supervision is 18%.[185]

Building permit authorities still have a duty to hold hearings and consultations with citizens.[186] These authorities do not have an advisory function in the substantive sense, and it is not their task to propose variants or solutions. Irrespective of this, the authority may request further evidence to be able to assess the facts correctly.[187]

Concrete process descriptions with regard to the procedure of building permitting, particularly building permit procedures, are rarely published or only described superficially. Only related facts can be found

[183] Own illustration, with the HOAI (2013) integrated
[184] TMBLM (2009), p. 10
[185] TMBLM (2009), p. 27 f.
[186] VwVfG (2019); Sec. 66
[187] VwVfG (2019), § 26

in the literature, from which processes can be derived in a broader sense or interpreted and evaluated as components of processes.

The current building permit procedure begins with the submission of a building application by the applicant and occurs with the authority. The procedure ends with the determination of building permissibility on the part of the building permit authority or the transmission of this decision (positive or negative decision) to the applicant.

The following processes in the building permit process can be derived from the literature[188]:

- receiving a building application
- checking the authorization to submit building documents
- checking the completeness of the submitted documents
- subsequently requesting (missing) documents
- examining the substantive regulations
- checking the structural engineering verifications
- conducting the participation of TöB
- acknowledging comments received
- issuing the notice
- notifying the applicant of information

A simplified representation of the process, including the parties involved and the documents they should prepare, can be found in Figure 14First, it can be assumed that there is preliminary coordination [−1] between the planner and the building permit authority. The planner receives necessary additional work from the inspection experts and specialist planners for preparing the construction documents [0], which are prepared for the building owner as the applicant. The building owner officially submits the building application [1] to the building permit authority, which then requests comments from the agencies of public interest to be involved. Depending on the project, inspection engineers are commissioned to prepare inspection reports. If information or documents are missing, additional requirements [2] are demanded from the planner. In this case, the planner will submit subsequent submissions [3] to the building permit authority. If the building permissibility can be determined, the builder owner will receive the building permit [4].[189]

[188] IT Planning Council (2016), p. 60 ff.; Icks and Richter (2001), p. 12; Menzel et al. (2015), p. 185
[189] Ponnewitz (2019), p. 238 f.

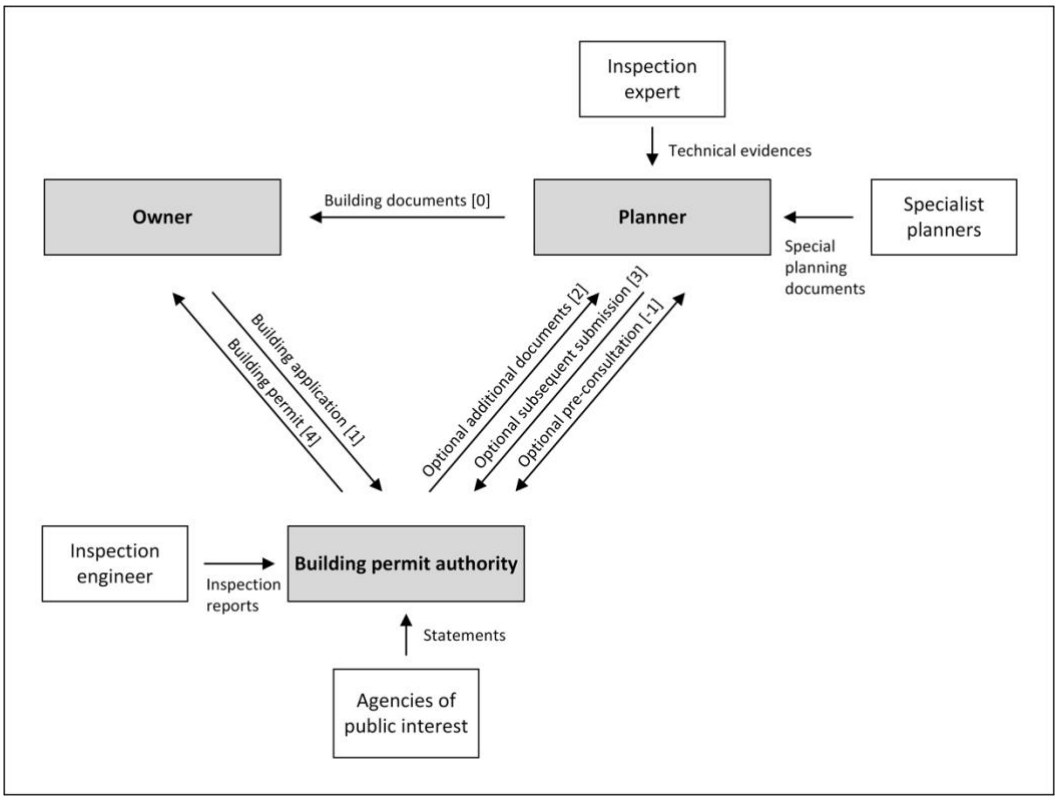

Figure 14 - Simplified representation of the building permit procedure in terms of participants and documents[190]

Weaknesses exist in the organizational area of the building permit authorities, which lead to delays in building permit procedures. Without sacrificing the quality of the permit decisions, there is potential to be explored in the administrative organization among others.[191] Schulte referred to the possibilities of accelerating procedures as acceptance management, which means communication, voicing of concerns, discussion, and presentation of information.[192] Essentially, acceptance management is aimed at increasing the transparency and intersubjectivity within the procedures.

3.1.2.3 Excursus on the international context

In a global context, each country follows its own building permit procedure and thus also a multitude of different building regulations. For planners working internationally in particular, dealing with and understanding **country-specific or local regulations** is a challenge. For building contractors, the various requirements can also be difficult. This also affects concerns of political science among others. For example, using the United States as an example, Springer described the interstate barrier due to the enormous variety of building codes in a federal system. A particular problem is the different use and interpretations of building codes by local authorities.[193]

[190] Own illustration based on Ponnewitz (2019), p. 238
[191] Schulte (1996), p. 43
[192] Schulte (1996), p. 58
[193] Springer (2018), pp. 253 ff.

In an international context, scientific publications on the subject of building permits and building supervision are rare.[194] The following is an excursus on the main research findings of recent years. The focus is primarily on the detailed processes for determining building permits and decision-making.

Doing business regularly involves collecting data on, among other things, the duration and number of process steps required to obtain a permit for a simple hall. The data are compiled from 190 countries, and the results vary greatly from country to country. In Germany, for example, nine procedural steps[195] and 126 days are required, whereas in Singapore, the building permit is issued after nine procedural steps and 35.5 days. In countries with electronic building permit procedures, such as Hong Kong and Denmark,[196] eight and seven procedural steps were identified, respectively. The procedures' durations are 69 and 64 days, respectively.[197] Thus, it can be seen that the number of procedural steps is not necessarily indicative of the duration of the procedure. In conclusion, it is not the individual components that are important, but rather their interaction.

In Europe, building permit procedures can be considered comparable.[198] This is the result of a **comparison** of 27 European countries and concerns the comprehensive building permit procedure. Although the basic procedures have changed little in recent years, a trend exists towards more efficient and faster processes.[199] With regard to the processes, the possible types of procedure (e.g., simplified procedure) are primarily considered. The level of detail of the processes is superficial.

Another report from 2011 that compared Germany, Denmark, Poland, and Lithuania confirmed that many similarities exist within these countries and that differences lie primarily in the details. Due to the different state building codes in Germany, the boundary conditions there are particularly complex. It was determined that a standardization is desirable, which would increase the transparency in the building permit processes.[200]

Meijer, Sheridan, and Visscher published two detailed comparisons, one dealing with official building inspections and the other with technical requirements in the legal texts of eight European countries

[194] Schleich (2018), p. 13
[195] The procedural steps refer to all processes that must be initiated by the developer to obtain a building permit. They do not refer to the processes within the authority.
[196] Fiedler (2015), p. 2
[197] Doing Business (2019)
[198] Fiedler (2015), p. 6; Pedro et al. (2011), p. 416
[199] Pedro et al. (2011), p. 435
[200] Rückert (2011), p. 54 ff.

(the Netherlands, the UK, France, Germany, Sweden, Norway, Belgium, and Denmark). In all of the countries studied, the local building permit authority is responsible for the building permit processes. The organization of these processes leads to a variety of possibilities and differences and was therefore not examined in detail.[201] The formulation of technical requirements in building codes has been a subject of discussion for many decades. A wide variation of formulations could be found in the countries studied. Often qualitative requirements are mentioned, which are however interpreted differently.[202] Basically, the countries that the authors studied are comparable. This applies above all to the purpose at which the laws are aimed. At the level of structuring and individual regulations, a large variation can be recognized.[203] It was highlighted that in Germany, in contrast to the other countries, particular difficulties exist with terminology.[204]

In a survey, architects in a European comparison valued **clearly and concisely described contents** in legal texts, which allow planning freedom without requiring a great deal of interpretation. An ideal building code for a particular country could not be named during the survey.[205]

From the point of view of economics, Schleich compared the aspects of building law between the English Building Code and the State Building Code of North Rhine-Westphalia. In terms of substantive law, hardly any **efficiency gains** could be identified in the English Building Code, while the formal law exhibited greater potential for efficiency. These are to be found, among other things, in the formulation, the duration of the procedure, and flexible verification. For cultural reasons, transferability is only possible to a limited extent. English law is fundamentally more open to individual cases and thus more flexible, which results in less legal certainty.[206]

In 2013, the Norwegian Construction Authority published the ByggNett study, which examined the **current state of practice** in selected countries with the aim of creating a development strategy for an online collaboration platform for the construction sector.[207] Based on this study, four stages of development were identified, which are illustrated in Figure 15. Furthermore, the comparison in the study revealed large differences in not only digitalization in the construction sector but also in the basic processes. However, the German construction sector was not considered in the study.

[201] Meijer et al. (2002), p. 171
[202] Sheridan et al. (2003), p. 8 ff.
[203] Sheridan et al. (2003), p. 20 ff.
[204] Sheridan et al. (2003), p. 65
[205] Schleich (2018), p. 13
[206] Schleich (2018), p. 511
[207] Holte Consulting (2014)

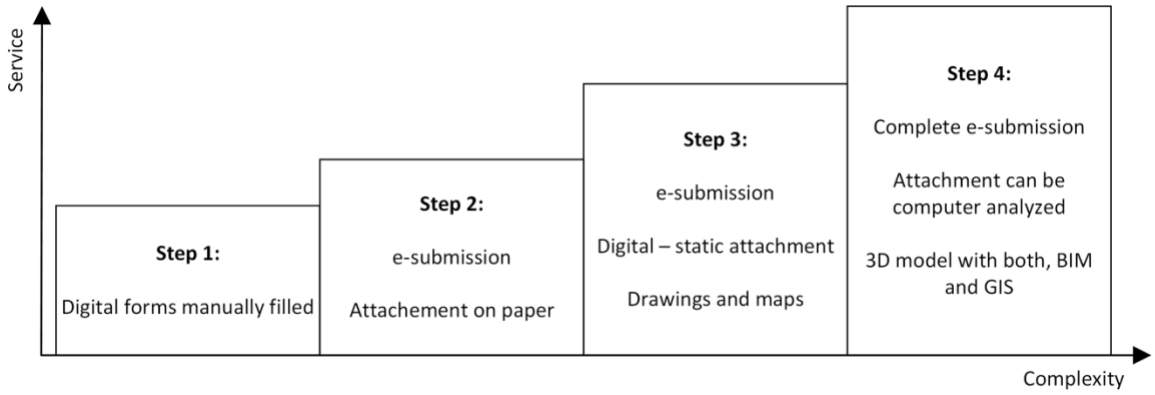

Figure 15 - Development stages of the digital building permit[208]

3.1.2.4 Specifics and focus

This subsection examines the specifics relevant to building permits. The literature has focused in particular on **legal influencing factors**, the handling of **subjectivity**, as well as **digitalization** in the determination of building permissibility.

The current law cannot cover all **eventualities** and circumstances. It would simply be impossible to include all possible constellations of assessments in terms of the ability to obtain a building permit in the legal texts.[209] Thus, it is precisely the determination of said ability that results in a case-by-case examination. To guarantee the freedom to build according to Art. 14 GG, a possibility exists to deviate from the legal requirements. Formally, this is done through separate or combined applications to a building application.

In terms of planning law, the instruments of **exception**[210] and **exemption**[211,212] can be used with the aim of the individual case justice.[213] Exceptions and exemptions are intended for the area of the validity of B-plans. [214] An exceptions refers to a deviation provided by the municipality in terms of type and scope from certain provisions (immanent to the plan), whereas an exemption is a deviation provided by the legislator that goes beyond the reference to the plan (external to the plan).[215]

[208] Own illustration based on Hjelseth (2013), p. 7
[209] See Section 2.4.3
[210] BauGB (2020), § 31 para. 1
[211] Sometimes also referred to as a dispensation.
[212] BauGB (2020), § 31, para. 2
[213] Schmidt (2015), p. 98; Battis (2014), p. 126; Erbguth and Wagner (2005), p. 218
[214] Rixner et al. (2018), p. 389; Battis (2014), p. 127
[215] Schmidt (2015) p. 98 f.; Battis (2014), p. 127

Under building law, a **deviation** request may be made primarily to preserve a conservation objective.[216] A deviation can have different possibilities[217]:

(1) Deviation – is a substitution power that corresponds to the state of the art;
(2) Exception – may apply in the case of non-mandatory rules;
(3) Exemption – may be applied to mandatory regulations if the decision would result in unintended hardship.

In practice, deviations are accompanied by **problems.** Caused by the ignorance of building owners, technical approvals, such as in the form of deviations in the fire protection certificate, are not applied for in the procedure. During the building permit review, many deviations are accidental findings. These are, insofar as they have not been identified and the installations have been erected, (at least) formally inadmissible.[218] A large proportion of authorities feel that municipalities are overburdened by assessing the permissibility of isolated deviations.[219] This can be attributed to their lack of experience in dealing with legal interpretation methods.

In addition, there are **simplifications** that only come into question for special buildings in connection with fire protection-relevant issues. According to § 51 para. 2 MBO, increased or reduced requirements can be offered for material regulations. In this case, special construction guidelines are used in the review.[220]

The existence of a collection of variances, exceptions, or exemptions and dispensations granted is unknown. **Court decisions** dealing with this subject matter represent only a small proportion of these cases, as they only reflect what was disputed and clarified in court. This is a contradiction, as no positive decisions can be used as a reference or empirical value for assessment.

In building law, **qualitative and quantitative contents** must be dealt with.[221] Their clear determination and uniform definition are missing from legal texts. In connection with qualitative content, the term performance-based building regulations can be found in the literature, whereas the term prescriptive

[216] MBO (2016), § 67
[217] Schmidt (2015), p. 175 f.
[218] TMBLM (2009), p. 25, p. 29 f.
[219] TMBLM (2009), p. 29 f.; TMBV (2006), p. 26
[220] Meissner (2014), p. 159 ff.
[221] See Section 2.4

regulations is used in the sense of quantitative regulations.[222] The integration of both qualitative and quantitative statements in a legal text is to be regarded as necessary.[223]

Since not every individual case can be clearly described in the building regulations, the use of **performance-based (also functional or target-oriented) building regulations** is considered advantageous. Such regulations are more responsive (in terms of the state of the art) without compromising on the legislative objectives and ensure simpler application. They are characterized by clear and comprehensible wording due to the regulatory intention and the means to fulfill the requirement.[224]

In 1976, a model was developed by the Nordic Committee on Building Regulations (NKB), which is presented in Figure 16This is the **five-level model for technical requirements**, and it describes the structure of performance-based building regulations. According to this model, the target is at the top (level 1) for achieving technical requirements, followed by qualitative functional requirements (level 2), and then quantitative operational requirements (level 3). The requirements are expressed in criteria and can be confirmed using evidence (level 4) or justified and reinforced using examples of acceptable solutions (level 5). The latter are solutions on which a building authority consensus is reached without evidence.[225]

The five-step model has been further developed over the past decades into the performance system model. Here, the indispensable flow of information from the target to the proof has the highest priority,[226] as can be seen in Figure 17. A particular problem is that current building codes do not clearly disclose targets, but only describe the technical requirements.[227]

[222] Fiedler (2015), p. 29; Schleich (2018), p. 16; Meacham (2010), p. 20, p. 28; Holte Consulting (2014), p. 17.
[223] Beller et al. (2001), p. 4
[224] Schleich (2018), p. 16 f.; Meacham (2010), p. 20, p. 28
[225] Meacham (2010), p. 10 ff; Schleich (2018), p. 15 ff.
[226] Schleich (2018), p. 17; Tubbs (2004), p. 3
[227] VfdB (2013), p. 30 f.; Schleich (2018), p. 17

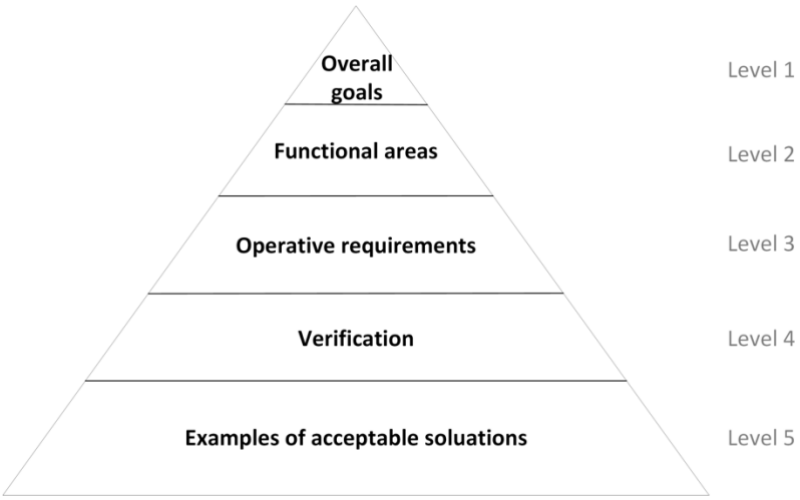

Figure 16 - Five-level model of technical requirements from 1976[228]

Scholten listed a number of **problems in practice** related to the use of building regulations. Many building regulations have insufficient scientific backing and their development is insufficiently documented; thus, their backgrounds can sometimes no longer be found or are unknown. As a result, much knowledge is lost. The responsible bodies themselves no longer understand their own regulations. Another problem is that many building regulations have a different disciplinary background, resulting in the inconsistent use of terms. Other causes of confusion and stress for users are the large number, volume, and complexity of building regulations, which are also prompted by different publishers (e.g., ministries, states, and municipalities).[229] It should be a matter of concern that a building regulation is formulated in a user-friendly manner and is downright readable.[230]

At the international level, the **trend in** the formulation of building regulations is towards performance-based (qualitative) building regulations rather than prescriptive (quantitative) building regulations.[231] In Germany, performance-based building regulations have not yet been applied despite their clear formulation.[232]

[228] Schleich (2018), p. 17; Oleszkiewicz (1994), p. 7 f.
[229] Scholten (2011), p. 163; Schleich (2018), p. 65
[230] Jäde (2003), p. 4
[231] Meacham (2010), p. 11; Holte Consulting (2014), p. 17
[232] Schleich (2018), p. 21

Figure 17 - Performance system model[233]

Building code objectives can be achieved by means of **engineering methods.** In Germany, these can be initiated by applying for deviations. Greater openness in building regulations is desirable here. However, the (German) building permit authorities are strongly inhibited in the admissibility of such alternatives, which is due to the liability risk.[234]

Furthermore, there are other **subjective influencing factors** in the building permit process. For example, the interaction between private actors and authorities creates an informal link. Factors such as experience and acquaintance play a role that is not insignificant here.[235]

Building permit authorities are also required to use state-of-the-art technology for communication and data exchange in their equipment.[236] Considering the **current level of digitalization** of building permit authorities in Germany, this does not correspond to the current technical possibilities. Many authorities work on a paper basis and the building application must still be submitted in many cases in printed form.

In Germany, various pilot projects and initiatives (e.g., the BIM cluster in Lower Saxony) aim to digitize building permit authorities. Municipalities in different federal states as well as the federal government intend to digitalize processes. It should be noted here that electronic building application submissions or digitization approaches are not to be equated with the use of BIM. Associations such as the chambers of architects see a need for adaptation here.[237]

[233] Own illustration based on Schleich (2018), p. 19; Tubbs (2004), p. 3
[234] Schleich (2018), p. 22
[235] Müller et al. (2017), p. 17
[236] Ibid.
[237] Pezzei (2019), p. 10 f.

The public sector has recognized the potential in the **digitalization of administrative processes.** Thus, the E-Government Act was introduced in 2013. E-government (electronic government) is a way, supported by information and communication technology, to digitally link administrative processes to accelerate and improve them.[238] The focus is on the business processes of the agencies of public interest.[239] In this context, an advisory board meeting was held in 2018 at which a consulting firm presented development potentials to the public sector. The involvement of practice in terms of building permit authorities was highlighted as a key point, as was the need for standard developments.[240]

The German chambers of engineers and architects have demonstrated a further initiative towards the digitalization of the building permit procedure. They are supporting the Online Access Act (OZG) by developing a database through which a digital query of the building submission authorization is possible.[241]

In November 2019, a hearing on the facilitation of digital building inspection procedures was held within the framework of the Conference of Building Ministers (in German: *Bauministerkonferenz*). It aimed to update the MBO and MBauVorlV with regard to the possibility of exclusively electronic communication.[242] With the amendment of the VwVfG in 2019, the law was adapted with regard to digitalization. § 35a of the VwVfG was amended to the effect that administrative acts may be automated insofar as the use of discretion is not necessary for the decisions.[243] In view of the large number of discretion-implicating decisions, the legally compliant use of this paragraph appears to be a major challenge and is accompanied by uncertainty among users.[244]

In some federal states (e.g., Berlin), building applications can already be submitted electronically (documents in PDF format).[245] In addition, there are **software applications** for internal use by the authorities, which primarily provide assistance for formal processing (e.g., completeness of building documents and word processing). These are applications in the sense of document management

[238] EGovG (2019)
[239] Dick and Karls (2012), p. 154
[240] Bourscheidt (2018), p. 11 ff.
[241] BIngK (2020)
[242] IS Argebau (2019)
[243] VwVfG (2019), § 35a
[244] Ponnewitz and Schneider (2019), p. 34
[245] BauVerfV (2017); eBG (2017)

systems with which e-files can be created and documents stored. Examples include specialist software applications such as BASE Bau (Boll und Partner Software GmbH)[246] and GekoSBau+ (GekoS mbH).[247]

On the side of public administrative science, a study titled "IT-oriented administrative development in lower building permit authorities" was conducted in 2013. This predominantly quantitative study revealed that there are clear differences in the dynamics of administrative development, but that the area offers potential. In terms of content, only electronic form processing was addressed.[248] This means that object-oriented issues, as offered by the BIM method, were not considered.

According to Etscheid, the **automation of public administrative processes** requires processes to be separated into subprocesses. This supports the decision makers in its action. Furthermore, identifying subprocesses that can be mapped electronically is necessary. It should be noted that although it is possible to automate individual cases, from a cost-benefit point of view this would involve a disproportionately large amount of effort. Nevertheless, partial automation can make it easier to handle simpler processes and concentrate personnel capacities on more complex processes.[249] Through a gradual integration of automation, trust in the technology that was previously lacking can be built up. To achieve this, it is particularly critical to act with transparency and traceability in the sense of the white-box method. For a prompt full automation, the legal basis as well as social acceptance are missing.[250] In addition, it is essential for the creation of algorithms to have access to a sufficiently structured collection of data, which must first be created in the area relevant to building permits. Although autonomous management is not expedient, the structuring of information and processes nevertheless offers added value in decision support.[251]

3.2 State of research

In this section, the topic of **BIM-based building permit processes** is addressed. It should be emphasized that this exclusively concerns the combination of BIM and building permits. Amendment approaches for the adaptation of building regulations or, for example, the expansion of electronic application in terms of data management (e.g., PDF applications) are not considered.

[246] Boll and Partner (2014)
[247] GekoS Construction+ (2019)
[248] Stember and Neutzner (2014)
[249] Etscheid (2018), p. 151 ff.
[250] Etscheid (2018), p. 148 f.
[251] Etscheid (2018), p. 156

At the present time, **research activities** on the topic of digital building applications are still ongoing.[252] A database search revealed interest in the topic in many countries, but that publications on the subject are low.[253] A model-based building application is no longer a utopia.[254] Although building permit authorities cannot avoid this topic, according to the current status, at least in Germany, no BIM use is known in the authorities.[255]

In a survey of BIM users, 45% viewed advantages to using BIM for a more efficient building permit process and recognized **great potential for improvement** through the submission of a digital model in the course of the building application. This can be understood as a call for the legislator to create the necessary framework conditions.[256] After all, authorities find it difficult to implement permit acceleration measures on a voluntary basis if they are not prescribed by law.[257]

An international **literature review** conducted as part of the present work focused on the following issues:

(1) Model-oriented rule checking (related to criteria relevant to building permitting)
   - Translation of the laws into a computer-interpretable language
   - Model-based automated testing through software applications

(2) Model-oriented consideration of the building permit phase.

Although a model-based building permit review is not necessarily the same as an **automated model check**, most research approaches have focused on this topic area. The basic idea of the automated review of permit documents is not new. Already in 2006, Al-Hussein et al. researched an automated review of construction documents, but with two-dimensional CAD programs. The investigation was mainly limited to site plan review, where the requirements for an urban zone were automatically generated from a database in the CAD model.[258]

Over the last decades, a multitude of methods have emerged that make the **translation of certain rules** possible. Since this technology is only tangential to the focus of this work, a limited selection of research on ACCC is outlined below. For further discussion, please refer to specific literature such as

[252] Bauch and Bargstädt (2021), p. 476
[253] Ponnewitz and Schneider (2019), p. 37
[254] Hennings and Mombour (2018) p. 54
[255] Hausknecht and Liebich (2016), p. 203
[256] Bialas et al. (2018), p. 57 f.
[257] Icks and Richter (2001), p. 34
[258] Al-Hussein et al (2006)

Zhang and El-Gohary,[259] Dimyadi and Amor,[260] Nawari,[261] Eastman,[262] Solihin,[263] Hjelseth,[264] and Garrett.[265]

From the research results, it appears that not all building codes can be coded. In this case, a manual compliance check is necessary,[266] as illustrated in Figure 18. Solihin et al. also described a problem with ACCC concerning the availability of certain data. It is clear from this that **difficulties** arise in practice when even the smallest links between objects in the BIM model are not correctly established. This problem correlates with the quality of the BIM model. Furthermore, given deviations (if-then formulas) lead to a disproportionately high effort in programming rules.[267]

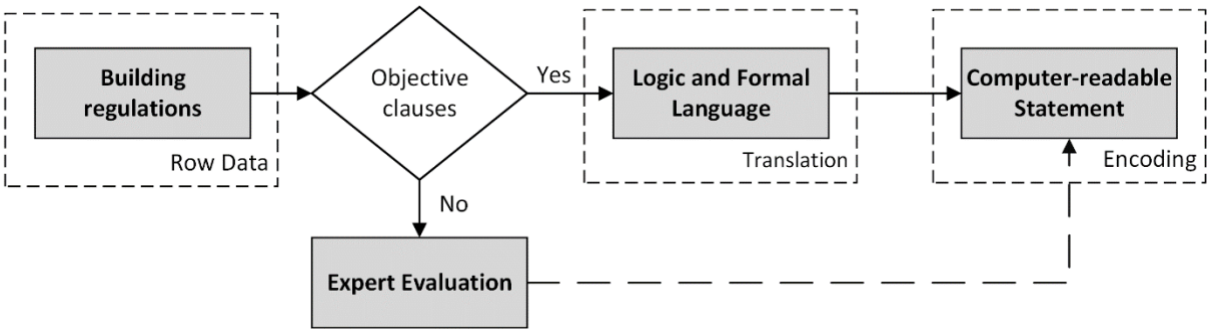

Figure 18 - Schematic process of ACCC[268]

The difficulty in translating the provisions of the law into **computer-interpretable language** is due to the legal texts that go beyond objective wording. These texts include the following[269]:

- conditional laws (here a direct interpretation is possible);
- ambiguous laws (a subjective case-by-case interpretation is necessary);
- content-related laws (cannot be divided into true or false, e.g., definitions); and
- dependent laws (dependent on other laws).

[259] Zhang and El-Gohary (2016); Zhang and El-Gohary (2019)
[260] Dimyadi and Amor (2013)
[261] Nawari (2018)
[262] Eastman (2009)
[263] Solihin (2016)
[264] Hjelseth (2015)
[265] Garrett et al. (2014); Garrett and Fenves (1987)
[266] Nawari and Alsaffar (2015), p. 166 ff.
[267] Solihin et al. (2017), p. 55 f.
[268] Own illustration based on Nawari (2018), p. 26; Nawari and Alsaffar (2015), p. 166 ff.; Ponnewitz and Bargstädt (2019), p. 1562
[269] Nawari (2018), p. 42

Using the example of ISO 21542,[270] Hjelseth identified the discretionary scope in 17% of legislative regulations, which makes **manual checking** necessary.[271] It should be noted that this example is a standard. It can be assumed that (particularly in German building regulations) a higher proportion of discretionary scope can be presumed after equivalent analysis.

A team of Korean researchers investigated the **incorporation of BIM into** the South Korean building permit system. Their research started with the translation of rules and regulations and proceeded to the testing of automated model checking. Furthermore, a distinction was made between automated checkable and non-automated checkable objects.[272] Recent approaches focus on user-friendly software use without programming knowledge by aiming at visual user guidance according to the white-box system.[273] This method results from the research of Preidel.[274]

Fiedler developed a method for checking legal requirements automatically using the example of the building permit procedure in Vienna (Austria) with the help of **rulesets** in Solibri Model Checker. Furthermore, Fiedler described what a concept for an overall automated check could look like.[275] However, qualitative aspects are not included in this automation approach.[276]

Another research approach dealt with **cloud-based solutions** for building permit review and mainly referred to formal information.[277] Other research aimed at the **combination of BIM and GIS.**[278]

At the beginning of 2020, the European Network for Digital Building Permit (EUnet4DBP) was founded to bundle expertise for uniformly advancing the **digitalization of building permit processes in Europe**. To this end, the pillars of process, rules and requirements, and technology should be further investigated in the future. The aim is to define a strategy for the development of digital building permit tools and methods.[279]

[270] Includes approximately 680 rules according to Hjelseth (2015), p. 46 f.
[271] Hjelseth (2015), p. 46 f.
[272] Kim et al (2017)
[273] Kim et al (2019)
[274] Preidel and Borrmann (2015); Preidel (2020)
[275] Fiedler (2015)
[276] Fiedler (2015), p. 25 f.
[277] Eirinaki et al (2018)
[278] Mahrous and Wahed (2017); Chognard et al. (2018); Noardo et al. (2020a)
[279] Noardo et al. (2020b); EUnet4DBP (2020)

BuildingSMART International addresses the concerns of authorities in the so-called Regulatory Room. One of the targets is the standardization of processes of authorities with regard to an **open, BIM-based data exchange** with the support of tools and application guides.[280] For example, a technical report was published that addressed the possibilities and requirements of a BIM-based submission of documents to the authority.[281]

From the point of view of strengthening and controlling **sustainability aspects**, Plazza et al. investigated building permit processes in the region of South Tyrol in Italy. For this purpose, among other things, the data management system G-Office of the local building permit authorities was statistically evaluated for the years from 2014 to 2018. Due to many individual actions and data, the results had little significance. This demonstrated that a standardized approach is essential for optimizing the diverse permit structures.[282]

Currently, no nationwide and uniform **data exchange format** exists. Therefore, the IT-Planungsrat of the Hamburg Authority for Urban Development and Housing developed the formats XPlanung and XBau in 2016. The published requirements specification described a loss-free data exchange in the construction and planning sector. Statements were made about required standards, which initially limit and specify contexts and services.[283] The detailed depth of decision-relevant processes required for this work was not mapped.

The research project "BIM-based building application" (in German: *BIM-basierter Bauantrag*), within the framework of the research initiative Zukunft Bau, ended in spring 2020. The target of the project was to create solutions for **BIM-based building applications.** The topic focused on the semi-automated creation and review of BIM-based building applications for selected topics. This included the development of a BIM-based platform and the creation of a modeling guideline.[284] Information regarding deviation requests will be provided using BCF.[285] Based on the results, a BIM-based building application is to be submitted for a pilot project in Dortmund.[286]

[280] BuildingSMART (2020b)
[281] BuildingSMART (2020c)
[282] Plazza et al. (2019)
[283] IT-Planungsrat (2016)
[284] Pezzei (2019), p. 11
[285] BBSR (2020)
[286] Westphal (2020), p. 58 f.

Grüner researched **legal aspects related to BIM** and the building permit procedures. The legal possibilities for implementing and applying the BIM method in building permit planning were analyzed, and the legal limits of automated review were explained. Accordingly, evaluative considerations and discretionary decisions cannot be mapped in an algorithm. A fully automated examination is, at least in Germany, legally inadmissible. The transfer of an official discretionary or examination decision to software is to be regarded as an error of judgment, since the authority is obliged to use its discretion and, above all, may not rely on a decision of another instance and thus also on a digital solution.[287]

The application-specific processes for determining building permissibility have not been sufficiently investigated to date. Although the **BIM reference process** of BIMiD presents the integration of the permit phase in the current process flow, the consideration is only conducted with the aid of BIM-based planning and design.[288] The plans are created as BIM-based, but the building permit authority is still involved in a conventional way. Thus, the required plans for the building permit authority are derived from the model. Optionally, a model check occurs in the sense of model checking. Figure 19presents a simplified overview of the processes involved in the building permit procedure.

[287] Grüner (2016), p. 216 ff.

[288] BIMiD (2016)

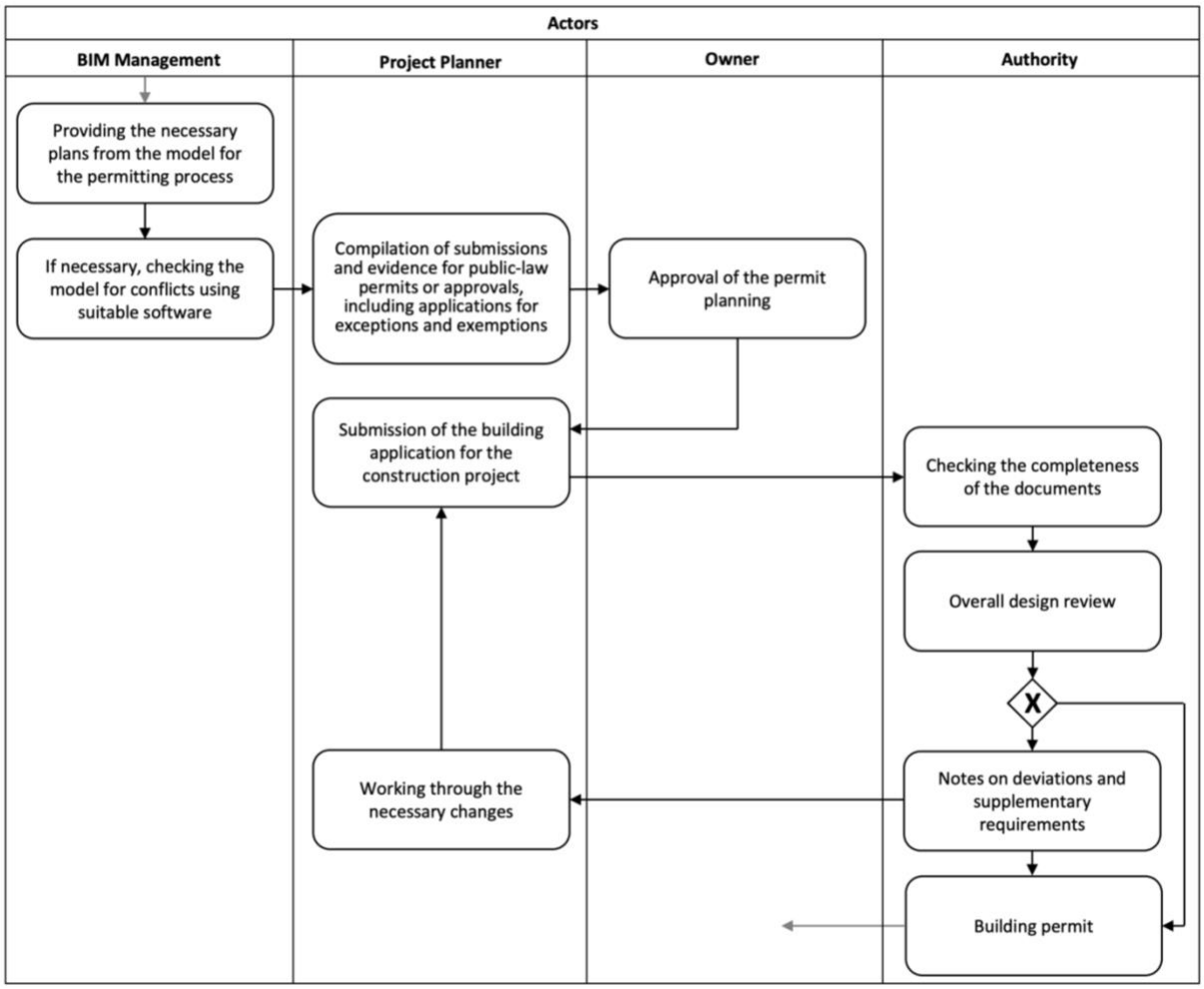

Figure 19 - Extract from the BIM reference process[289]

In a **potential analysis**, Müller et al. examined the use of semantic standards for building permits and planning. Among other things, the scenarios described potentials in an automated data transfer of the statistical survey form and in a possible submission and review of a building application with BIM. The study was not profound enough to derive recommendations for action or detailed processes.[290]

In **international practice,** only a few countries are working with BIM-based files in building permit authorities. **Singapore is a pioneering example**. The country is taking on a revolutionary role in building permit review,[291] not in the least due to the BIM application that has permeated the construction sector for decades. Since 2015, the submission of a BIM model has been mandatory for construction projects with an area of more than 5000 sqm.[292] The Building and Construction Authority in Singapore developed a continuously revised guideline on how to submit a BIM model.[293] The application

[289] Own illustration based on BIMiD (2016)
[290] Müller et al. (2017)
[291] Borrmann et al. (2015), p. 13
[292] Fiedler (2015), p. 33; BCA (2016a), p. 1
[293] BCA Singapore (2016b)

CORENET e-Plan Check takes over the compliance check based on a BIM model on an IFC basis for a large part of the Singaporean building regulations.[294] The check is performed using the black-box method.[295] Requested deviations are still discussed in person.[296] Due to the forced use of BIM, the building permit authorities in Singapore are now faster at processing.[297]

Due to the **federal structure** in the USA, comprehensive nationwide standardization and uniform guidelines are difficult to achieve.[298] Only individual local authorities have developed guidelines for model-oriented planning and review. An example is the city of New York, which foresees the use of BIM in public projects.[299]

3.3 Evaluation of the state of the art and research

In the future, BIM will play a major role in the construction and real estate sector, including in the area of building permits. However, there is still a **need for research** into the interaction of law, construction, and public administration. This requires a procedural and target-oriented approach as well as the inclusion of project management methods.

Literature review has demonstrated that research approaches mainly aim for an automated overall review of BIM models, but this has **technical and legal limitations**. Figure 20illustrates that manual expert review in terms of subjective decisions has been outside of the scope of previous research. Due to the nature of building regulations, ACCC can be applied thoroughly to prescriptive building codes (with quantitative content), but only partially applied to performance-based building regulations (with qualitative content). Furthermore, other building regulations have neither a prescriptive nature nor characteristics of a performance-based building code.

[294] Dimyadi and Amor (2013), p. 179 f.
[295] Preidel et al. (2015), p. 326
[296] Fiedler (2015), p. 33; Nova City Nets (2002)
[297] Berger (2018); Fiedler (2015), p. 32
[298] Westphal and Reich (2018)
[299] New York City (2012)

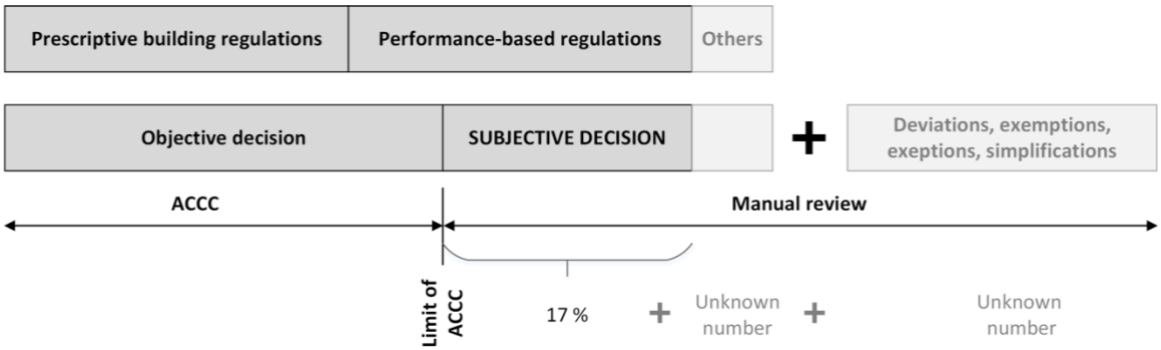

Figure 20 - Approaches and limitations of ACCC[300]

At present, it is technically impossible, given the **laws in force today**, to process a building permit review completely automatically. It will not be the aim to translate all legal texts into a computer-interpretable language. This is due to the enormous variety, complexity, and constant amendments of building regulations at the national and international levels as well as their lengthy implementation. Complementary approaches are required to accompany the ACCC in identifying strategies for optimizing building permit review in compliance with the law. The trend towards performance-based building regulations underpins this need.

The **individuality of each construction project** also stands in the way of overall automation. Hardly any project corresponds to the standard case, which is why manual case-by-case assessments are necessary. Subjective decisions are unavoidable. Even in BIM pioneer countries such as Singapore, manual assessment occurs in the event of deviations from the by-right case. To nevertheless bring about an optimization of the building permit, an alternative solution should be sought. Regardless of the degree of automation used, the real conditions must be recorded. This requires practical data material for, above all, processes at different levels of detail, but also for other elements of the environment relevant to building permits in building permit authorities, as well as for the scope for decision-making. Since building permit procedures are similar in an international context, statements regarding German conditions can be assumed to be transferable to other countries.

[300] Own illustration

4 Empirical study

4.1 Research design

The literature review[301] revealed insufficient or inaccurate data for a detailed investigation and subsequent model development regarding the determination of building permissibility.

Empirical research is used to investigate facts that are true to reality. It offers methods for collecting, processing, and evaluating data to support the answering of research questions.[302] A distinction is made between quantitative and qualitative research as well as mixed methods. **Quantitative research** usually takes a theory-proving or deductive approach. The data collected can be used to prove theories. It is standardized data that primarily indicate frequencies or statistical values. Consequently, social facts are formulated in numbers. However, some data cannot be queried quantitatively. In theory-generating or inductive research, **qualitative research** is used. This allows, among other things, for an in-depth understanding of complex phenomena as well as for subjective ways of thinking to be explored. In contrast to quantitative research, this also applies to a small number of cases considered.[303] Thus, the individual case is the object of research as well as the actions and patterns of interpretation of individual units of analysis.[304]

Scientific research procedures follow a certain structure. In this thesis, qualitative research procedures were applied, and the procedure is illustrated in Figure 21 In principle, empirical research begins with a preliminary study, which consists of the triad of formulating research questions, developing preliminary theoretical considerations, and deciding on a research design. The resulting choice of methods may change depending on the advancement of knowledge and understanding. After the preliminary study, data collection begins followed by data processing. The processed data are then analyzed. Qualitative empirical research concludes with an interpretation of the results. Depending on their quality and significance, all or individual steps are repeated or rearranged.[305]

[301] See Chapter 3

[302] Gläser and Laudel (2010), p. 33

[303] Gläser and Laudel (2010), p. 26 ff; Riesenhuber (2007), p. 6; Burzan (2015), p. 21 ff.

[304] Gey and Zinke-Wehlmann (2014), p. 88 f.; Hering (2005), p. 134 ff.

[305] Gläser and Laudel (2010), p. 35

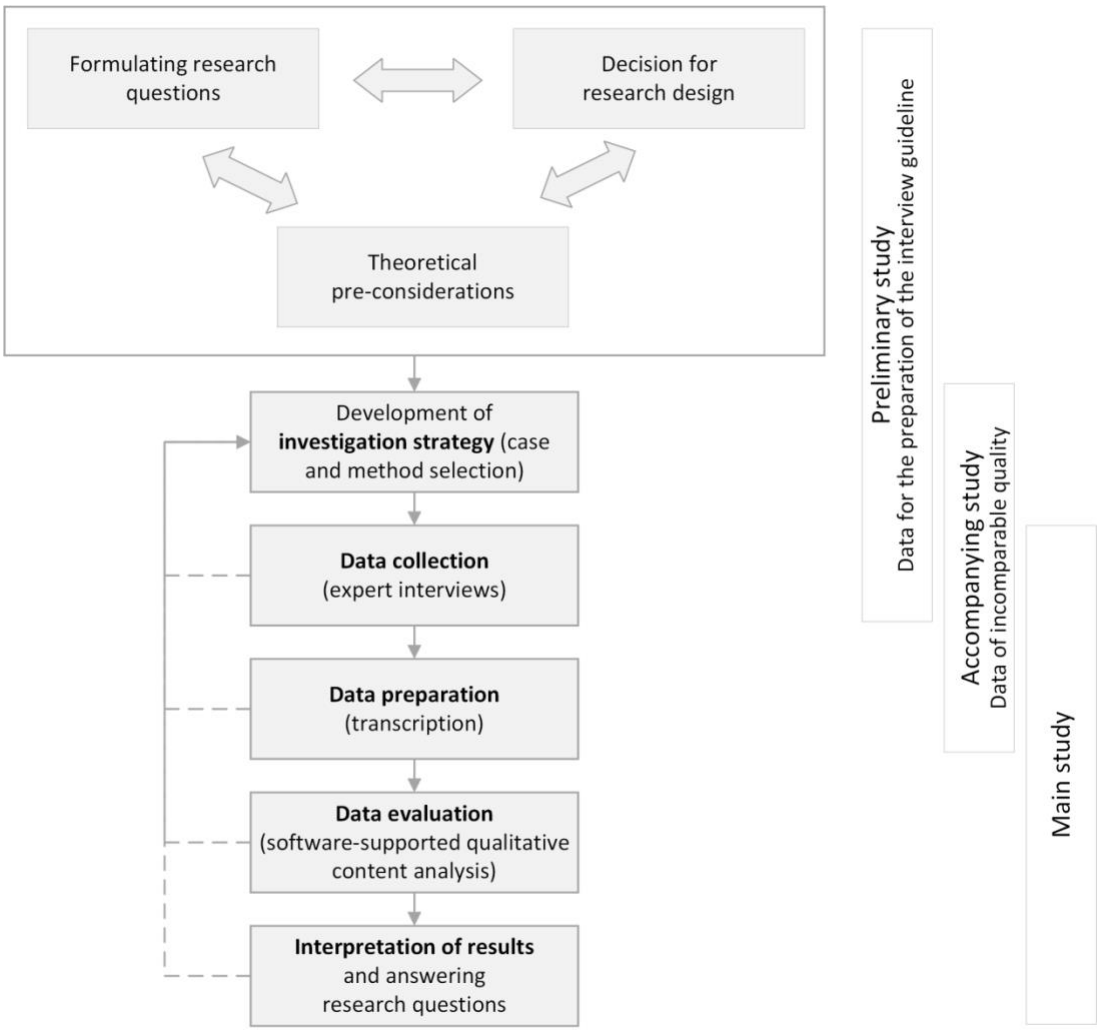

Figure 21 - Research process of the empirical study[306]

4.2 Objectives

To answer research questions[307] by means of an empirical study, **research questions** must be derived.[308] This empirical study sought to answer the following research questions:

- What do the processes look like in detail from the perspective of a building permit authority? Can a generally applicable process be derived? Which influences have an effect on the processes?
- What internal structures exist with regard to the forms of organization in building permit authorities? What influences have an impact on the structures?
- How is the scope for decision-making dealt with? What role does subjectivity play? Are patterns discernible? What influences have an impact on the scope for decision-making?

[306] Own illustration based on Gläser and Laudel (2010), p. 35; Ponnewitz (2017)

[307] See Section 1.4

[308] Gläser and Laudel (2010), p. 62 ff.

- How can digitalization, especially the BIM methodology, influence building permit processes?

The aim was to map a process and structure analysis in the results. An investigation of internal processes and structures in building permit authorities was performed to provide a basis for generalized statements. The handling of subjectivity and the scope for decision-making in the building permit process as well as examples were examined. Other influences on the building permit process were also included. Furthermore, digitalization was kept in view.

4.3 Procedure

Qualitative expert interviews[309] were conducted. The data were collected by different interviewers in substudies. Through this qualitative study, no representative, statistical evaluation was possible, but the purpose of the research could be served.

The study was divided into a preliminary study, an accompanying study, and a main study.[310] The preliminary study provided findings that, in addition to the literature research, were indispensable for the creation of the interview guideline and theoretical preliminary considerations. The accompanying study contained data sets that were collected in parallel to the main study. However, the collected data material was not completely comparable with the data material of the main study. For this reason, these data sets had to be separated from each other in the evaluation. Detailed information can be found in the data inventory in Appendix A.

4.3.1 Structure of the interview guideline

To create an interview guideline, prior knowledge is necessary, which is generated from the literature and assists in asking the "right" questions. The interview guideline is an aid for conducting an interview. This method is called a **semi-structured interview**. Asking a specific question is not obligatory but must be adapted to the situation. The aim is to keep the interview as natural as possible. The exact wording of the questions is not relevant, but the sense and understanding of them are. Questions can be omitted or added depending on the situation. This is the case, for example, if individual questions have already been clarified in the context of previous answers or if the interviewee does not respond to the topic or does not wish to.[311]

[309] The interview partners are referred the **interviewer** and **interviewee**, which are briefly defined here for clarity. The interviewer is the person who conducts the interview, whereas the interviewee is the person who is interviewed. Duden-Online (2019), search terms: Interviewer and interviewee

[310] See Figure 21 - Research process of the empirical study

[311] Gläser and Laudel (2010), p. 42; Mayring (2002), p. 66 ff.; Mayring (2015), p. 56; Schreier (2013), p. 224 ff.

The **structure of the interview guideline** was based on the research questions. The main topics of the interview guideline were divided into the following question blocks:

(1) Introductory questions
(2) Processes and structures
(3) Decision-making scope
(4) Examples
(5) Digitization

At the beginning, (1) introductory questions were asked as "warm-up questions," which put the interviewee and interviewer in the mood[312] for the question-answer procedure. These questions, on topics such as profession or professional experience, did not serve to answer the research questions, but could be used, if necessary, in future research based on the data material. The second block of questions addressed (2) processes and structures. The third questionnaire block addressed the (3) scope for decision-making and dealt with the possibilities of the authority to make a decision on whether to grant a permit. By means of (4) examples, the context was better illuminated. Thus, the interviewer provided insight into the real processes of practice, especially regarding subjectivity and decisions latitude. The interviewer was able to derive generally valid conclusions without the need for the interviewee to operationalize themselves. At the end, the interviewee was asked questions about (5) digitalization. These questions were aimed both at the current situation in the authority or company as well as at the personal ideas of the interviewee.

The interview guideline was tested for refinement. Test interviews were used as the instrument.[313] The interview guideline was adapted for different groups of experts.[314] Depending on the group of experts interviewed, questions were adapted or omitted.[315] Appendix B contains the interview guideline with the basic questions.

4.3.2 Participants

The participants of this empirical study were **actors in the building permit process**. In the context of the study, building officials in building permit authorities (B), planners (P), project developers (PE), and other experts (A) were interviewed. The other experts included staff at ministries, city councils, and housing cooperatives as well as lawyers. Although this study analyzed the processes and structures within the building permit authority, it was crucial to obtain other perspectives on the issues of

[312] Gläser and Laudel (2010), p. 147
[313] Gläser and Laudel (2010), p. 150
[314] See Section 4.4.2
[315] Gläser and Laudel (2010), p. 117

decision-making scope and digitalization. This is the reason for this wide-ranging variation of interviewees.

This study was **internationally** oriented to broaden the view of the building permit processes, create a certain comparability, and work out possible special features. In addition to Germany, the USA was chosen for the main study because it is also structured as a federal political system and it was also possible to conduct interviews in person (on field).

4.3.3 Conducting the interviews

Prior to the interviews, initial contact was made by email. The individuals who had expressed interest were sent an interview guideline for preparation and an appointment was made for an interview.

At the beginning of each appointment, the interviewers briefly introduced themselves and the research approach. With the consent of the interviewee, the interview was recorded using a mobile recording device.

In the case of interview appointments where the interviewee did not agree to audio recording, their answers were transcribed. In addition, some interviewees responded by e-mail. These data were not included in the main study due to the lack of comparability. They were part of the accompanying study instead. The interviews in the main study were conducted in person or by telephone.

Information on the **scope of the interviews**, the participants, and the data material is summarized in Figure 22. The work of the three study phases occurred between October 2016 and February 2019. All interviews were documented in a **data inventory**, which serves to present the interviews in an encoded form and provides information about essential contents as well as processing steps. The data inventory can be found in Appendix A.

For comparability, all audio files of the main study (as well as parts of the preliminary and accompanying study) were transcribed. **Transcribing** the audio recordings was essential for establishing traceability and transparency in the research. The English-language interviews were not subsequently translated.

	Preliminary and accompanying study	Main study	Amount
Scope	55 interviews Approx. 32 h audio records	45 interviews Approx. 38 hours audio records	100 interviews Approx. 70 h audio records
Participants	49 + 3 interview partner 30 building officials in 29 building authorities 13 + 2 planner/developer 6 + 1 other experts	40 + 1 interview partner 19 + 1 building officials in 14 building authorities 8 planner 6 developer 7 other experts	89 + 4 interview partner 49 + 1 building officials in 43 building authorities 27 + 2 planner/developer 13 + 1 other experts
Country	Germany - 7 federal states (36 interviews) France (11 interviews) Singapore (2 interviews) USA (4 interviews) Norway (1 interview) Finland (1 interview)	Germany - 7 federal states (33 interviews) USA (12 interviews)	Germany - 9 federal states (69 interviews) France (11 interviews) Singapore (2 interviews) USA (16 interviews) Norway (1 interviews) Finland (1 interview)

Figure 22 - Summary of the data material of the empirical study[316]

Various transcription steps were used for data preparation. All of the transcripts used underwent reductions. Passages with the same meaning were reduced and the language was smoothed. Since it was not necessary to document linguistic peculiarities, such as pauses in speech, dialects, or colloquial filler words to answer the research questions, these were not transferred to the transcripts. Furthermore, the transcripts were anonymized.

Audio recordings whose quality proved to be poor were identified, and for these it was not possible to produce transcripts that were comparable to the other data material in the main study. These data were assigned to the accompanying study.

4.3.4 Data evaluation

In addition to coding, free interpretation, and sequence analysis methods, qualitative content analysis is a common approach for evaluating data and was applied here.

A free interpretation was chosen for the preliminary and accompanying studies due to the different data materials. The data material in the main study was examined[317] with the help of a **qualitative**

[316] Own illustration

Notes: The difference between the scope of the interviews and interviewees resulted from multiple interviews with one interviewee. Information provided by participants marked with a "+" refers to interviews in which several interviewees were present. In some cases, several interviewees were interviewed within one building permit authority, which is why the number of building permit authorities is lower than the number of interviewees.

[317] MAXQDA (2019) software application was used for this purpose.

content analysis. So-called codings were created, which were derived on the basis of the research questions. Examples of codings are *process*, *decision,* and *subjective*.

Figure 23procedure for software-based qualitative content analysis. The procedure can also be summarized as follows:

- Creating the codings on the basis of the research questions
- Material flow
- Selection of qualitatively usable text passages within the codings
- Delimitation of variants (with supporting documents for the interviews)
- Visualization and description of the individual variants

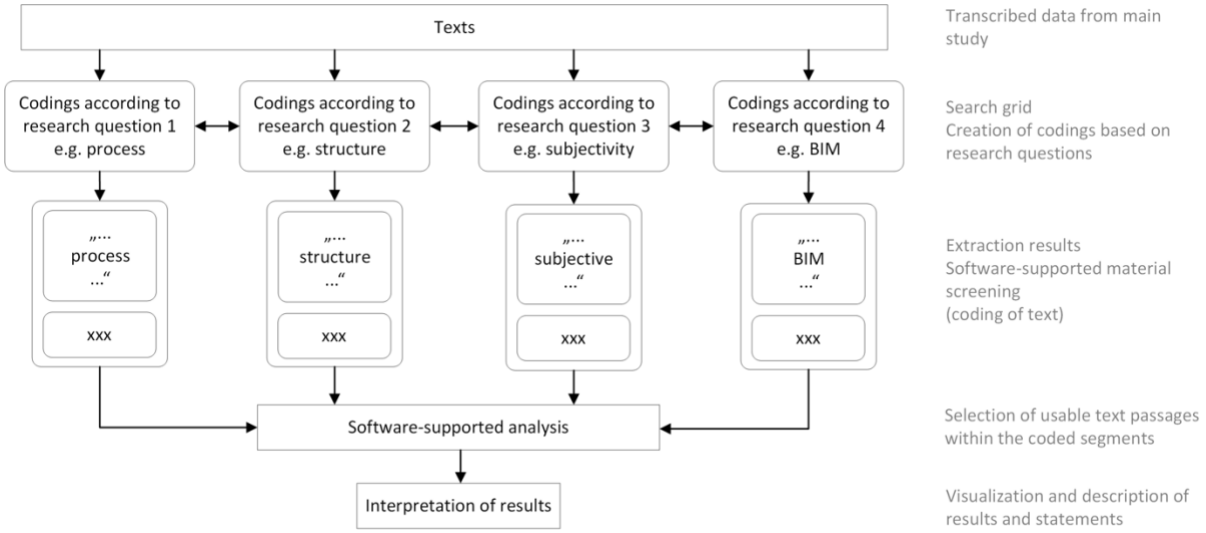

Figure 23 - Procedure of qualitative content analysis[318]

In the previous chapters, various empirical studies[319] have been mentioned that involved quantitative data collection. The qualitative data collected here cannot be compared with quantitative data.[320]

4.4 Interpretation of results

After the completion of the data evaluation, the interpretation of the results and thus the answering of the research questions followed, as indicated in Figure 21The descriptive model, which represented the actual state, was thus derived.

[318] Own illustration based on Gläser and Laudel (2010), p. 200

[319] Holte Consulting (2014), Stember and Neutzner (2014), Fiedler (2015), TMBV (2006), TMBLM (2009), Icks and Richter (2001)

[320] Bachmann (2007), p. 100

On the basis of the data material, 12 internal process variants and 12 organizational variants from the perspective of the building permit authorities were identified. In each of the following sections, three relevantly different variants are presented for comparison.[321] All process variants are provided in Appendix C, and the organizational variants can be viewed in Appendix D.

4.4.1 Processes

The first research question was as follows:
What do the processes look like in detail from the perspective of the building permit authority? Can a generally applicable process be derived?

The 12 identified process variants were essentially distinguished by the sequence of the process steps and the number of actors within the authority. The internal process variants 1, 3, and 12 are presented here as examples.

Figure 24presents intra-authority process variant 1. A building official handles all processes independently, such as the completeness check, participation of agencies of public interest, and the content check. After a decision has been made on whether a building permit can be issued, the building official signs the decision on his or her own responsibility. The head of the office is only consulted if necessary.[322]

[321] In the illustrations, the literal terms from the interviews are used as a matter of priority.
[322] This intra-authority process variant is part of intra-authority structure variant 1; see Appendix D.

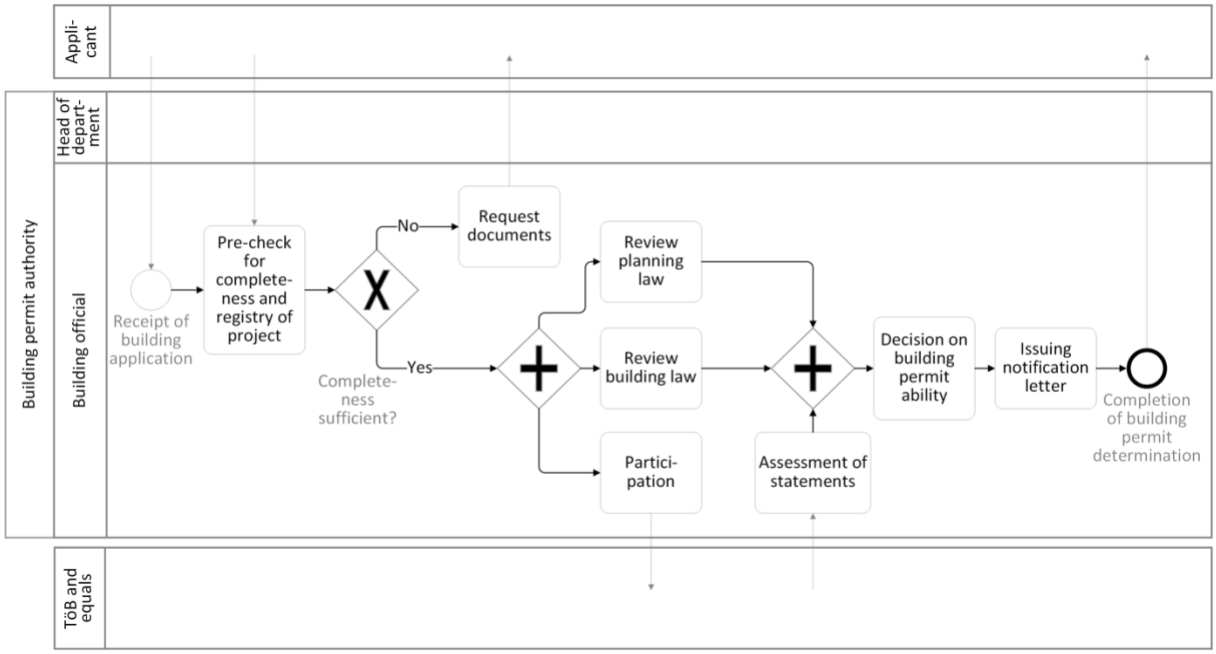

Figure 24 - Intra-authority process variant 1[323]

In the case of intra-authority process variant 3 (Figure 25), the building application arrives at the reception/secretariat, where its completeness is checked. A possible additional request to the applicant is also made by this department. Then, the project is assigned to a building official for processing. The building official involves the TöB as well as the municipal urban planning department and performs an examination with regard to planning law and building law. Once a decision has been made on whether the project is suitable for a building permit, the decision is signed by the head of the department. If necessary, the team leader is involved.[324]

[323] Own illustration

[324] This intra-authority process variant is part of intra-authority structure variant 3; see Appendix D.

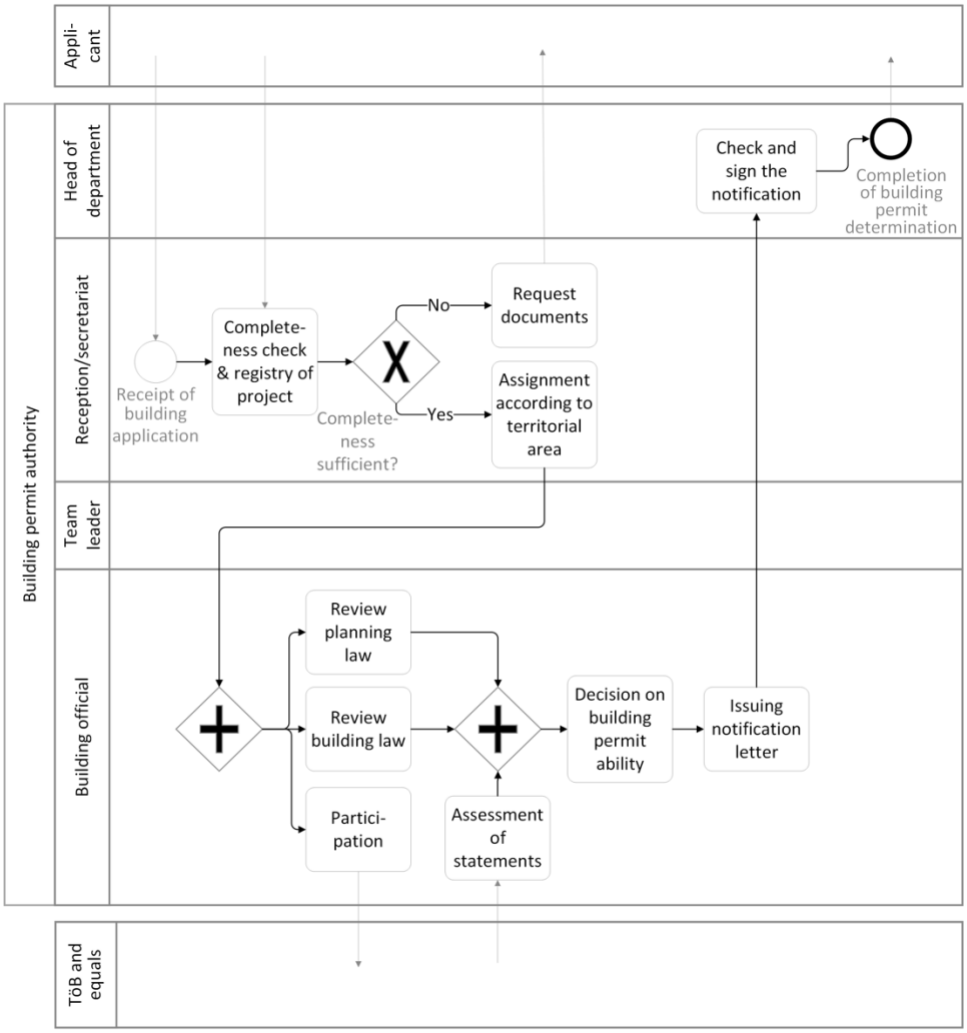

Figure 25 - Intra-authority process variant 3[325]

Intra-authority process variant 12 (Figure 26, page 85) starts after the receipt of a building application with the registration by an administrative building official. A technical building official then performs a completeness check and decides on the participation of the TöB. Then, an administrative building official initiates the participation. At the same time, the planning law and building law are checked by the technical building official. The decision on whether a building permit can be granted is made by the technical building official, while the letter is again prepared by an administrative building official. Finally, the decision is signed by the head of the department.[326]

[325] Own illustration

[326] This intra-authority process variant is part of intra-authority structure variant 12; see Appendix D.

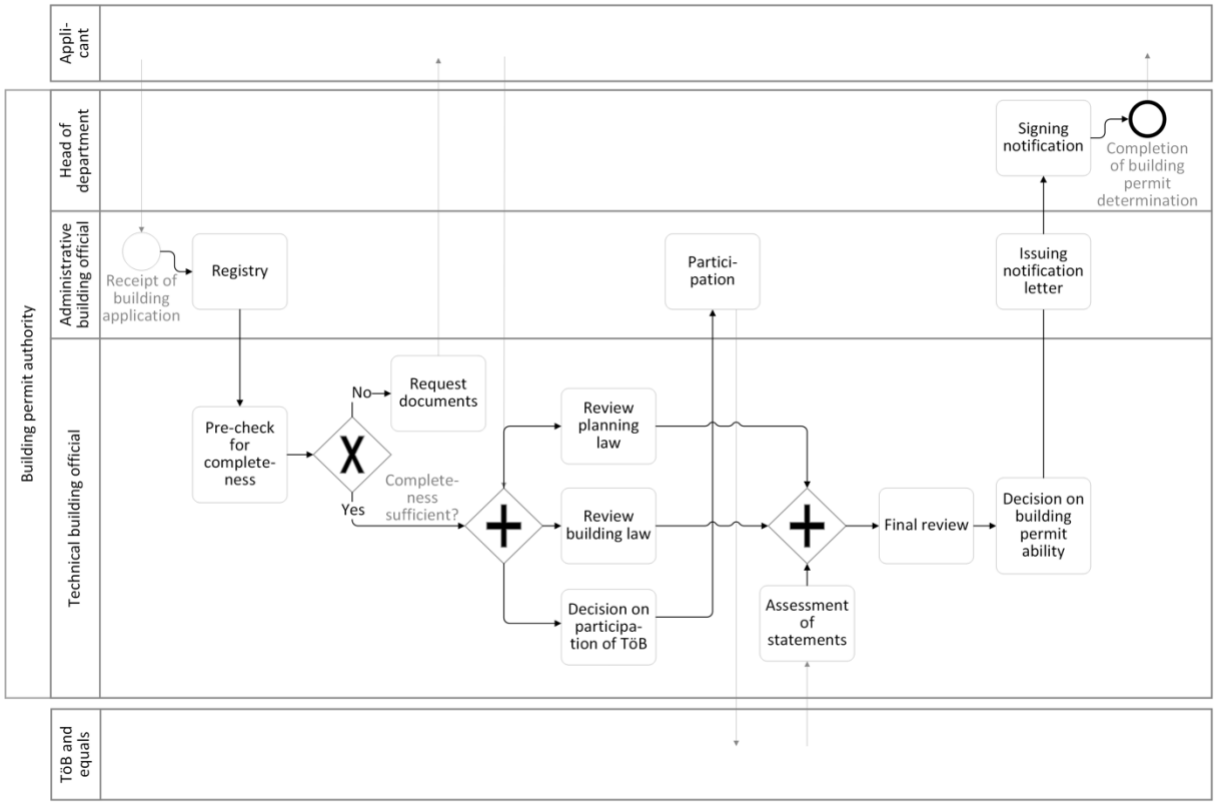

Figure 26 - Intra-authority process variant 12[327]

From the interviews, it was gathered that the processing of building applications to be examined according to priorities is basically dependent on the organizational structure. There were almost no indications of a clear or uniform **order**. In most cases, planning law (whether building is allowed) is examined first, followed by building regulations law (how building is allowed). However, both examinations sometimes run in parallel. The reasons for this are personnel capacities and the organization in the authority (e.g., in case the building application is processed by one or more building officials). On the formal side, the procedures seem more structured. Each building permit procedure begins with the submission of the building application and ends with the issuing of the decision. The processing in between depends on the official organization and working methods. Exceptions here are those processes associated with statutory deadlines, such as feedback to the applicant from the authority within two weeks of receipt of the application. This is often associated with a (at least rough) formal review.

The processes are highly authority-dependent, such as holding office conferences or consultations. **Communication** is an essential element during the examination, whereby problems can often be solved. This applies to internal exchanges (e.g., with colleagues) as well as to an external meeting with the applicant. This statement was confirmed by all of the interviewees.

[327] Own illustration

A selection of individual processes that could be identified in the data is listed as follows:

- Non-binding preliminary discussions and inquiries
- Acceptance of the building application
- Registry of the construction project
- Acknowledgment of receipt of the building application
- Completeness check of the application documents
- Possible additional requests for missing documents or information
- Assignment of the building application to building official(s)
- Involvement of public authorities, neighbors, municipalities, inspection engineers, etc.
- Collection and appraisal of comments from agencies of public interest and other interested parties
- Examination according to planning law
- Examination according to building law
- Holding of intra-authority meetings
- Consultations with external authorities (e.g., with higher or supreme building supervisory authorities)
- Hearings between building officials and applicants, also to invite subsequent submissions
- Preparation of the building permit notification letter

The interviews revealed that in certain situations, alternative courses of action are required that go beyond simply prohibiting or confirming the proposed content of the building application. On the basis of the examples asked (question block 4), it became clear that these alternative courses of action depend on legal leeway as well as the subjective considerations of the decision-makers.

Meetings take on different scopes and differ between building permit authorities. They are mainly dependent on the authority. The impetus can also come from a building official (building official-dependent). Collective interactions are called conferences, consultations, team meetings, commissions, or building rounds, among others. In principle, all forms are collegial, project-specific exchanges. Such exchange can occur in case of problems or questions as well as routinely. This routine can have content-related or time-related backgrounds. Content-related means that the exchange occurs depending on the project, such as in the case of a heritage-listed building or a special building. In other authorities, an exchange is scheduled on a rotational basis. For example, every two weeks a meeting is held between the building officials to discuss current projects. The forms of interaction differ in the number of participants and in their personnel composition, such as the inclusion of other

specialist offices. The individual consultation of a colleague can also be understood as collective interaction.

Participation is a particularly diverse subprocess as it involves numerous possibilities. The selection of possible TöB[328] to be involved is extensive. Added to this are the different ways in which the building permit authorities deal with this issue. First of all, the process differs in terms of who makes the decision (e.g., the building official or head of department) and who is involved. In some cases, certain authorities are always involved and others are consulted depending on the project. In some building permit authorities, the selection of the TöB depends exclusively on the individual case. This can also depend on the approach of the building official. An exception to this is when the TöB are asked whether they wish to be involved or whether they consider it necessary to submit a statement. For this purpose, the local authorities are provided with a brief description (with details of the building project, area, and type of use) and a site plan. With regard to the participation of the municipality, it should be noted that in the case of independent towns, the municipal urban planning office assumes the role of the municipality and, in certain cases, takes over the entire examination under building law. The decision as to which inspection engineer is commissioned in the case of special buildings depends on the authority or the building official. The federal state of Brandenburg, for example, plays a special role in this respect as it commissions inspection engineers through a central contracting agency.

Compared with building regulations and the organization of authorities in Germany, the **building permit process in the USA** is similar in the city studied. However, differences exist at the level of detail. For example, planning law and building law are strictly separated from each other, organized in two separate authorities. In addition, deviations from planning law are only possible with the participation of the public through so-called hearings. A hearing is basically also a type of meeting, which is usually moderated by a building official of the building permit authority (assigned under planning law). The applicant can present their proposal. Afterwards, the public has the opportunity to express thoughts on the building project. The building official records all input and submits it to the decision-maker (e.g., supervisor or head of department) afterwards. The applicant, or their representative, must make their own representations to the specialist agencies involved and obtain their opinions (including a planning opinion) before the final assessment is made by the building permit authority. There are additional fee-based services for guiding the applicant through the process, such as those for complex projects. The basic form of the processes is comparable to the German procedure. Special features can be mapped in the process scheme.

[328] This refers to TöB in the broadest sense. It also includes other specialist bodies that need to be involved.

4.4.2 Structure and organization

The second research question was as follows:

What internal structures exist in terms of organizational forms in the building permit authorities? Which influences have an impact on the structures?

Structures primarily refer to the **organizational forms and hierarchies** in the building permit authorities. This study demonstrated that a variety of structures exist in building permit authorities,[329] and these structures have an influence on the processes. Related to the structures are external factors such as the integration of checklists, seal authorization, and use of technologies. In total, 12 internal authority structure variants could be identified. The differences are illustrated here with structure variants 7, 10, and 11.

Figure 27depicts intra-authority structure variant 7. In this building permit authority, there is a head of department and several building officials.[330]

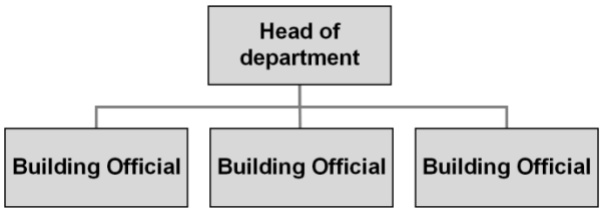

Figure 27 – Intra-authority structure variant 7[331]

In intra-authority structure variant 10, two departments are used in addition to the head of the department to process the determination of building permissibility. The department is divided into an administrative and a technical section. As Figure 28illustrates, each department can be staffed with several building officials.[332]

[329] The number of individuals is chosen solely as an example.

[330] This intra-authority structure variant is part of process variant 7; see Appendix C.

[331] Own illustration

[332] This intra-authority structure variant is part of process variant 10; see Appendix C.

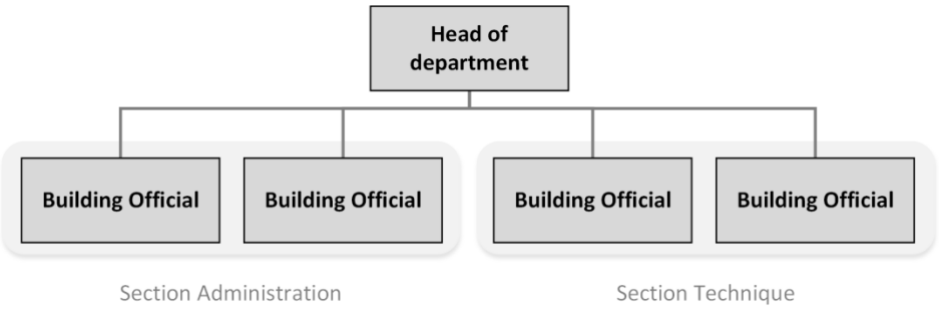

Figure 28 – Intra-authority structure variant 10[333]

Figure 29depicts internal structure variant 11. The head of department leads a secretarial office with various administrative building officials. Furthermore, there are various technical building officials in this building permit authority. These include building officials with a special area of expertise, such as urban land use planning, urban development, and building inspection. Other technical building officials are responsible for either planning law or building law.[334]

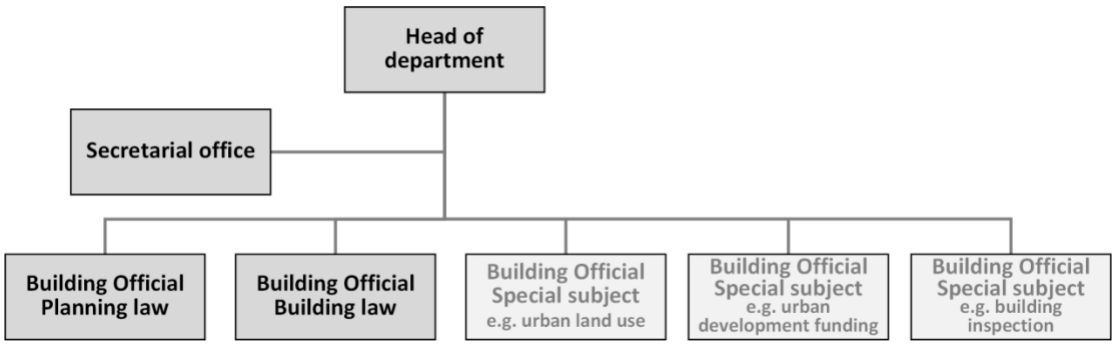

Figure 29 – Intra-authority structure variant 11[335]

In public authorities, **building officials** are employed with different qualifications and professional training. From a hierarchical point of view, building officials are led by a supervisor. Depending on the authority, the hierarchy can be divided into several levels. For example, team leaders, heads of department, or deputy heads of department are integrated into the authority hierarchy alongside the building officials. Furthermore, there is a subdivision into technical and administrative building officials. Technical building officials deal with all substantive aspects of building regulations. Depending on the expertise of the building official, a further subdivision can occur here. A common division is that according to planning law and building law. By contrast, administrative building officials handle all formal aspects of a building application, such as confirmation of receipt, the completeness check, and registration.

[333] Own illustration

[334] This intra-authority structure variant is part of process variant 11; see Appendix C.

[335] Own illustration

Checklists are in circulation in some building permit authorities. They have either been prepared by the entire authority or are only used by one building official. They serve as internal work aids and thought support. They vary in content and can be divided into the following three categories:

- Formal – checklist regarding the completeness of application documents
- Processual – checklist regarding the internal procedures of the authority (also participation of public authorities, "docket" or “routing slip” (in German: *Laufzettel*)
- Substantive – checklist regarding substantive contents to be reviewed (notes on processing and references to tangential aspects, such as ancillary building law)

An **authorization to seal** means the legal authorization by which the decision of an authority is officially confirmed. A seal is affixed to each decision after it is finalized. The person in a building permit authority who possesses a seal authorization depends on the authority. Thus, possession of the seal authority is determinative of the completion of the building permit determination. In some authorities, every building official has a seal authorization, while in other authorities, this act is the exclusive responsibility of a team leader or the head of the department.

4.4.3 Decision-making scope and subjectivity

The third research question was as follows:
How is the scope for decision-making dealt with? What role does subjectivity play? Are patterns discernible? What influences have an impact on the scope for decision-making?

Through the preliminary study, the **sensitivity** that exists on the subject of subjectivity became clear. Awareness of the subject varied widely. It turned out that the decision-making scope for determining the ability to obtain a building permit is manifold. Building officials are rarely aware of the decision-making scope and do not see it as a tool. This not only makes it more difficult for the building officials to determine whether a building can be approved but also for other parties involved to make decisions that are transparent and comprehensible.

The interviews made it clear that when it comes to the issues of **discretion and subjectivity**, the majority of the interviewees did not have a uniform idea of what they mean, nor did they have a uniform basis upon which to draw. Although how and when to act it is clear to a certain extent from legal texts,[336] there is only limited operational guidance on how to deal with the legal methods. The result is uncertainty on the part of the building officials conducting the review in the building permit authorities. This results in the fear of wrong decisions, which sometimes leads to an excessive desire

[336] Particularly from VwVfG in this case.

for hedging and also, for example, to the unnecessary involvement of an excessive number of experts and TöB. This demonstrates how important specialist knowledge[337] is to these authorities and that access to it is explicitly necessary in the authority as well as in the building permit review.

In addition to criteria that do not allow a quantitative assessment,[338] there are numerous subjective **decision-making processes,** which are mainly due to decisions made by individual building officials. These subjective processes occur throughout the entire building permit procedure. For example, the selection of the TöB is a subjective process. Improper selection increases the length of the review. Other examples are undefined legal terms that are directly linked to specific legal texts or that become apparent from the context. Gray areas in the building regulations, in the form of facts that are not clearly described or that do not clearly fit the building application, leave room for interpretation. Through the block of questions on examples, the use of tolerance areas became apparent. These relate to minor variations where the building official weighs up a decision without insisting on a variation application. An example of this is a few centimeters short of the setback area. Basically, a high degree of subjectivity in the building permit processes was confirmed. Furthermore, interviewees reported that **compensations** often occur.

At this point, individual opinions should highlight the **diversity** of the topic. For example, it was claimed that the scope for decision-making depends on the federal state and the municipal authority. Depending on the authority and the building official, the leeway ranges from thinking highly constructively to being faithful to the law (in the sense of being faithful to the letter). "Germany consists of small states."[339]

Another opinion was that a decision is objective as long as the objective of the law is achieved.[340] The different opinions implied that there is no unified idea for dealing with legal methods and the scope for decision-making.

The evaluation of the data material confirmed that applicants feel unfairly treated, and that a feeling that decisions on approvability vary depending on the particular building official arises.[341]

[337] MBO (2016), § 57 (3)
[338] For example, insertion according to § 34 BauGB (2020), § 34
[339] Interview partner P3
[340] Interviewee B1
[341] Interview partners B1, B12, and B14

Consequently, the aim must be to increase transparency in the processes and decisions as well as to strengthen intersubjectivity by disclosing the procedures and decisions.

Many building officials see a problem in the building regulations, especially with regard to the **objectives of the law**. The objectives of the individual regulations are often not clear from the legal texts and are not fully known to the examiners. The legal texts are therefore not user-friendly. Supplementary common literature, such as commentaries on the legal texts, provide assistance but only compensate for the deficit to a limited extent.

4.4.4 Digitization

The fourth research question was as follows:
How can digitalization, especially the BIM methodology, influence building permit processes?

The answers to the question of digitalization went in very different directions. Some interviewees had never heard of the term BIM, whereas others spontaneously came up with possible applications and advantages (e.g., a combination with virtual representations of the environment or terrain modeling in the model). The study indicated that even small steps in connection with BIM can support the building permit process (e.g., through visualization, realistic building modeling, measurements in the 3D model, and BIM as an argumentation tool in case of deviations). As an optional building document for the building application, such an application met with greater approval than the compulsion to use a BIM model. This is one way to successively introduce the BIM method to building officials and implement it in building permit authorities.

Approximately 71% of the interviewees[342,343] expressed **concerns and fears** or were skeptical about technical innovations and changes with regard to familiar knowledge and processes. The following are some of the reasons provided by the interviewees for being against digitization: the fear of new technologies (software use), fear of not being able to master (handle) the BIM software, associated uncertainties of being forced into a situation (if the government decides to use BIM), too few financial training opportunities, and concerns about data security and compatibility with the currently applicable legal situation (e.g., handwritten signed application form).

[342] This refers to the number of interviews in the German building permit authorities assigned to the main study.
[343] This statement merely reflects the conditions in the sample.

4.5 Summary of the empirical results

Empirical data were collected and evaluated through expert interviews and qualitative content analysis. One finding was that a great diversity exists in processes relevant to building permits. In combination with the internal structures of the authorities, the **variants and external factors** seem endless. Furthermore, it can be summarized that

- authority-dependent (depending on an authority),
- building official-dependent (depending on one person), and
- project-dependent (depending on the construction project applied for)

work methods exist. The more authority-dependent processes that are specified, the fewer building official-dependent processes can be found. Table 3summarizes a selection of the identified **dependencies**. In addition, various external factors were identified that influence decisions.

Table 3- Selection of dependencies relevant to the building permit process

Authority dependency	Building official dependency	Project dependency
Priorities with regard to the processing of building applications		
"Grown," implied processes	"Grown," implied processes	
Holding of regular conferences or consultations	Convening of (spontaneous) project-related meetings	Need for a meeting
Participants in the discussion rounds	Participants in the discussion rounds	Participants in the discussion rounds
Use of checklists	Use of checklists	
Granting of a sealing authorization		
Organizational form of the authority		
Experience of the Authority in terms of reference projects/procedures	Personal preferences, experience, and expertise	
Political and economic targets or objectives of the county or city.		Political or economic objectives related to the project
TöB to be involved	TöB to be involved	TöB to be involved

This study underlines the sensitivity on the part of building officials and the uncertainty regarding the **scope for decision-making** and the decisions to be made. Qualitative decisions require **specialist knowledge.** However, construction expertise and staff capacity are decreasing in the building permit authorities.

Both the literature and this empirical study have indicated a problem regarding the lack of explicitly explained **legislative objectives** in building codes. An approach for preparing the law objectives for the decisions is authoritative for model development.

A high deficit is emerging in the area of **digitalization**. Public authority employees are biased by fear and skepticism towards the BIM methodology. This represents a significant problem that should not be underestimated. The BIM method undoubtedly offers potential for building permit authorities. However, fundamental support from building officials and a gradual integration seem more desirable than a sudden, complete automation of the process. Thus, building officials can be persuaded and brought up to speed. Although ACCC represents a valuable approach to building permit checking, there is still a need for further and above all more fundamental optimization in the building permit authority than, for example, for automated rule checking to be perfected. The successive implementation of a BIM-based solution is one possibility that can be brought into line with the ideas of the building officials.

Decision-makers in building permissibility are looking for **suitable instruments** for their assessments. Above all, it is necessary to make the processes and decisions more transparent for all stakeholders. With a suitable instrument, it will be possible to create added value for these stakeholders; for example, conflict potential can be reduced and the security when dealing with decisions can be strengthened.

Further research is required to identify all cross-relationships before a model can be developed to determine whether a building permit can be granted. This study implied that many problematic issues can be mitigated by using a **structured approach** within the authority. A reappraisal of the processes in terms of system-oriented project and process management seems to make sense. Especially in process modeling, an unbiased perspective is helpful for identifying all processes and process hierarchies.

5 Analyses as the basis for a model

5.1 Concept of the analyses

Based on the results of the literature research and the empirical study, this chapter presents the considerations and analyses that served as the basis for the model and system. The analyses are summarized in Figure 30

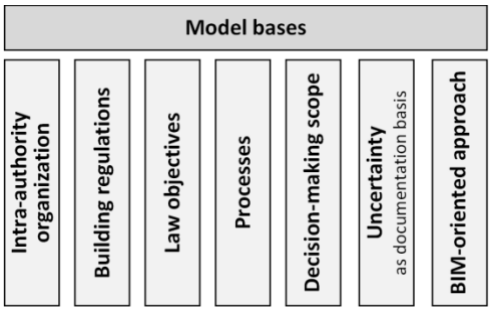

Figure 30 - Model bases

5.2 Authority organization

The **right of municipal self-administration** is anchored in Art. 28 of the Basic Law.[344] It regulates the so-called personnel and organizational sovereignty, which is incumbent on every district administrator and every mayor. Thus, each authority can determine its own structure. For this reason, general statements on the structures are only possible to a limited extent.

A universally applicable internal authority structure could not be gleaned from other sources, so the data material from the empirical study was used as the data basis.[345] Each organization is made up of a **combination of administrative and building engineering expertise** for assessing both formal and substantive requirements. Building officials contribute the subject matter expertise. The organization of building officials is usually hierarchical. To preserve the sovereign right of local self-government, the developed model needed to have a high degree of flexibility.

5.3 Selection and analysis of building regulations

Legal texts from the building regulations are used to determine whether a building can be approved, the most crucial of which are the BauGB, BauNVO, and MBO (representative of an LBO). They serve as references in the following. Legal texts consist of paragraphs. A paragraph comprises a superordinate test content. For example, § 6 MBO *Distance areas* (in German: *Abstandsflächen)* comprises the review

[344] GG (2019), Art. 28

[345] See Section 4.4.2

content *review of distance areas* (in German: *Prüfung der Abstandsflächen*). Checking for compliance with the regulations on the basis of these paragraphs seemed to make sense, as this compilation is anchored in building regulations and is thus already structured in an overarching manner.

First, a selection was made of the directly **relevant paragraphs in terms of substantive law**. This procedure served to differentiate from non-relevant regulations, since not all paragraphs become relevant in the context of determining the ability to obtain a building permit. The reasons are as follows:

1. A paragraph has only a descriptive and not a directive character. This includes, for example, descriptions of definitions and boundary conditions.
2. The responsibility for achieving the review content has shifted from the building permit authority. Examples of this are technical verifications, which are now only formally checked for completeness by the building permit authority.
3. For the determination of building permissibility, the formal and substantive examination must be distinguished. The paragraphs of the VwVfG regulate the formal criteria and are not part of the review content.

Table 4provides an overview of the remaining relevant paragraphs.[346] Depending on the building project, additional building regulations must be considered. As an example of this extension, the Model Accommodation Ordinance (MBeVO) is included here in the further steps.

Table 4 - Overview of relevant paragraphs for building permit determination

Planning law	Building law
BauGB §§ 30, 34, 35	MBO §§ (3), 4 - 6, 8 - 9, 13 - 16, 27 - 51
BauNVO §§ 15, 23	MBeVO §§ 3 - 9, 11 -12

The legal texts were subjected to a lexical analysis and a contextual analysis. In the process, text passages that imply **uncertain terms** were identified. Thus, reference was made to their scope and complexity. Among others, this analysis searched for the terms "immediate," "may," and "minor."[347] Examples are provided in Table 5, with the uncertain terms highlighted for illustrative purposes. Full extracts of the analysis can be found in Appendix E.

As a result, numerous uncertain terms were identified. Within the 48 relevant paragraphs, 176 subparagraphs were examined. Individual fuzzy terms or fuzzy word groups were counted. In total, 173 fuzzy terms were found in 86 paragraphs.

[346] The relevant paragraphs are always used as a basis below, unless otherwise stated.

[347] See Section 2.4.3

Table 5 - Examples of fuzzy terms

§ 35 BauGB - Building in external areas
(1) 4. [...] because of its special requirements for the surroundings, because of its detrimental effect on the surroundings or because of its special purpose should only be carried out in the outside area, [...] (1) 7. [...] use of nuclear energy for peaceful purposes or [...].
§ 9 MBO - Design
(1) Structures must be designed in such a way that they do not appear disfigured in terms of shape, scale, relationship of the building masses and components to one another, material and color. (2) Structural installations must not disfigure the street, local and landscape appearance.
§ 50 MBO - Barrier-free construction
(3) [...] because of difficult terrain conditions, [...] because of unfavorable existing development or [...] can be fulfilled with a disproportionate additional effort.

5.4 Identification of the objectives of the law

The diagnosed vagueness **demanded** closer consideration of the objectives of the law.[348] To make a balanced decision on a matter of building permissibility, the decision-maker must be aware of the objective of the law. These objectives can only be identified through an analysis of the legal texts and other specialist literature, such as specialist publications and commentaries on the law.

A target is defined as a desired state that is different from the current state. A **target system** is thus a set of target variables (of an individual).[349] Target systems are critical in decision theory as well as in the system-oriented approach of project management. In the decision-making process, the target system represents the preferences (targets) of the decision-maker.[350]

Criteria such as legality can be referred to as legal **performance objectives** and are considered an indispensable prerequisite or a strict secondary condition of a normative nature for the actions of public administration. The general good (or the public interest) is to be regarded as a political success target of public administration.[351]

For traceability purposes, the targets that were developed were recorded in a **database.** Table 6presents the schematic structure of the database and two examples. The data records were sorted according to the individual sections of the building regulations. Furthermore, the respective objectives were listed along with explanations if required. In addition, a literature reference was provided, including a reference to the jurisdiction (if known). Arranging the data in digital tabular form enabled

[348] See Sections 3.1.2 and 4.4
[349] Laux et al. (2012), p. 34
[350] Laux et al. (2012), p. 18
[351] Braun (1988), p. 101 ff.

them to be filtered and sorted (e.g., by section or by building code). The database is provided in Appendix F.

Table 6 - Schematic structure of the target database with examples

Information on the paragraph and its content	**Destination**	**Explanation of the objective**	**Source**	**Reference to jurisdiction** (if known)
Building regulations MBO § 4 Construction of buildings on the properties (development)	1 - Enabling the rescue of people and animals 2 - Secured access for supply and rescue vehicles	Regulates development in accordance with building regulations as a prerequisite for building	Meissner (2014), p. 43 (derived from ThürBO)	
Planning law BauGB § 34 Admissibility of projects within the context of built-up areas (admissibility in inner areas)	1 - Statutory plan replacement or plan amendment 2 - Enabling the development of an area in an appropriate manner		Rixner et al. (2018), p. 425	

The research along with the subsequent analysis produced a variety of different targets. They differed, among other things, in the area of law (planning law or building law). Accordingly, the objectives could be ordered. To ensure concrete compliance with the objectives, the objectives needed to then be transferred into a system of objectives.

To enable individual use, the target database should be expandable. Thus, future internal requirements of authorities, specific legalities, or legal amendments can always be entered in an up-to-date manner. As an example, test contents of the MBeVO are added here as a possible special building regulation. The preparation of further relevant legal texts is thus guaranteed.

5.5 Formalization of the processes

In contrast to the organizational structures of authorities, a generally valid pattern could be determined from the individual process variants. The extracted five main processes as well as essential allocations are presented in Figure 31. The process illustrated there corresponds to the period from the reception of the building application to the issuance of the decision. This is a **general, descriptive model** that demonstrates the current state. It is clear that the processes go beyond those specified in the building regulations.

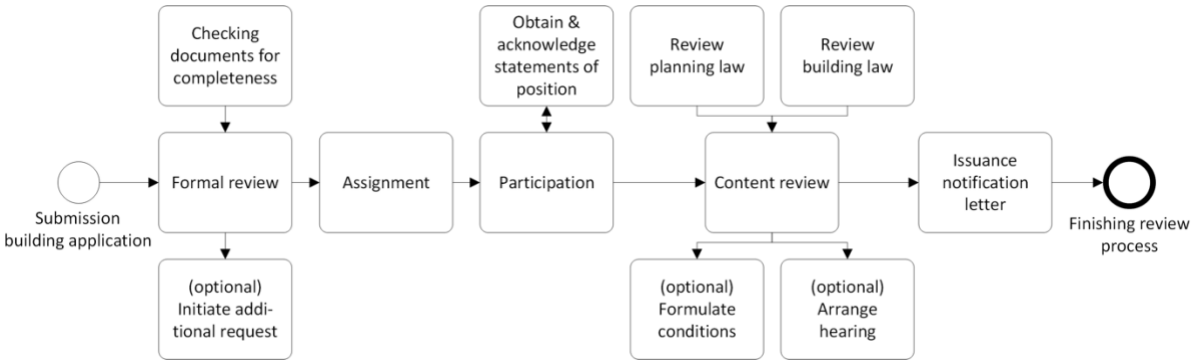

Figure 31 - Schematic overview of the main processes for determining building permits[352]

It should be noted that some process steps are only **optional** in a building permit procedure or that certain processes are only triggered by corresponding decisions. For example, a statement by a public authority can only be acknowledged if it has also been involved. The processes are thus largely dependent on external factors. This demonstrates the need for flexibility and adaptability.

Due to the individual nature of each case, qualitative decisions cannot be fully standardized or automated. This means that certain processes must always be conducted manually. Up to a certain degree of decomposition of the processes, the specification of **selection options** can standardize the procedure.

By way of example, Figure 32depicts a simplified process under planning law with regard to deviations. The figure also illustrates the processing steps in which interpretations and discretion can occur during the determination of a building permit.

[352] Own illustration

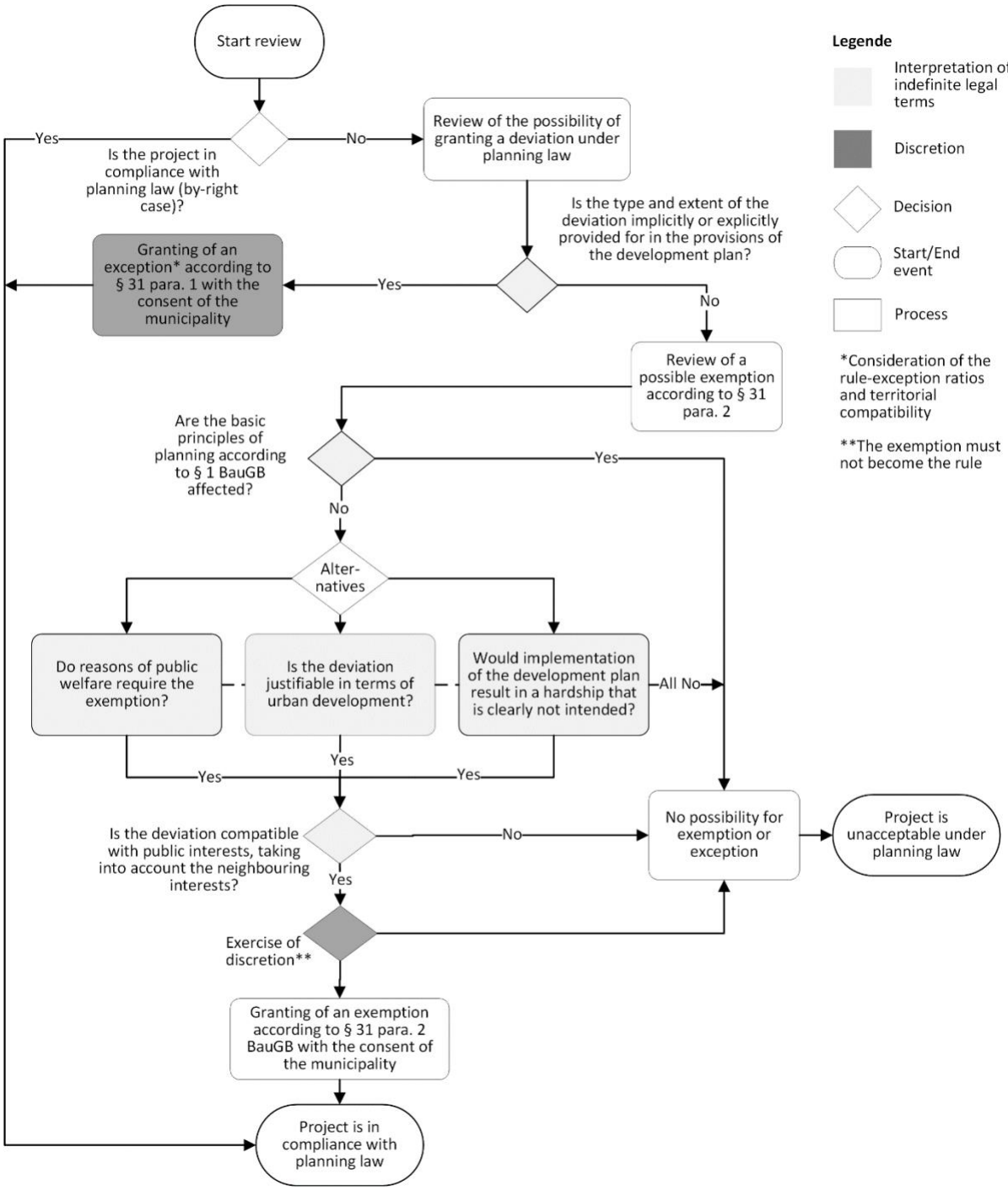

Figure 32 - Exemption and exception decision tree under planning law[353]

5.6 Typification of decision-making scope

The decision-making scope for determining whether a building can be approved is complex. Moreover, no uniform perception exists in official practice. Therefore, a typification is helpful and necessary.

[353] Own illustration

In the substantive review, various decision-making margins offering **alternative courses of action** could be identified. Alternative courses of action open up in the case of margins of interpretation, tolerance ranges, and applications for deviation,[354] as well as through conditions. Figure 33presents the four types of decision-making scope:

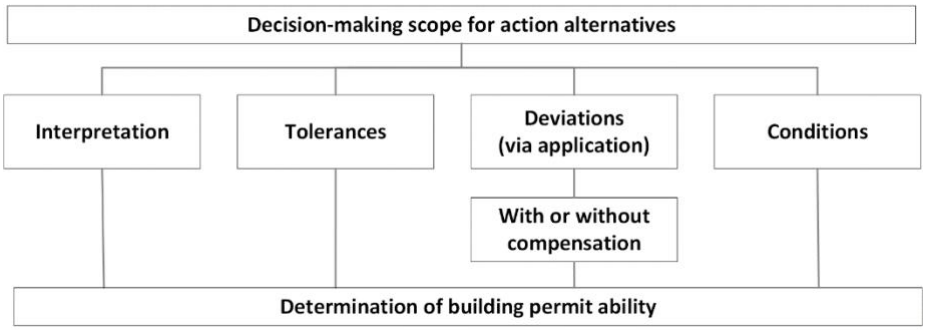

Figure 33 - Classification of decision-making scopes[355]

Interpretations are expressed through indeterminate legal concepts in legal texts and through the associated method of legal interpretation. Their application is mainly unconscious, through implicit (tacit) knowledge.

Tolerances are minor deviations from actually quantitative, numerical specifications, which are not explicitly regulated by the legislator but occur in practice. They are approved without a request for deviation. An example of this is the exceeding of the building line by the thickness of a plaster and the rounding up or down of the floor space ratio with more than one decimal place. Here, the decision-maker will weigh in independently.

Applications for deviations include requests for exemptions and exceptions as well as simplifications for special structures, and they require justification. Whether a justification warrants a variance is up to the decision-maker. Also at the discretion of the decision-maker is whether a compensatory mitigation measure must be offered for the variance and whether it meets the intent of the law.

Compensations can also be typified, as Figure 34shows. They can be divided into six types. Applications for deviation without compensation require no further explanation. Technical compensations primarily refer to technical solutions that are not specified in the law, but that correspond to the state of the art or even surpass it. For example, a water fogging system can be used instead of a fire protection wall. Architectural or planning compensation means a design or planning adjustment. An example might be

[354] For simplicity, the term deviation is used hereinafter as a proxy for variance, exemption, exception, and simplification, unless otherwise noted.
[355] Own illustration

a visual suggestion of an escape for a floor that is actually indented. There are also monetary compensations, which refer to compensation payments to the municipality, for example, for parking spaces that have not been built. Finally, legal or contractual compensation can be offered. Examples include the registration of building encumbrances on the neighboring property or the purchase of compensation areas in connection with an urban development contract.

In addition, supplementary **special evidence** can serve as a means of argumentation vis-à-vis the authorities and thus as compensation. One example is evidence provided by experts regarding the number of parking spaces that should be made available. If a sufficient number are available in the adjacent public space of the building project or there is a connection to the local public transport system, the required number of spaces can be reduced under certain circumstances.

Compensation measures thus serve to achieve the legal objective in an individual manner. There is no obligation for the building permit authority to accept them. Furthermore, not all compensation measures are possible for every construction project.

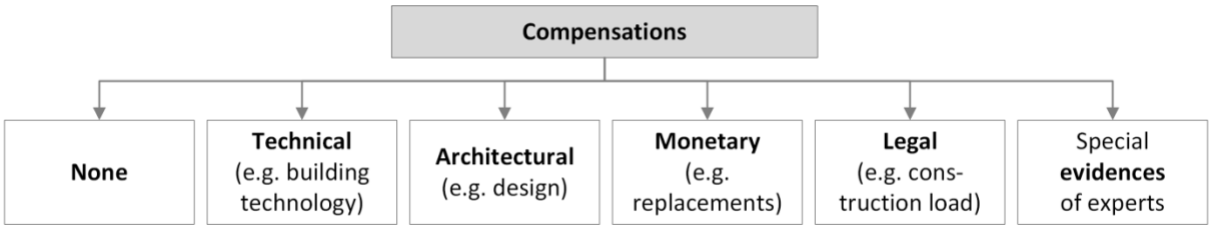

Figure 34 - Options for compensations [356]

Conditions provide a tool for the building officials of a building permit authority to enforce a legislative target. This allows a project to be approved if the builder meets the requirements decided by the authority. The conditions are part of the building permit notice. Conditions can also be imposed by the TöB and other parties (e.g., the municipality).

Public authority staff have a dual role in advising the applicant on questions of building law and procedural law.[357] Consequently, knowledge of their scope for decision-making is also essential information for the applicant to prepare and process the construction documents and as argumentation support in a hearing or justification.

[356] Own illustration

[357] See subsection 3.1.2.2

Subjective aspects in the formal sense could also be identified. To determine the suitability for building permits, it is necessary to **obtain the statements** of the TöB and equals. Which TöB are to be involved is at the discretion of the decision-maker.

As part of the completeness review, exceptions are often made at the discretion of the decision-maker. The **severity of the incompleteness** of construction documents is subjective and dependent on the decision-maker. An example is requesting the resubmission of a missing signature, while simultaneously passing on the application without waiting for the correct resubmission to arrive. This example can also stand for a missing proof, a missing indication, or something else.

Furthermore, the **assignment** of a request to be processed to a building official by a superior can be understood as a subjective aspect. Depending on various factors (e.g., the expertise or experience of the building official), the supervisor decides who will process the request. Since a criticism has been made that the handling and outcome of an examination depend on the building official him/herself, this aspect should not be neglected.

Basically, the **sequence of the processes** is to be assessed as subjective, since there is no legally prescribed sequence.[358] It can be assumed that the processes observed in practice have "grown" over many years in the building permit authorities and are followed intuitively. Basically, the order in which a building application is processed depends on the official organization, as does the order and urgency of several building applications in relation to each other.

5.7 Investigation of integrating the theory of uncertainty

The theory of uncertainty has not been applied in its original form to date because no membership functions can be defined. Indeterminate legal terms make system development imprecise. The complexity of building regulations, the demand for case-by-case justice, and the associated need for case-by-case interpretation represent hurdles in the application of fuzzy logic.

Nevertheless, **basic ideas of fuzzy logic** can be included in the considerations and analyses for decision making in building permit determinations. They help in understanding and categorizing legal requirements. For this purpose, some regulations are considered in more detail here. Figure 35presents examples of fuzzy functions that map the fuzzy elements in the form of the decision-making scope within German building regulations.

[358] See Section 4.4.1

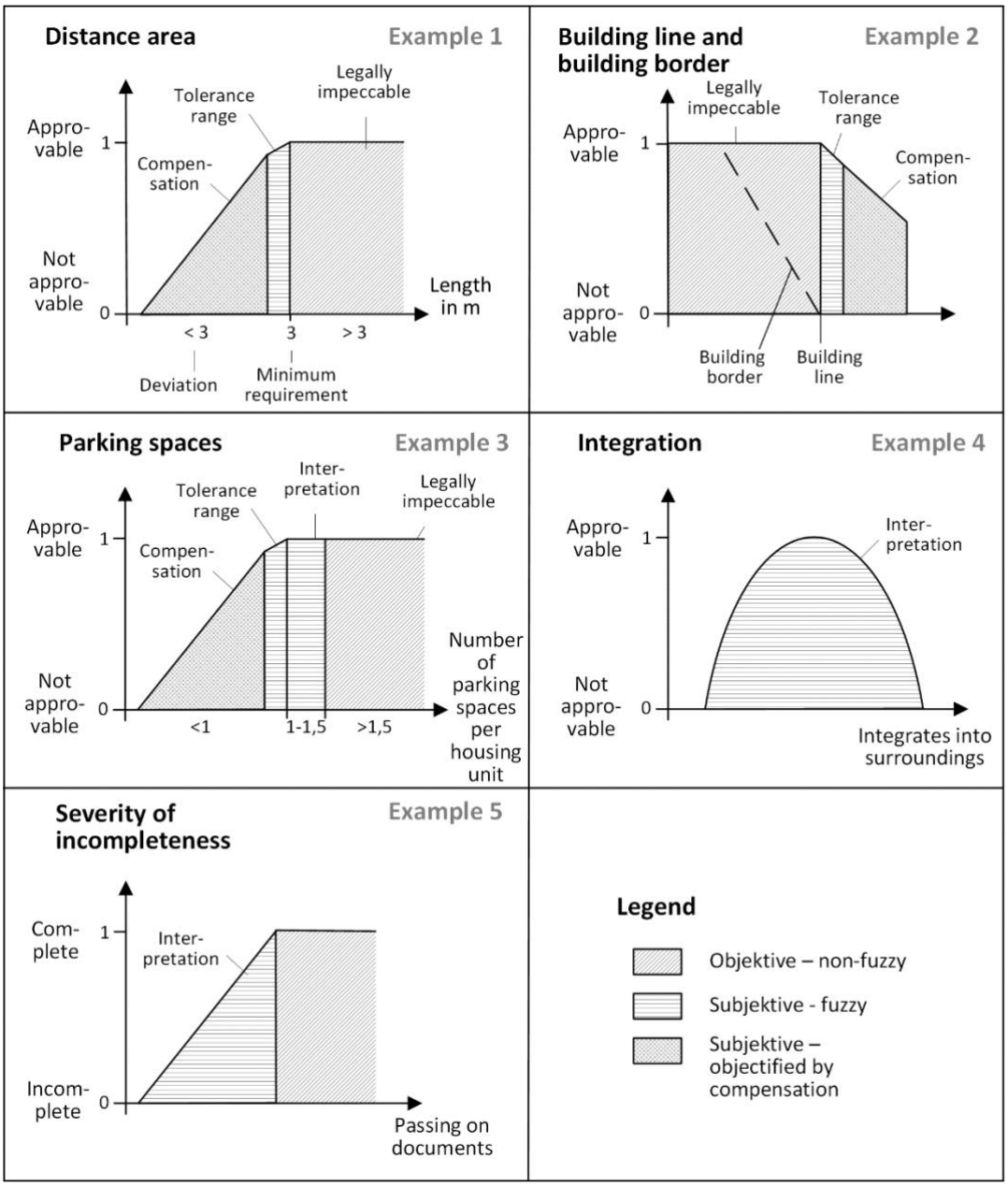

Figure 35 - Schematic illustrations of decision-making scope[359]

In Example 1, a given **distance area** of 3 m is assumed. This specification forms the boundary between a subjective and an objective decision. All values below 3 m represent a deviation. For example, the application of a subsequent insulation plaster may fall within the accepted tolerance range. Furthermore, compensation options can be considered for deviations below 3 m, such as the erection of a fire protection wall or the choice of a flame-retardant insulation material.

Example 2 demonstrates that all planning at the **building line** is objectively and legally impeccable. The value is based on the specification in the B-Plan. In addition, there may be exceptions or exemptions,

[359] Own illustration

depending on the definition in the explanations of the B-Plan or a specific situation in the sense of the individual case permits it (e.g., an angled corner property that is difficult to compare with the surrounding development).

Example 3 assumes that a residential development is to be built with a requirement of 1–1.5 **parking spaces per housing unit** (PS/HU). At 1.5 PS/HU or more, this is an objective decision and a legally sound specification. In the range between 1 and 1.5 PS/HU, room exists for interpretation. Relatively small deviations, such as one missing parking space out of a total of 300 planned and required parking spaces, are counted as part of the tolerance range. Furthermore, compensation measures are considered within the scope of a deviation to compensate for parking spaces missing in the planning.

Example 4 deals with the **integration of a building** into the surrounding development. Due to the large number of undefined legal terms in § 34 BauGB,[360] this is always a subjective decision in terms of interpretation.

Vagueness functions are possible in the decision-making scope, not only in the substantive sense but also in the formal sense, as in the decision regarding the **severity of incompleteness,**[361] as Example 5 indicates. The less incomplete the documents are, the earlier they are passed on without waiting for the subsequent submissions to be requested.

Theoretically, the assignment of building applications to building officials can be determined by a person (building official-dependent) or by a building permit authority (authority-dependent), thus creating specific ordering functions. This can be used, for example, to identify hardship cases or to keep certain variances small. Nevertheless, it is helpful if such fuzzy areas are documented in the processing order of construction projects; thus, they will achieve greater balance, transparency, and comparability. This is also an essential point for model development, for providing a suitable **documentation template** for structured data collection and collation. These data can be collected and evaluated regarding, for example, tolerances, interpretation, or compensations, which helps for future decisions and communication. Furthermore, conclusions can be drawn with regard to an implementation of fuzzy logic or knowledge-based systems.

[360] BauGB (2020), § 34

[361] See Section 5.6

5.8 BIM-oriented approach

The investigation has thus far demonstrated that a fully automated check is currently not legally possible and technologically infeasible. For this reason, this study aimed to link the necessary manual check with the option of checking on a BIM model.

This approach requires basic prerequisites and requirements for a building information model to allow the **manual BIM-oriented determination of building permissibility** under consideration of the legal, technological, and procedural aspects. This check is to be conducted with the most intuitive, already existing technological possibilities and legal conditions possible. An uncomplicated use should be aimed for, especially because many employees of the authorities must be introduced to working with BIM models.

Figure 36provides an overview of the methodology of the manual BIM-based determination of building permissibility. This overview does not ignore the fact that quite a few simple checks can be automated or at least pretested.

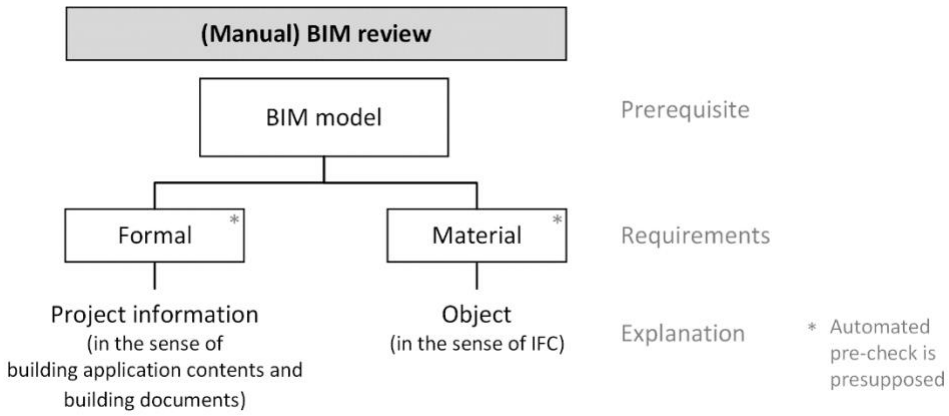

Figure 36 - Basics for manual BIM-oriented review[362]

A **prerequisite** for the BIM-oriented determination of building permissibility is the provision of all required information in the building information model when submitted to the authorities as a relevant information basis. To this end, certain **requirements** must be achieved, which are defined by the authorities. Based on the legal conditions, both formal and material information[363] must be placed in a BIM model.

Formal information means all of the information related to application forms, including the submitted construction documents. It is therefore referred to as project information. Information relating to the

[362] Own illustration

[363] See Chapter 3

building official as well as time information (e.g., dates of receipt) is formal information. Formal information is stored in the project information of the BIM model. Likewise, additional documents can be stored in the BIM model, such as supplementary application forms, expert reports, and proofs, insofar as they cannot or should not be integrated into the model.

Material information is understood to be the objects relevant to the building permit and their parameters in the BIM model. They serve to verify the substantive law.[364] It is necessary for the authority to provide the building owner or architect with a uniform template for creating the BIM model. This includes details of the MVD and the LOD.[365] Various details such as the marking of escape routes and fire doors/sections are to be clarified by the authority. Depending on the level of knowledge of the authority as well as their willingness, the involvement of model checkers as well as BCF should be suggested. Thus, the quantity check could be available as a supporting (digital) option and the building official can limit him/herself to a plausibility check of these performed automated queries.

To identify all **objects** relevant to the building permit, an analysis was conducted. The paragraphs relevant for the examination were examined according to the principle of decomposition. The resulting **building law object catalog** considers the object-related information. Thus, the object catalog includes specifications of the requirements that a BIM model must meet to determine the ability for a building permit to be obtained. Table 7presents two example lines from the object catalog. Based on the object catalog, an MVD can also be created for the building permit review, or it can serve as an aid for the building official to navigate in the MVD. The object catalog can be found in Annex G.

Table 7 - Example paragraph from the object catalog (MBO § 6 distance areas, distances)[366]

Paragraph to be examined	Review content	Required information for the test	Determination of the information	Objects and entities to be included in the model	Reference to the IFC entity
§ 6 MBO	Distance areas	Distance from property line to outer building dimension	Determination	Property, building, exterior walls	IfcSite, IfcBuilding, IfcWall[367]
	Building height	Distance from top of ground to roof peak	Determination	Property/terrain, roof	IfcSite, IfcRoof, IfcSolarDevice[368]

[364] See subsection 3.1.2.1

[365] See Section 3.1.1

[366] The designation based on the IFC was used as a matter of priority. In cases where no IFC designation existed, a generally valid formulation was chosen.

[367] BuildingSMART (2019), 7.4.3.39, 5.4.5.53 5.4.3.5

[368] BuildingSMART (2019), 5.4.5.53, 6.1.3.40, 6.1.3.52.

A **deposit of the targets** in the object properties was not pursued, since the targets do not only refer to an object alone. Accordingly, the targets must be placed in a higher-level position.

One result of the analysis was the realization that the current IFC standard[369] is not complete in terms of information relevant to building permits. This means that, for example, no IFC object designation exists for property boundaries. Furthermore, it is conceivable to integrate temporary objects for aspects relevant to building permitting, which are only mapped to determine whether building permits can be granted. An example is distance areas, which can function as an IFC object in the form of an area. Similar to a distance area plan, the shell developments of a building could be represented as objects, which are used as temporary objects only for the determination of the building permissibility.

It became clear that an MVD or **MVD bundle** is a suitable means of providing all material information to the building permit authority. An MVD bundle can be structured in such a manner that the MVDs list all of the inspection contents of the sections and record their material information, thus presenting the objects relevant to building permitting. It is also possible for an MVD to correspond to each inspection content of an individual paragraph and its material information. In addition, deviations or their compensation measures could also be depicted as temporary objects in an MVD. In doing so, the MVD should only contain the information relevant to the building permit to limit the size of the file.

In the following list, the essential work processes[370] are presented for how the data relevant to building permitting can be manually checked in a BIM model. These processes serve as an aid for **handling the BIM model** using tools provided in the software. Only basic knowledge of the program is required for execution. The tools vary between the programs (e.g., in their terminology), but basically contain the same functions, and accordingly, deliver the same results.

(1) Specific objects are **filtered** according to the respective paragraph (the procedure depends on the software).
(2) One should become familiarized with the **tools and functions** of the software, such as displaying views or visualizations, measuring, and calling up the stored object-specific information. Depending on the respective inspection content and the available documents (e.g., application for deviation), information from the BIM model is requested (e.g., for manual calculations). The options for **determining the required information** were differentiated as follows and stored in the object catalog[371] at the respective position:

[369] ISO 16739 (2017)
[370] Order and selection are to be considered individual.
[371] See Annex G

a) **Selection** – This refers to the selection of objects whose properties (e.g., fire resistance classes, parcels) are to be displayed and checked.

b) **Determination** – The refers to the determination of values by measuring or counting one or more objects (e.g., distance between objects, number of floors, or number of certain furnishing elements), outputting lists of components, and using the search function (e.g., for all penetrations of a wall alignment). Using the example of the distance areas, Figure 37presents the use of the *Measure* tool (measurement of the distance between the outer edge of the outer wall and the property boundary).

(3) Calculations or specified documents are **compared** with the determined, queried, or observed values or the visualizations in the BIM model.

(4) A **decision** is made on the ability for building permission and **document** the justification.

For information technology support, reference is made at this point to the results of the research project "*BIM-basierter Bauantrag*."[372] There, possible modeling guidelines were described, including the data exchange standards and formats XPlanung and XBau, which were observed for modeling a BIM model suitable for the building application. Exemplary project specifications can already be found in the BIM guidelines for the Free Hanseatic City of Hamburg.[373]

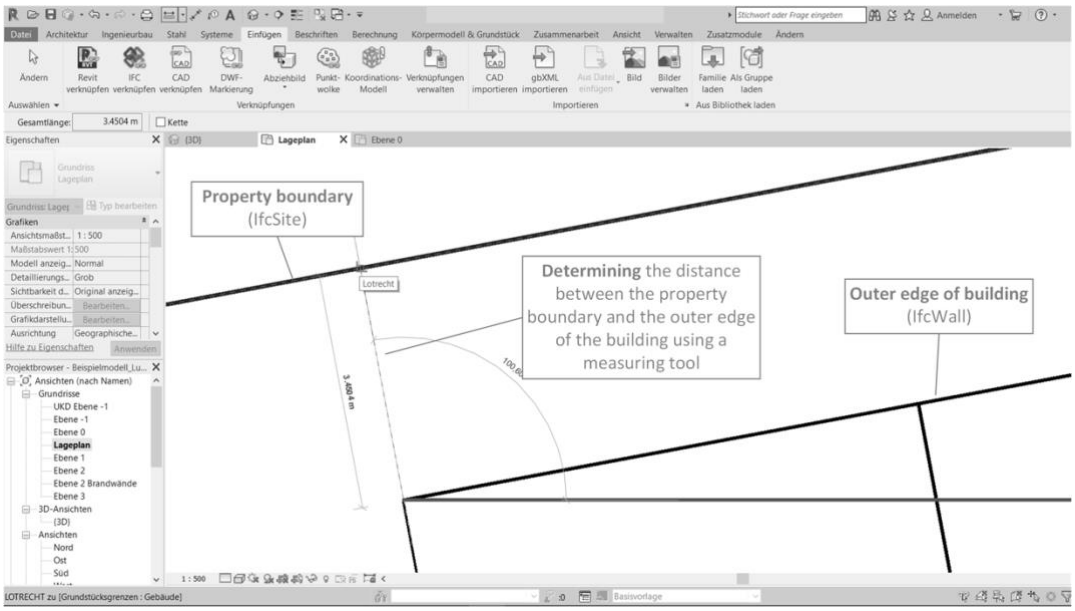

Figure 37 - Screenshot of a measurement of the distance areas[374]

5.9 Findings and results of the analysis

[372] BBSR (2020), Annex 3 - Modelling guidelines

[373] Stadt Hamburg (2019), p. 15

[374] Own illustration. Created with Autodesk Revit (2019)

Large amounts of information from different dimensions were incorporated into the assessment of building permissibility. The following findings and results were transferred to the model development:

- The consideration of the individuality of the forms of organization in the building permit authorities;
- The determination and investigation of relevant paragraphs from the essential building regulations;
- The identification of legal objectives and their preparation in the form of a database;
- The formalization of a generally valid process description of official procedures;
- The creation of a typology of decision latitudes;
- Structured data collection and compilation on decisions with fuzziness as a documentation template;
- Principle step sequences for a BIM-oriented manual check through describing prerequisites, requirements, and work processes.

6 Model for determining building permissibility

6.1 Approach and systematics

For the sake of clarity and comprehensibility, a major challenge is the high degree of complexity of aspects to be considered when determining the ability to obtain a building permit. The creation of the following system, described by a model, was performed from the perspective of the examining building officials as decision-makers. This generalized model can be used as a sample template across agencies. In terms of project management, the general model can be individually specified and adapted to specific projects.[375]

6.1.1 Structure of the model

The model developed for determining the ability to obtain building permits consists of an upper system, which is divided into the following four subsystems: the product system, target system, actor system, and action system. Figure 38presents a schematic representation of the model.

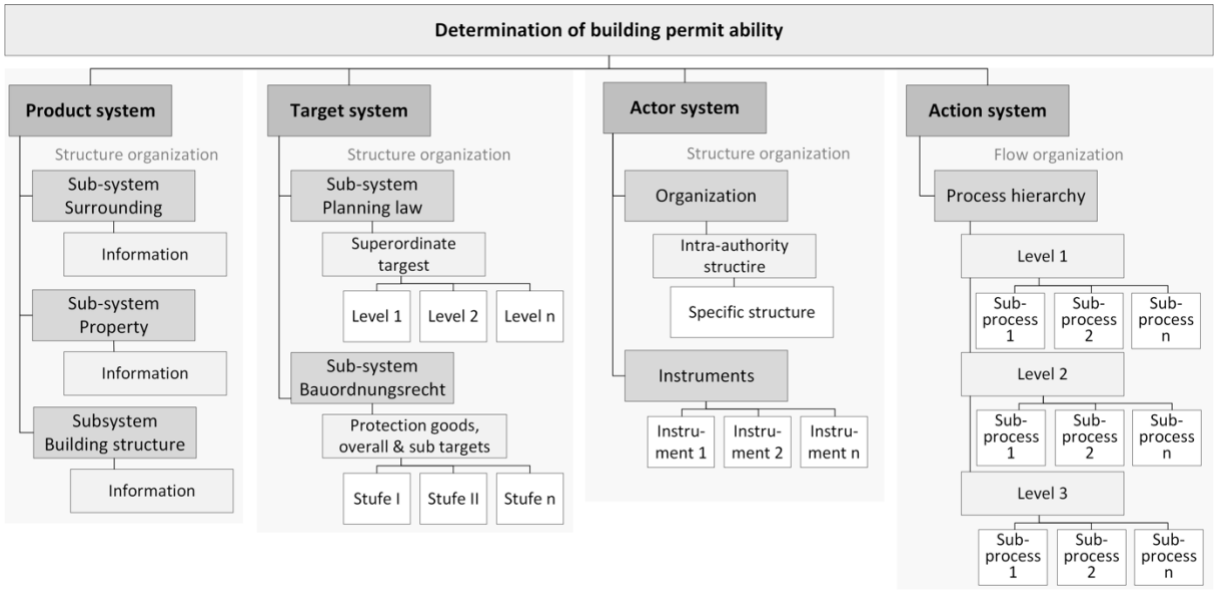

Figure 38 - Structure of the model for determining building permissibility[376]

6.1.2 Focus and delimitation

The following aspects are considered in the model:

- Basic contents of the building law
- Objectives of the legislation

[375] See Chapter 2

[376] Own illustration

- Intra-authority processes
- Official structures
- Scope for decision-making
- Quantitative and qualitative aspects
- Alternative courses of action
- Relevant external factors
- BIM methodology

In the previous chapters, several other problems were identified that are not considered further here. The following circumstances are therefore assumed to be given or met:

- A trustworthy environment (data security) exists;
- Data protection is respected;
- The authorization problem is secured (e.g., verification of identity, such as with a signature or the authorization to submit building documents);
- Hardware and software (also compatibility) are available and working properly;
- No interface problems exist when exchanging BIM model data (interoperability);
- Participants have further education and training; their technical knowledge is assumed and proficiency in basic BIM application is given;
- The archiving (file formats) is clarified;
- There are no proprietary data formats and no specifications regarding the software (manufacturer neutrality);
- There is a possibility of digital submission of the model-based building application (i.e., the complete relevant data model);
- Formal conformity is assumed as far as possible, unless otherwise stated;
- The software is able to check quantitative criteria automatically, provided they are stored object-oriented in the model;
- Other technological possibilities are assumed to be applicable without interference (e.g., model checking, MVD, and IFC compatibility).

It has been demonstrated that the structures as well as the processes that occur within them offer numerous variants. Since at least the internal composition of the authorities is subject to sovereign law,[377] it is not appropriate to assume standardization at this point. It is true that general aspects can be determined for achieving a comprehensible illustration. However, this generalization is unsuitable for practical application, which is why the model must be **flexible**. Furthermore, the developed model

[377] See Section 5.2

must be expandable. In view of the constant changes in the law or the consideration of municipal statutes, **extensibility** is fundamental. Thus, it absorbs the necessary **complexity** without being **dependent** on a specific building regulation or its amendment. The model can be used **immediately** and applied without any change in the law or technical development.

The model also provides high added value for **project developers and planners**. If the procedure is applied transparently, uniformly, and comprehensibly in the authorities, applicants will already have aligned their documents and processes with it in advance and accordingly established their own review processes.

6.2 Model description

This section discusses the subsystems for determining building permissibility. This is an abstract model description of said subsystems. The product system, target system, and actor system are based on a structure system, while the action system follows a sequence system.[378]

6.2.1 Product system

The product system contains all information on the building project. It consists of the planned building structure, the property, and the surroundings. The combination of these three aspects always represents a contextual and conceptual uniqueness, which is why all relevant information must be made available for the determination of building permissibility.

Formal and material information is available on the **surroundings**, **property,** and **building structure.**[379] This information can be transmitted in the form of application documents. Figure 39presents the schematic structure of the product system.

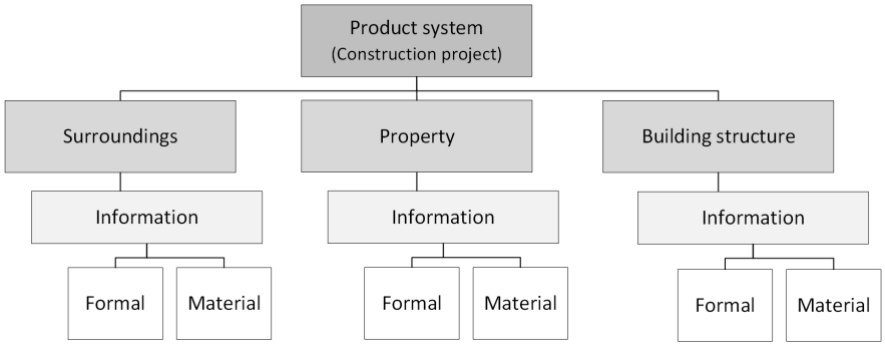

Figure 39 - Schematic structure of the product system

[378] See Figure 38

[379] See subsection 3.1.2.1 and Section 5.8

6.2.2 Target system

The **target system** consists of the overall target and the subtargets. The overall target always forces the determination of the ability to obtain a building permit. For the purpose of application, the targets are arranged according to the review contents in the order of the respective paragraphs of the relevant building regulations to ensure clear assignment for the reviewer. Figure 40presents the schematic structure of the target system.

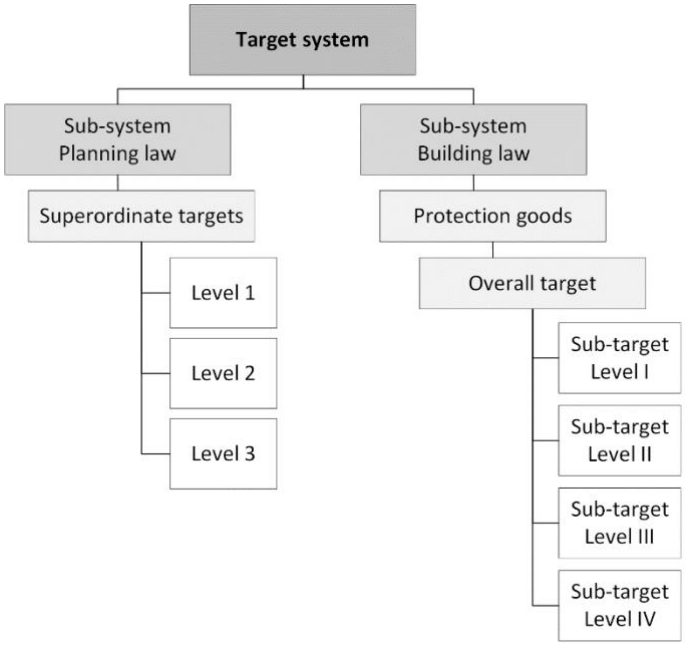

Figure 40 - Schematic structure of the target system[380]

In the development of the target system, the countercurrent method was used as an **approach.** This represents a combination of deductive and inductive methods and is frequently used in practice. The non-operational overall targets are broken down into subtargets, which in turn are broken down into individual targets (deductive). Furthermore, individual targets are collected, related, and aggregated up to the overall targets (inductive).[381] The target system follows a **hierarchical order**. When considering the targets, the planning law and the building law are separated from each other. The target system is divided into the subsystems of planning law and building law. While planning law mainly pursues concerns, building law pursues objectives.

The **planning law subsystem** is further divided into three stages, as depicted in Figure 41 and Figure 42. The stages can be described as follows:

- Stage 1: Respective area of application for permissibility under planning law;

[380] Own illustration

[381] Patzak (1982), p. 169; Eisenführ and Weber (2003), p. 62 f.

- Stage 2: Conditions of admissibility or a further subdivision of the respective area of application;
- Level 3: Relevant requirements below level 2.

The **subsystem of building regulations** mainly contains protection objectives, which can be divided into four levels of subobjectives in addition to the overall objectives. Upstream of these are the protected goods, as can also be seen to be evident in Figure 43 and Figure 44. The diagram depicts an end–means relationship. The required **extensibility** is also implemented in the target system. It is illustrated by the example of MBeVO [382]in Figure 43 and Figure 44. Thus, among other things, individual objectives (e.g., objectives of a political nature, which cannot be generalized) can be added to the target system on a project-specific basis.

Some subtargets serve to fulfil several (overall) targets. For example, the subtarget "*stairs" is* relevant for both overall targets of "*fire protection"* and *"traffic safety."* Nevertheless, the complementarity of targets cannot be assumed if the fulfillment of one target at least partially favors the achievement of another.[383] Legal requirements cannot replace others—all must be met in full. Furthermore, most subtargets are indifferent to each other, and they are independent of each other (e.g., accessibility versus design). Since the target system was developed from the perspective of official decision-makers, there are no conflicting targets. Conflicts may arise for the design writer as, for example, fire safety requirements may complicate other requirements. In the context of building permit determination, these conflicts are meaningless.

[382] MBeVO (2014)

[383] Patzak (1982), p. 171 f.; Schneeweiß (1991a), p. 58

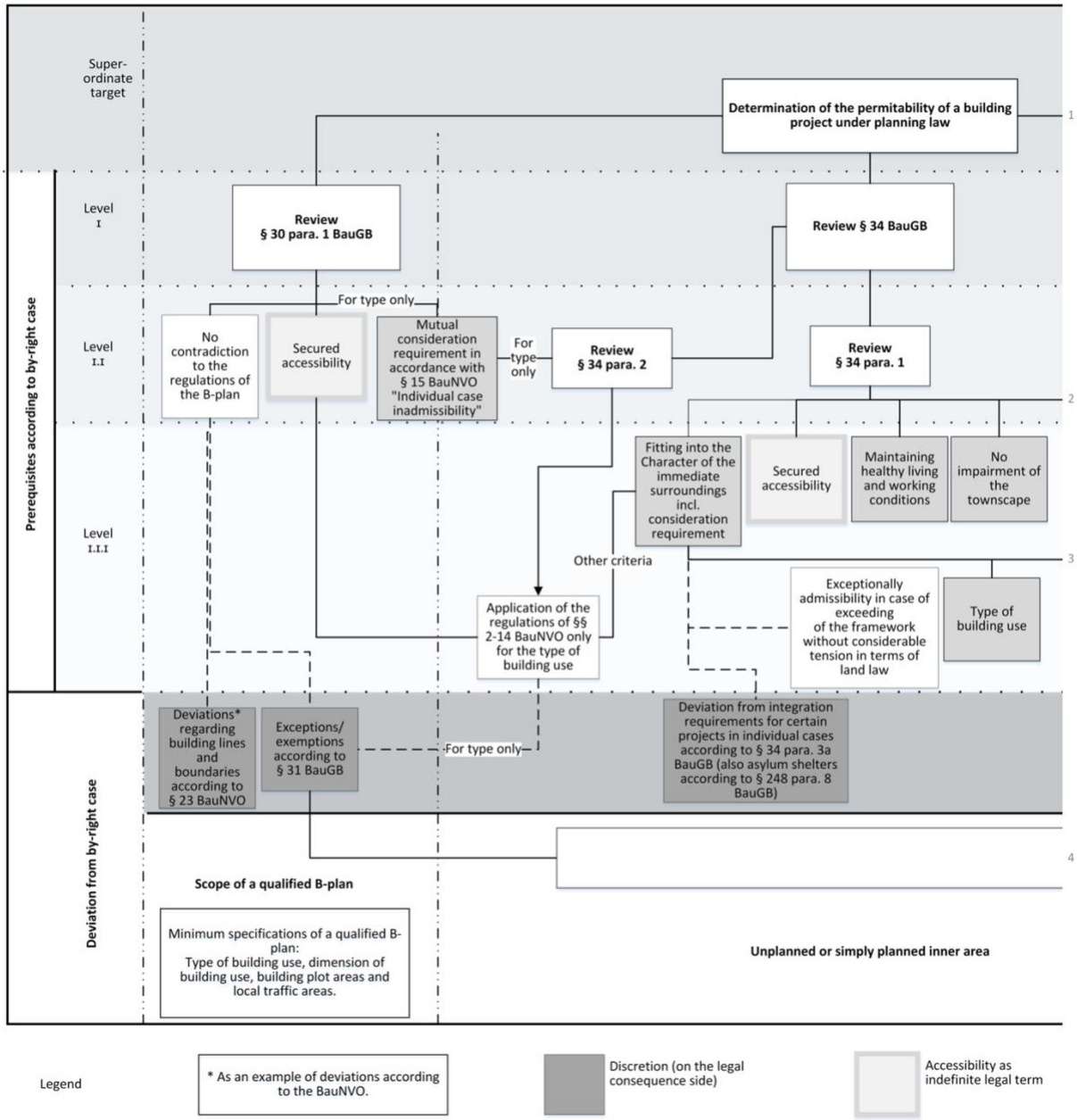

Figure 41 - Target system for planning law (Part 1)[384]

[384] Own illustration

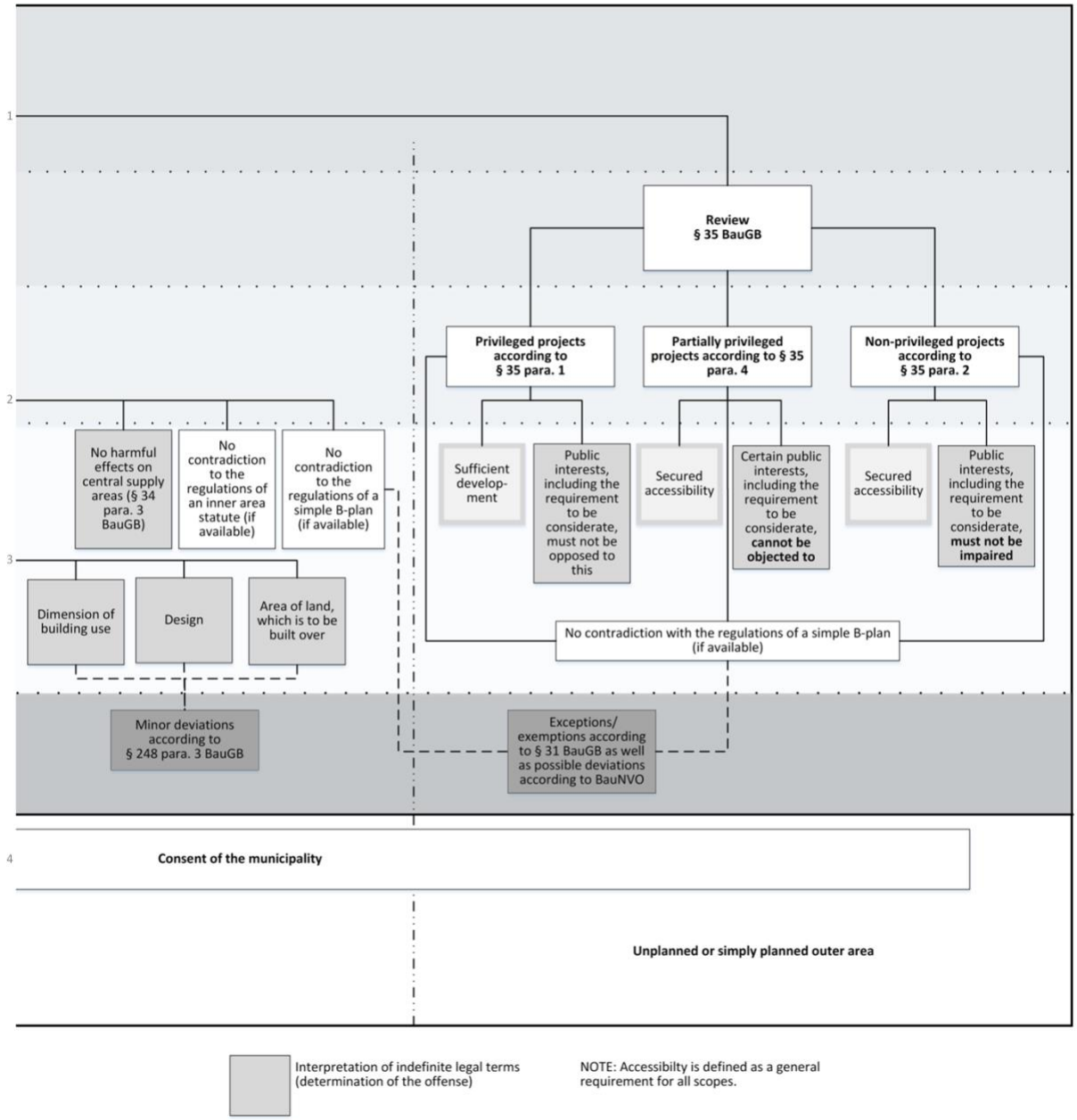

Figure 42- Target system for planning law (Part 2)[385]

[385] Own illustration

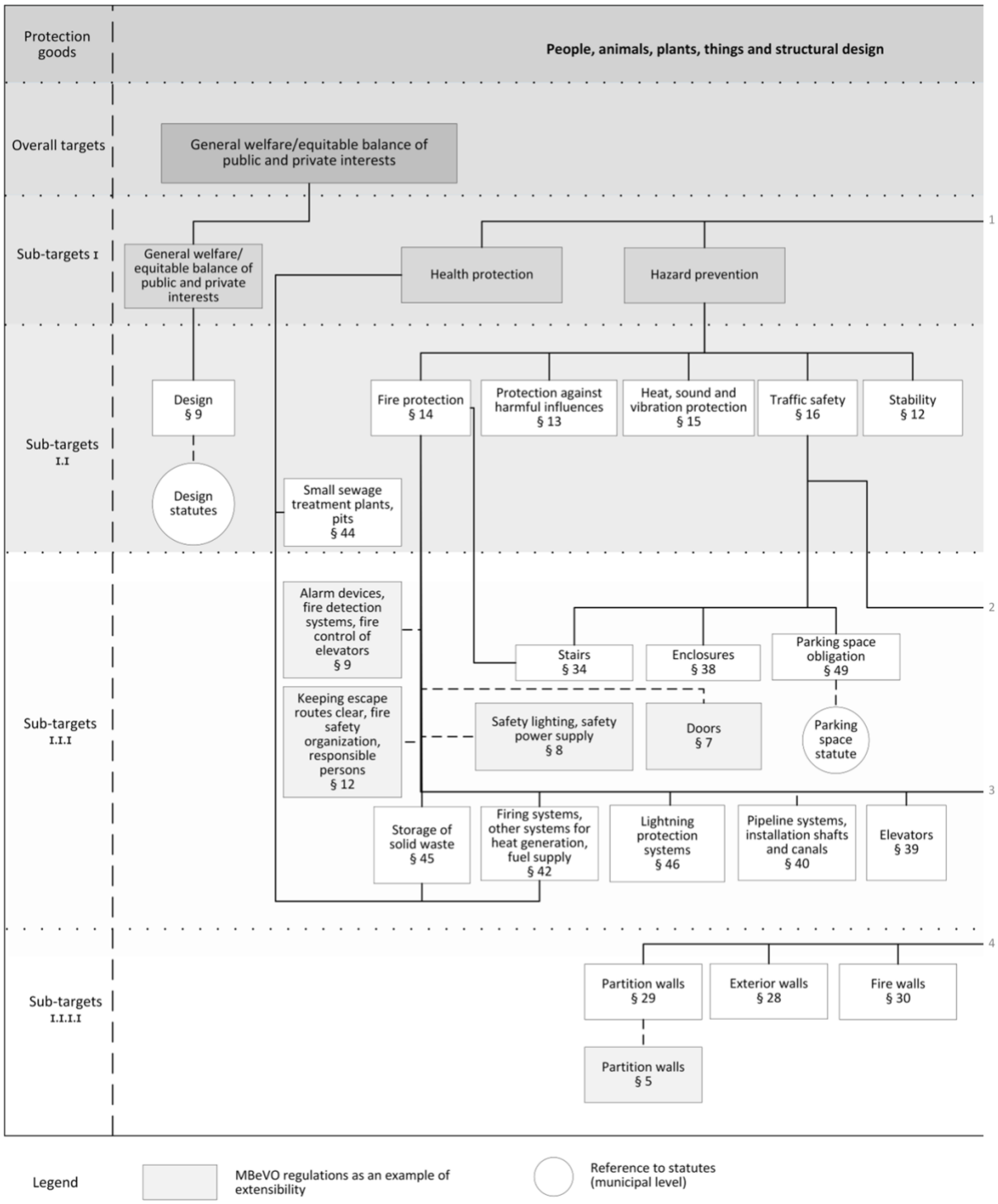

Figure 43- Target system for building law (Part 1)[386]

[386] Own illustration

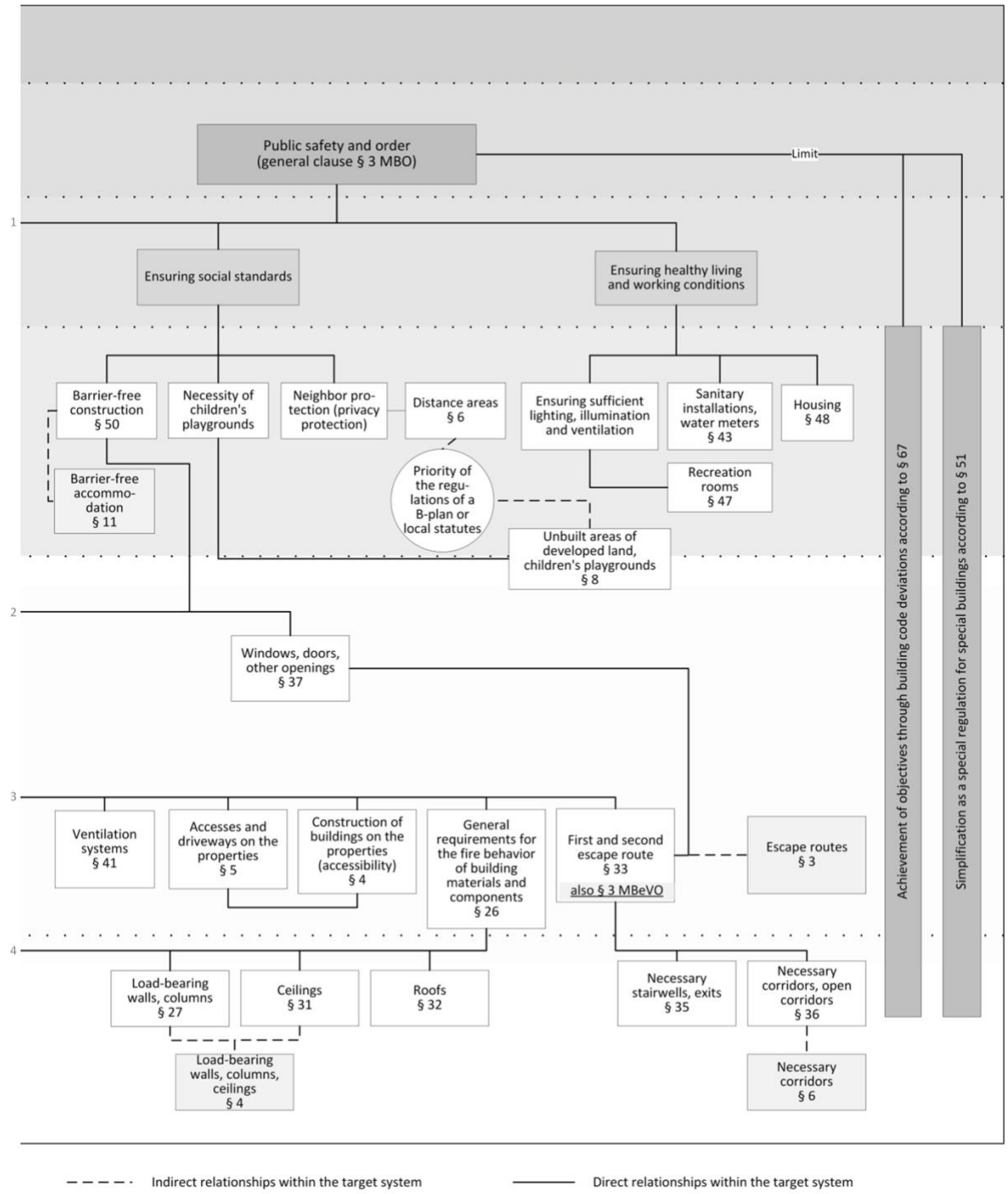

Figure 44- Target system for building law (Part 2)[387]

[387] Own illustration

Details on the targets of each review content can be found in the database[388] in Appendix F. The target database and the target system have a complementary function. The model gives the system a structure, while the data sets contain the targets and their explanations. The targets are not variable, meaning that they are not changeable. However, the targets can be achieved in different ways.[389]

6.2.3 Actor system

The actor system describes resources and factors that affect the action system and are not under the influence of the decision-maker.[390] These are various instruments as well as the official organization. Figure 45presents the schematic structure of the actor system.

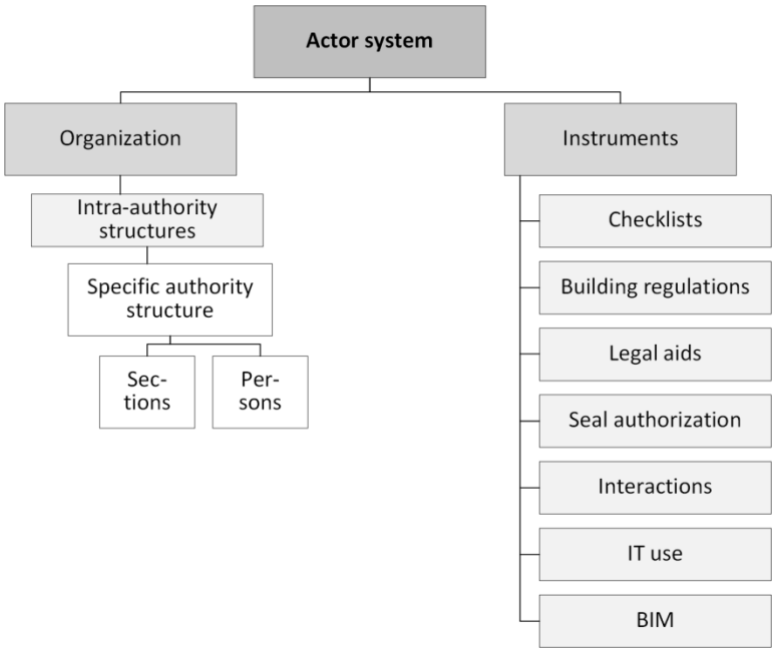

Figure 45 - Schematic overview of the actor system[391]

One component of the actor system is the official **organization** in the form of internal authority structures.[392] In principle, an almost infinite number of organizational possibilities are conceivable. For the resulting concrete models, the respective specific authority structure must always be applied.

One of the focal points of the actor system is the **instruments**, which can be referred to as elements that can be resorted to or dispensed with. This is an intra-authority decision at this stage. The list in Figure 45is not exhaustive but essentially maps the results of the previous studies.

[388] See Section 5.4

[389] Reference should be made here to the scope for decision-making as described in Section 5.6.

[390] See Sections 2.1 and 2.3

[391] Own illustration

[392] See Sections 4.4.2 and 5.1

Checklists[393] can function as a tool of a building permit authority (authority-dependent) or a building official (building official-dependent). However, they have not yet been used in all authorities and are highly individual. The contents of a corresponding checklist could be incorporated into the model.

Building regulations are anchored in the target system, but are also considered external factors for determining the ability to obtain a building permit. They affect the model and cannot be influenced by the decision-maker.

Legal aids can primarily be understood as the interpretation of decision-making scopes.[394] Specialist literature, particularly commentaries on legal texts, extend the spectrum. Furthermore, case law, such as in the form of court rulings, completes the legal aids. If existing within the authorities, practiced tolerance ranges can serve as a starting point for an assessment aid. Likewise, interpretation references could be used. For this purpose, it is necessary to continuously collect, document, process, and maintain decisions (even without a legal dispute).[395]

The **seal authorization**[396] influences the course of a building permit procedure. Depending on the award of the seal authorization within the building permit authority, another building official may be involved.

Various collective **interactions**[397] occur depending on the building permit authority and the building official. They occur on a rotational or spontaneous basis. The composition is also individual and depends on the building project to be reviewed.

IT use can be used in a variety of ways. Examples are document management systems of the authority, administrative programs, digital building applications, and online platforms for communication or data exchange as well as the use of GIS.

[393] See Section 4.4.2
[394] See also Section 5.6
[395] See Section 5.7
[396] See Section 4.4.2
[397] See Sections 4.4.1 and 4.5 - Dependencies

The use of **BIM** can be understood as a specific use of technology. The BIM use cases of quantity review and quality review,[398] which are relevant for building permits, can be applied when determining suitability for building permits.

6.2.4 Action system

The action system includes the processes in building permit procedures within the authority. These are the processes that are currently run through during the determination of building permissibility. These processes are divided into subprocesses to be able to map the existing complexity. For clarity, the subprocesses are subdivided into different levels. Action alternatives are integrated directly into the process levels. Figure 46presents the schematic structure of the action system, including the gradation of the levels and the list of individual processes.

In general, the **process levels** can be referred to as follows:

(0) Building permit process
(1) Main processes (of the building permit determination)
(2) Contents
(3) Conformity (material)
(x) Decisions[399]

Level 0 describes the breakdown of the entire internal **building permit procedure.**[400] This determination of building permissibility comprises only a part of the building permit procedure.

Level 1 contains the **main processes** that are necessary for determining whether a building permit can be issued. These include the formal examination, allocation, participation, substantive examination, and issuing of the decision.

[398] See subsection 3.1.1.3
[399] See Section 2.3, Figure 8
[400] See subsection 3.1.2.2

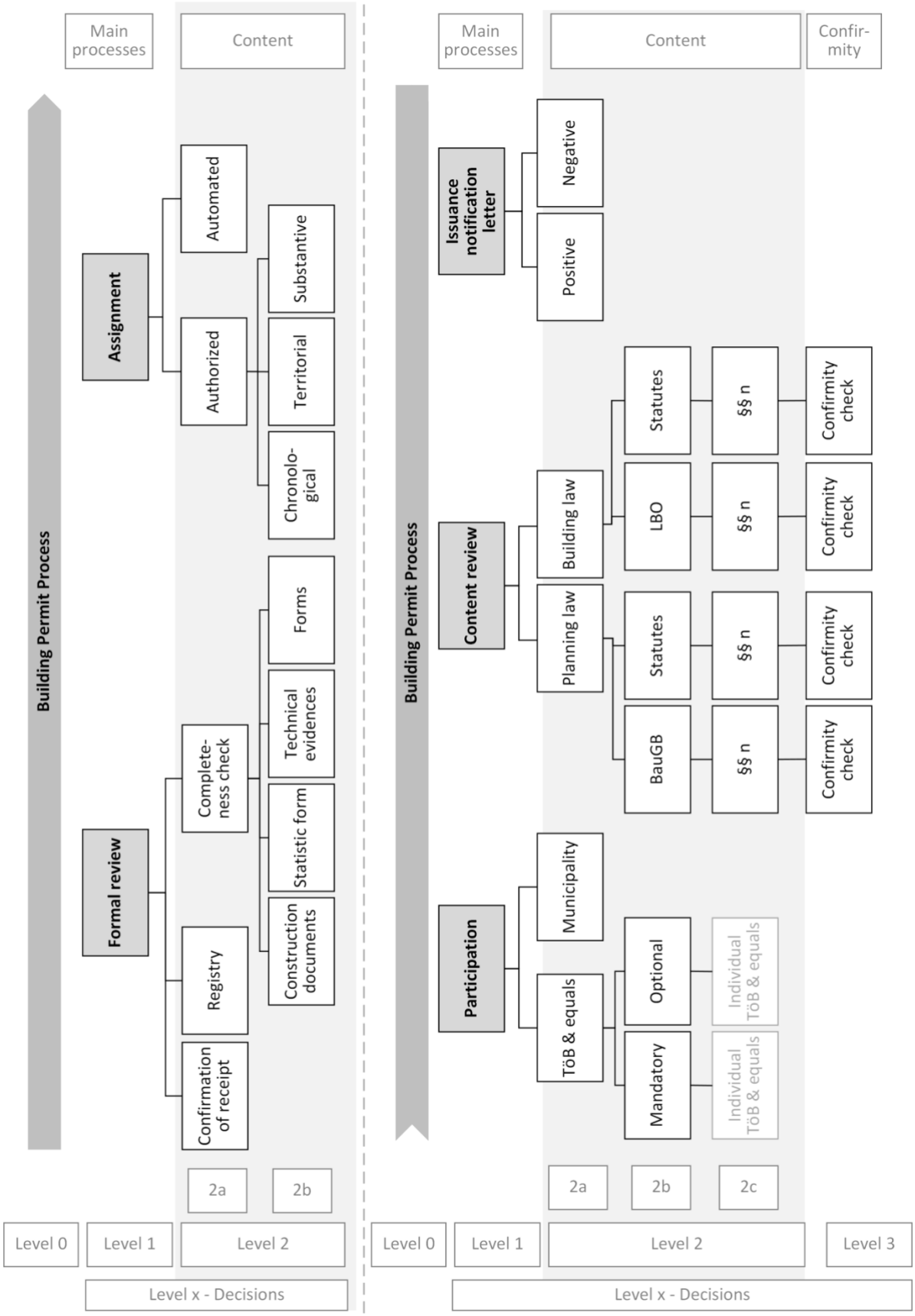

Figure 46 - Schematic overview of the levels and processes of the action system[401]

[401] Own illustration

Figure 47demonstrates that the process starts with the reception of the application documents and ends with the transmission of the decision. The chronological order of the processes is not fixed. They can run in parallel as well as sequentially until the decision is issued.[402]

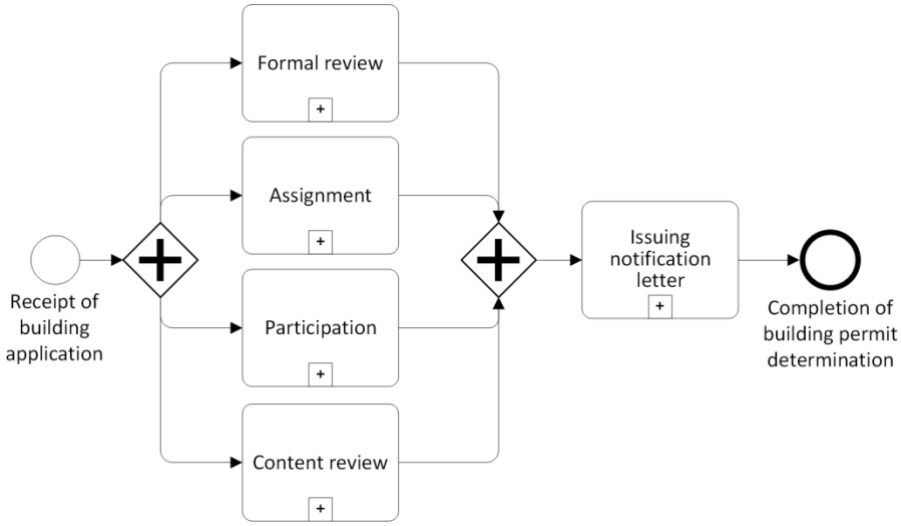

Figure 47 - Main processes (Level 1)[403]

Level 2 contains **content-related issues**, which are partly subdivided into further sublevels (2a, 2b, and 2c). In level 2a, the **formal check** is subdivided into the processes of confirmation of receipt, registration, and checking of the completeness of the documents. They can run sequentially or in parallel, as illustrated in Figure 48As soon as an application is received by the building permit authority, the **confirmation of reception** takes place. The **registration** is a process that is partly taken over by a data management system, but it can also be performed manually.

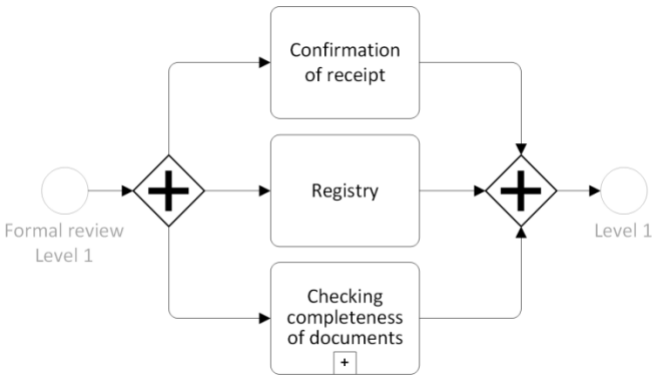

Figure 48 - Formal review processes (Level 2a) [404]

The **check for completeness** of the documents is divided into the following four subprocesses in level 2b (Figure 49):

[402] Ponnewitz and Bargstädt (2019), pp. 1563 f.
[403] Own illustration
[404] Own illustration

- **Review of application documents (including the BIM model)** - The type of submission of the planning documents, whether in paper form, digital documents, or a BIM model, is irrelevant. A combined submission is also conceivable. This is the decision of the individual authority or legal requirement. The completeness check must be adapted accordingly.
- **Review and forwarding of statistic form** - The building permit authority collects the statistical survey form as part of the building application and forwards it to the responsible authority. Only the submission of the document is checked by the building permit authority.
- **Review of technical evidence** - This includes the evidence provided by inspection experts. The certificates for fire protection, structural safety (statics), sound insulation, and energy saving (EnEV) must be issued and submitted on behalf of the applicant.
- **Review of forms** - The forms represent not only the building application itself but also supplemental applications (e.g., requests for deviation).

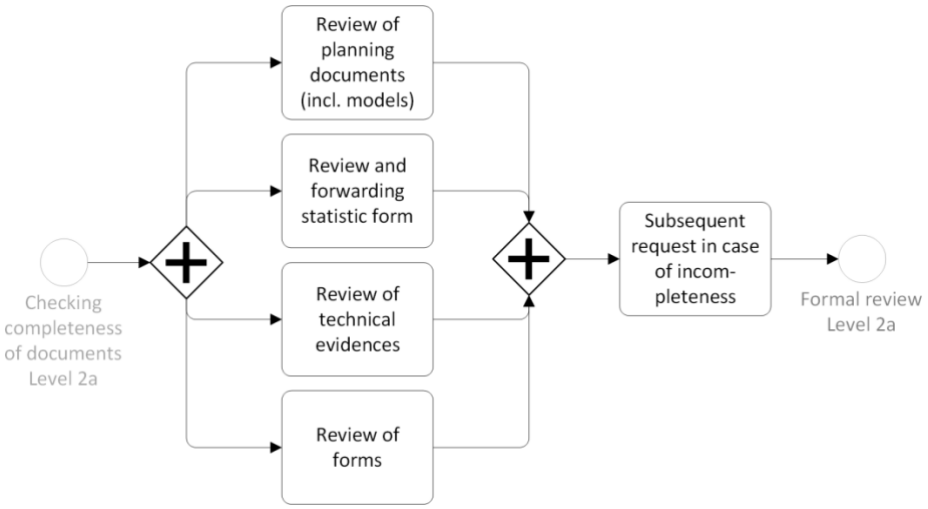

Figure 49 - Processes of checking for completeness (Level 2b)[405]

In this process, a subjective aspect comes into play in connection with the subsequent demand in the event of incompleteness. In practice, it is common for incomplete documentation to be submitted to the building permit authority. The variation ranges from the absence of an indication (e.g., house number of the developer) to missing planning documents or evidence. An assessment of the relevance of the documents to be submitted is made here.[406] A decision is made as to whether the missing information or documents are marginal, so that participation and substantive examination can nevertheless begin without waiting for subsequent submissions. Depending on the organization of the authority, a subsequent request may be made at the same time as the confirmation of receipt.

[405] Own illustration

[406] See Section 5.6

The **assignment** process describes the way in which an operation is passed on for content review. A distinction can be made between authorized assignment and automated assignment, as illustrated in Figure 50. **Authorized assignment** means that the assignment of the project to be reviewed is made by an authorized person (e.g., head of office, department head, or team leader). Authorized assignment in the second substantive level (level 2b) is chronological, territorial, or even substantive.

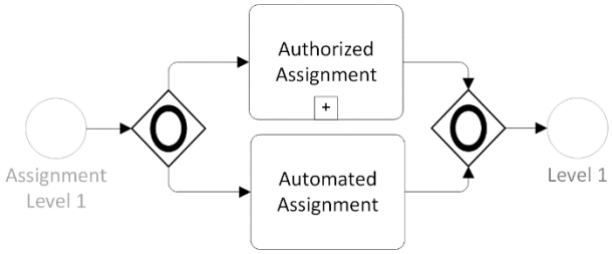

Figure 50 - Assignment process (Level 2a)[407]

An assignment is described as chronological if the next request is processed by the next free employee. In the case of a territorial assignment, a certain building official processes the urban areas (mainly in the case of cities) or localities (mainly in the case of counties) assigned to him/her. If a project is received by a building permit authority that is located in this city area, then that building official processes the relevant application. The option also exists of assignment based on content. In this case, the processing is favored by a certain building official who has specific expertise or experience with, for example, special buildings[408] or specific buildings (e.g., an airport). An economic or political priority may also be considered when deciding on the assignment. In addition, it is possible to entrust an "easy project" to an inexperienced staff member for familiarization. An employee's intercollegiate network may also justify an assignment decision. Authorized assignment, especially substantive assignment, can be understood as a subjective decision. Figure 51presents a procedural diagram of the subprocesses.

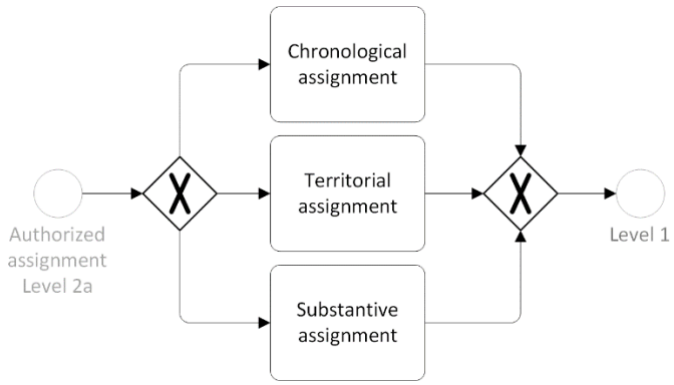

Figure 51 - Authorized Assignment Process (Level 2b)[409]

[407] Own illustration
[408] MBO (2016), § 51
[409] Own illustration

Since the empirical study demonstrated that, from the applicants' point of view, decisions regarding the ability to obtain a building permit are strongly dependent on the individual building official (building official-dependent), the allocation should be regulated in a business assessment plan and deviations from it should be documented with reasons.

An **automated assignment** is conducted as an independent process depending on the internal organization of the authority. The possibilities of assignment are basically the same as for authorized assignment, but are determined in advance and occur without intermediate action by an authorized person. Thus, the existence of a clear business judgment plan can be assumed.

Which allocation is considered depends on the internal organization of the authority. Both possibilities can run independently of each other or in combination. For example, a team (several building officials) may be assigned to a city area, but the individual assignment to a building official is made by the team leader. Factors influencing a decision in the form of assignment include

- the areal listing of the building permit authority (county or city),
- the staffing of the building permit authority, and
- the individual expertise of each building official.

Another main process is **participation**. This refers to the participation of TöB as well as “equals” and local authorities, as can be seen in Figure 52"equals" refers to all specialist authorities (for ancillary construction law), utility companies, and other experts. Furthermore, their opinions are obtained and evaluated. This also includes evidence and inspection reports. Finally, the contents of the comments are incorporated into the decision.[410] Conditions for the construction project may be integrated into the comments.

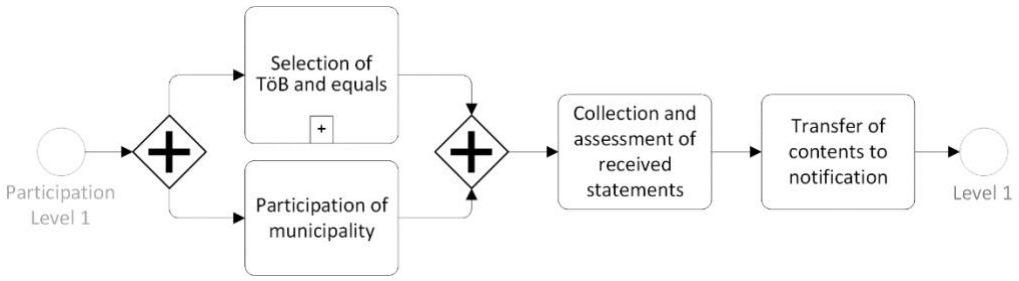

Figure 52 - Participation process (Level 2a)[411]

The participation of the TöB and equals is subdivided into the subprocesses of mandatory and optional selection, which can be observed in Figure 53Depending on the internal structure and working

[410] See the main process of issuing a decision

[411] Own illustration

methods of the authority, certain agencies of public interest and equals are always asked for their opinion (i.e., independently of the project). **Mandatory** participation also takes place in accordance with statutory regulations and depending on the project. For example, the monument protection authority must be consulted in the case of a listed building or the nature conservation authority if the property is adjacent to a nature conservation area. In addition, inspection engineers are involved in the case of special buildings.[412] **Optional** participation also occurs depending on the project and the assessment of the building officials. The latter thus seeks such further opinions and reports from equals as they deem necessary to determine whether the building permit can be granted. The process is identified as a subjective process.[413]

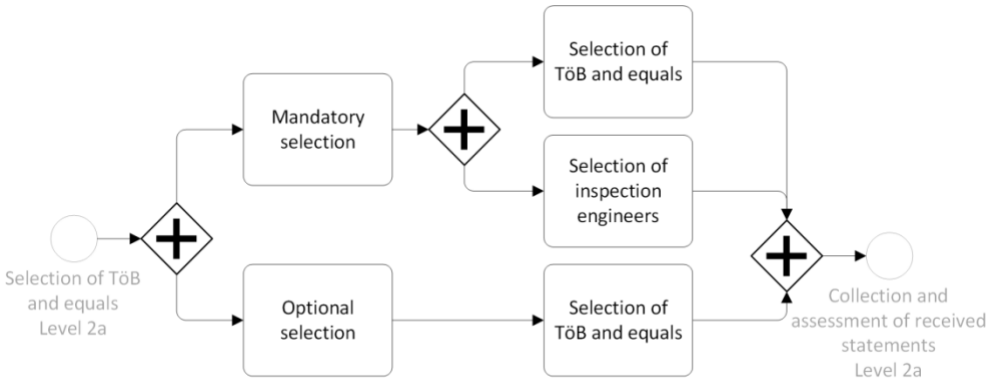

Figure 53 - Process of selection of TöB and equals (Level 2b)[414]

Particular attention is paid to the **substantive examination** in building permit determination. This is understood to mean the examination of substantive building law. This substantive examination is first divided into planning law and building law, as Figure 54shows.

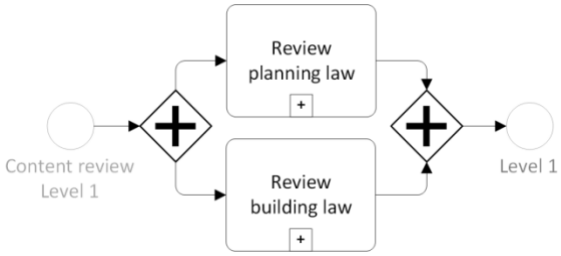

Figure 54 - Content review process (Level 2a)[415]

Planning law is usually reviewed before building law. Alternatively, the processes can run in parallel. In the subprocess (level 2b), the review of planning law is divided into the review of possible statutes

[412] See subsection 3.1.2.2
[413] See Section 5.6
[414] Own illustration
[415] Own illustration

with planning law content and the review in accordance with the BauGB and BauNVO. Figure 55presents an example of how the model is structured along the individual paragraphs (level 2c).

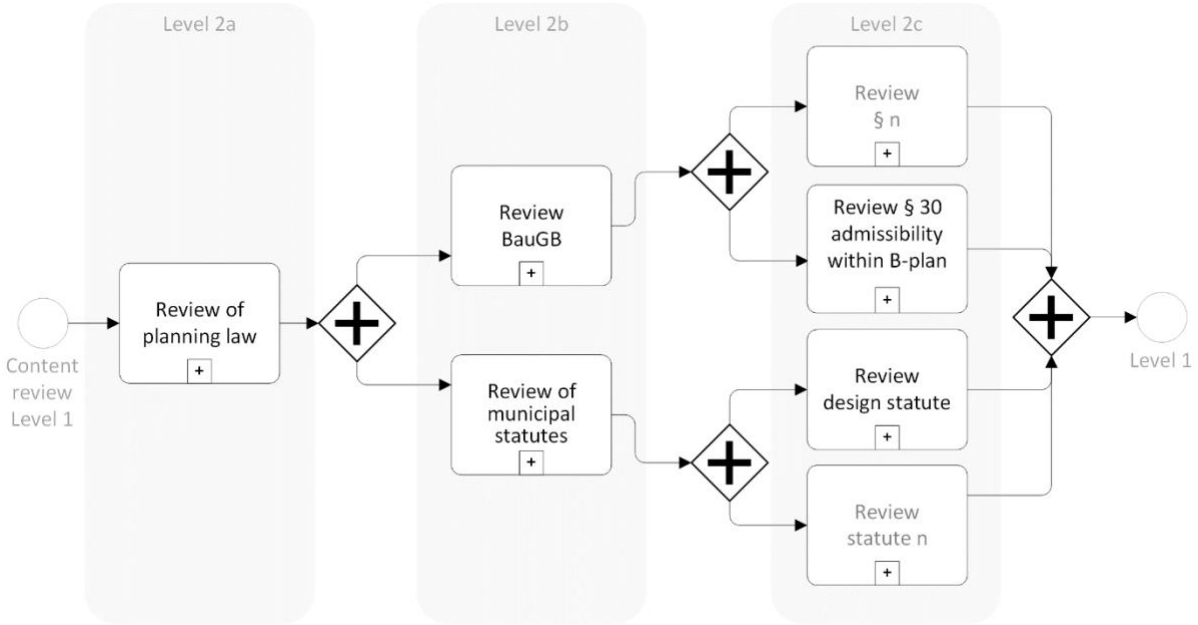

Figure 55 - Process of determining planning law (Levels 2a, 2b, and 2c)[416]

The examination of building law is divided into examination according to the applicable LBO (here MBO) and examination according to the statutes with building law content (level 2b). As with building planning law, the model leans on the individual paragraphs at this point for a structured and transparent process for the examination (level 2c). Figure 56depicts this process.

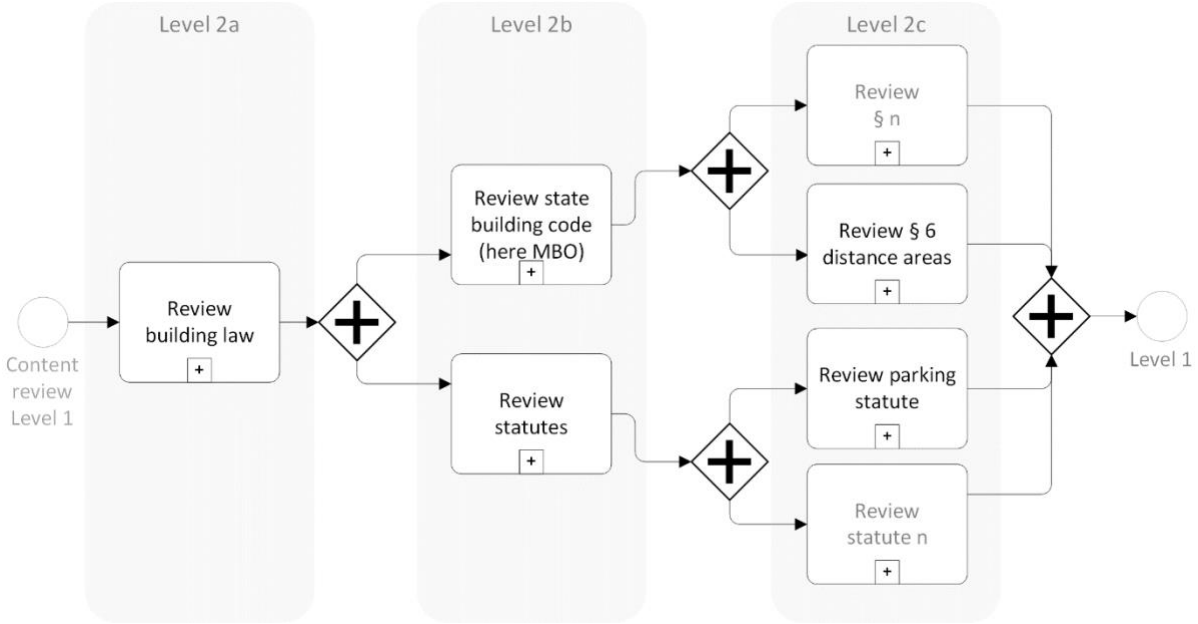

Figure 56 - Process of determining building law (Levels 2a, 2b, and 2c)[417]

[416] Own illustration

[417] Own illustration

A further sublevel (level 3), which lists the material conformity of each review content and is arranged according to the relevant paragraphs, is used for the substantive review. Figure 57presents the process of **checking conformity** for each paragraph [a]. For comprehensible identification, the choices are enumerated with numbers and the individual subprocesses with letters. The entire process begins by asking whether an application for deviation [1] exists. If no application is present, whether a deviation can nevertheless be established must be checked [2]. If a variance is found, the next step is either a decision on whether a building permit can be issued [b] or whether the variance can be tolerated [d]. If the decision is within the building official's tolerance [d], then a choice [4] can be made as to whether to take further action to determine whether building permits can be granted, and if so, what action. There may be a consultation with the applicant [f], an intra-authority meeting [g], or a decision on whether the building permit can be granted [b]. After the consultation [f], a selection is again made [5]. Initially, the building official may refer the applicant to an application for deviation or suggest that said application be revised [h]. Furthermore, the building official may call for planning adjustments [i] or make a decision on whether building permit can be granted [b]. If there is a resubmitted or revised application for deviation [h], the application for deviation review [c] will be rescheduled. If requests for planning adjustments occur[418] [i], the entire compliance review [a] shall begin again. If there is an application for a variance, the application and its contents [c] shall be reviewed first. Then, [3] whether to weigh a discretionary action [e] or make a decision on the ability to issue a building permit [b] must be selected directly. In the case of an exercise of discretion [e], the question arises as to whether compensation is available [7]. If no compensation is available, the selection [4] is made as to whether a consultation [f], intra-authority meeting [g], or decision on constructability [b] will occur. Depending on the selection that follows, the appropriate subsequent processes are conducted. If a compensation is available, its review [j] takes place. After that, whether the compensation is adequate for the legislative target must be decided [8]. If the compensation is adequate, a choice is again made of whether to proceed to a consultation [f], intra-authority meeting [g], or decision on whether to grant a building permit [b]. If the compensatory mitigation is adequate, the decision on building permissibility [b] is made. The decision on the ability to grant building permit [b] is always followed by a statement of reasons for recording this decision transparently. Subsequently, the other regulations are checked for conformity until all paragraphs to be checked have been worked through.

[418] This is also called a *Tektur* in German.

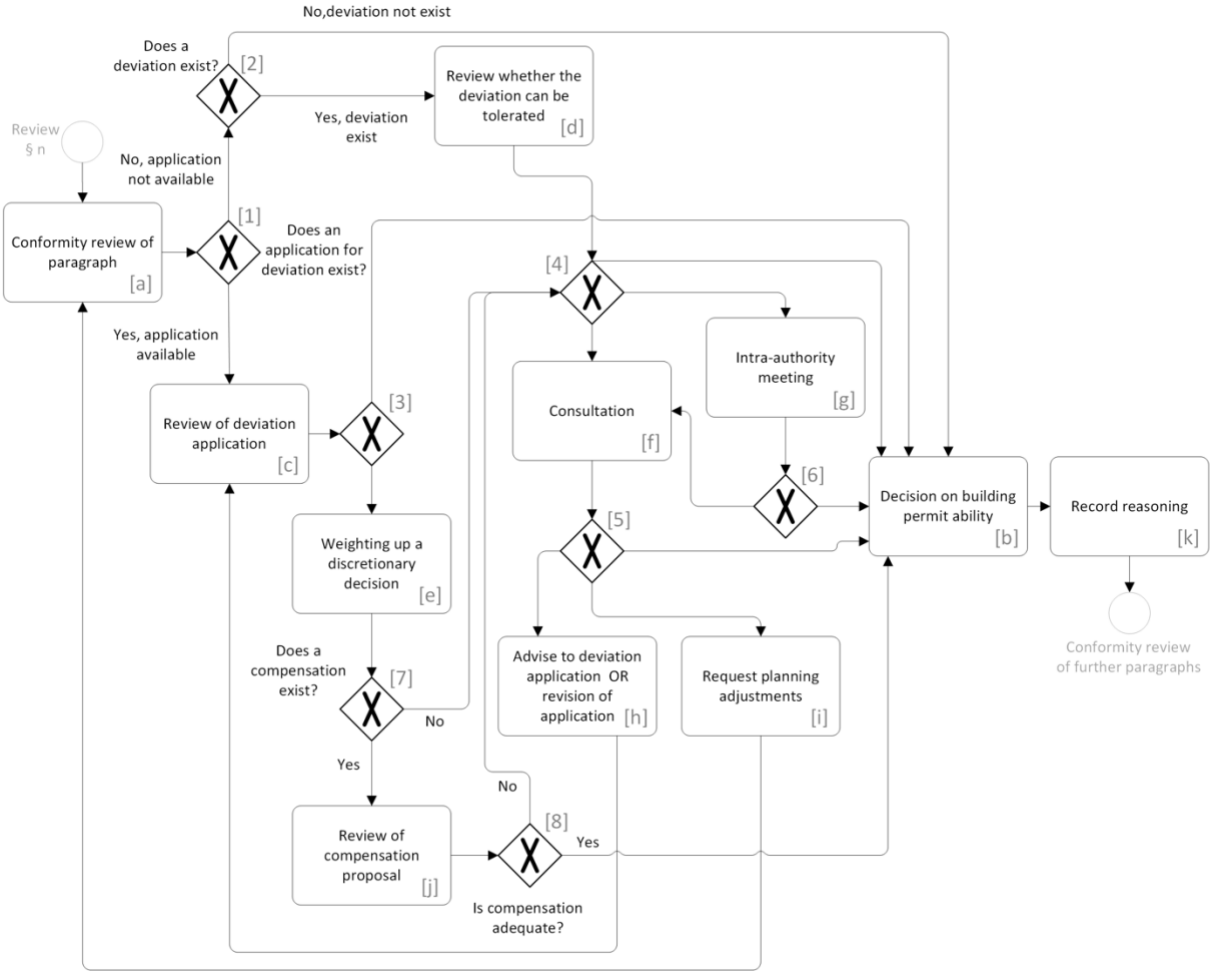

Figure 57 - Conformity assessment process (level 3) [419]

Interpretations are not explicitly mentioned (in contrast to other decision-making scope,[420] such as tolerances, deviations, and conditions), since they usually occur implicitly or unconsciously. In the case of an interpretation, the building official will directly choose the decision of building permissibility [b].

The final main process is the **issuing of the decision**. Depending on the outcome of the previous review and the related decisions, a choice exists between a positive or negative decision. In the case of a positive decision, conditions may have to be integrated as part of the assessed comments and the examination under planning law and building law, whereas for a negative decision, a statement of reasons must be provided. Finally, the decision is issued and handed over, which concludes the process of determining whether a project is eligible for a building permit. The process is illustrated in Figure 58

[419] Own illustration

[420] See Section 5.6

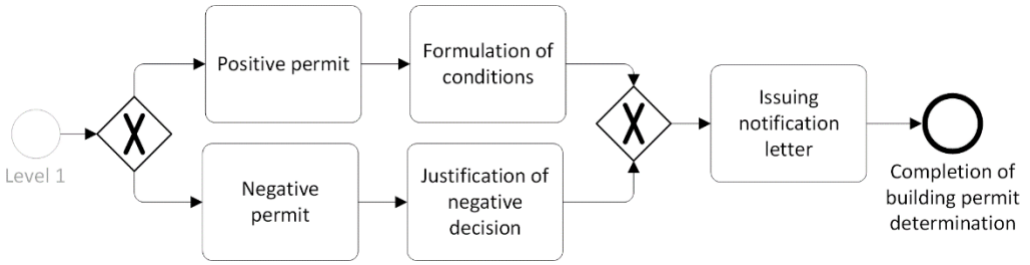

Figure 58 - Notification issuance process (Level 2a)[421]

The elements (processes) presented are considered to generally be valid. Some elements are fixed and others are flexible. Fixed elements include the planning law and the building law in the case of a fully comprehensive building permit review. Fixed elements depend on the authority. Depending on the organization, the building permit authority determines constant elements, such as in which cases an internal meeting within the authority is mandatory.

Decisions are made at each level described, which is why the **decisions** (level x) act across levels. This is where the decision fields and decision processes of each individual building official come into play.[422] In principle, a decision is made for every selection option.

6.3 Synergies and interactions within the model

In the course of the process flow for determining building permissibility, all subsystems are interconnected. With the information on the building project, the product system contains the essential data for the individual setup of the other subsystems. The actor system influences the action system because it represents the organization of the authority. If an element in the organization changes or an instrument is added, the processes automatically change since, for example, other people have to be involved or a tool must be addressed in terms of process. The target system also has an effect on the action system. The action system accesses the target system as soon as a decision process occurs.

Figure 59presents an excerpt of examples for linking the systems and their contents. The subsystems can also be considered independently of each other, but this only represents reality to a limited extent and is also incomplete with regard to their usage.

[421] Own illustration

[422] See Section 2.3

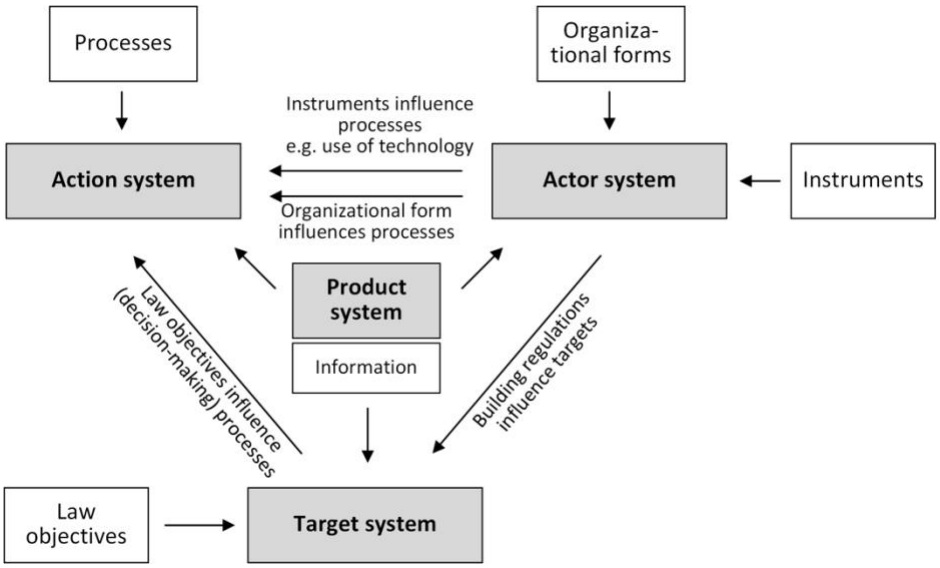

Figure 59 - Examples of synergies and interactions between subsystems[423]

6.4 Summarized findings

The presented model is a **general decision model**. It structures and organizes all external influences, targets, and processes for determining the building permissibility. The general decision model provides the project management with a basis for deriving concrete decision models, which can be adapted to a specific situation in a building permit authority or an individual building project.

The developed decision model serves as an **aid for decision-makers**. It brings critical aspects of the building permit procedure to the attention of decision-makers, so that no "operational blindness" or unnecessary bias occurs in the work of building officials. Even if intuitive and subjective aspects cannot or should not be completely excluded, the model makes it possible to objectively focus on important influences a decision. Furthermore, the decision model offers a valid structure for a documentation basis.

The model depicts a procedure that structures the internal processes of the authorities for determining whether a building can be approved, and furthermore, it can also be **processed in a BIM-oriented manner**. The processes always follow the same pattern and thus become transparent. The model is designed to be independent of both manual action and specific software. This ensures that digital methods such as BIM can be introduced successively, independently of software, and adapted to the existing level of knowledge.

[423] Own illustration

7 Application and validation

7.1 Application scenarios

For a practical application, this chapter describes the theoretical model[424] by way of example using fictitious practical scenarios. The subsystems are also tested for interoperability.

7.1.1 Basic application - Scenario 1

In general, the developed model can be considered a theoretical basis, decision support, or recommendation for action. Each building official of a building permit authority can implement the model or parts of the model individually according to his or her ideas. The use of digital means also remains individual. BIM can be used but does not have to be. This means that each building permit authority determines the extent to which the BIM model is used for itself.

Even without BIM, the subsystems can be prepared and applied in accordance with manual checklists. With this limited application alone, a gain in transparency can be expected.

7.1.2 Project management approach and web application - Scenario 2

Scenario 2 represents a further developed approach in two parts. On the one hand, it consists of an upstream project management approach and, on the other hand, of the actual operational review. To support process optimization, the operational review is supplemented digitally in the form of a web-based application,[425] as Figure 60shows. This consideration ensures the project-related approach, as certain target factors are defined here before the actual review.

The **project management approach** must be determined before each audit. This can be both authority-dependent and building official-dependent. It is mainly based on the actor system and can be adapted to the respective building permit authority. It is at this point that the tools and organization are communicated and decided. In combination with the typified processes of the action system, adapted processes are determined. The target system forms the basis for the decisions to be made. This can be individually adapted and extended depending on the legal texts to be considered (e.g., municipal statutes). The necessary information comes from the product system. This approach is particularly flexible with regard to BIM implementation. Even if the BIM model initially only provides supportive

[424] See Chapter 6

[425] Referred to as “web application” hereinafter

assistance, the scope of its function can be coordinated during the project management approach phase. Accordingly, it can be used in stages.

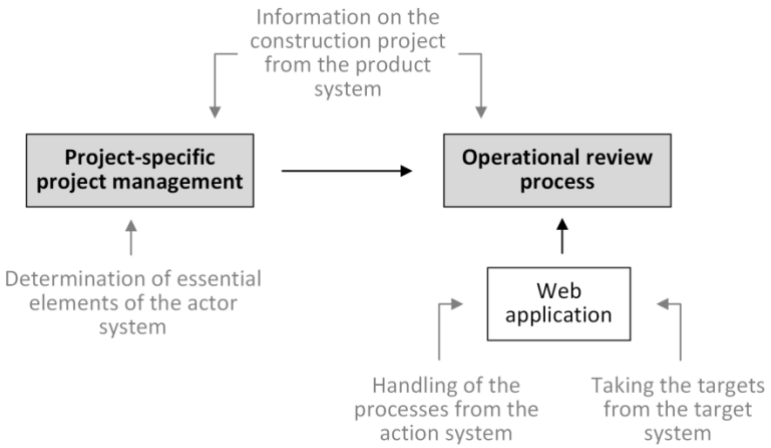

Figure 60 - Schematic representation of the practical application[426]

The **operational review process** is the actually expedient and largely manual assessment for determining the suitability for a building permit. The BIM model is an active component in the BIM-oriented, operational review of the review content based on the paragraphs. In principle, the sequence can be freely determined. It can be predetermined in the project management phase or it remains individually dependent on the person in charge.

A **web application** was developed for the procedural approach and its programming was arranged and implemented externally. All content-related information as well as mockups for the graphical preparation of the application were provided. It is thus part of and simultaneously an aid for the operational review. The web application guides the decision-maker through the process of determining whether a building permit can be issued and provides information as well as alternative courses of action to implement.

The web application is a prototype that illustrates the principles using exemplary individual processes and legal regulations. From this principle representation, it can be inferred that the developed model is transferable to fully comprehensive programming.

The **structure of the web application** is presented as an example in Figure 61[427] The main processes are displayed as tabs in the upper part of the screen. The subprocesses open when the respective main process is selected. Each decision has a **documentation field** that provides space for a rationale for the

[426] Own illustration

[427] A full collection of screenshots of an example is provided in Appendix H.

decision. Also on the right side of the screen are the project name, an image of the project, options for saving and exporting data, and a collection of data. The **data collection** contains all of the necessary documents for the review. In the example, these are a link to the BIM model (MVD), a record of a hearing, a record of the results of a digital model check, and the database for the target system.

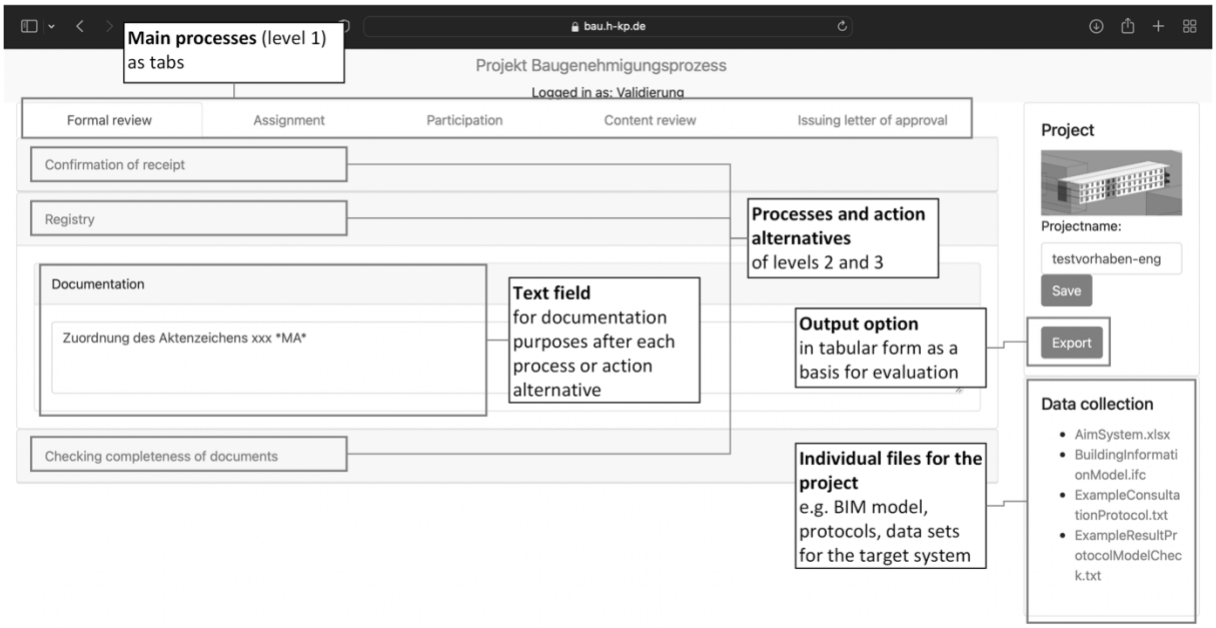

Figure 61 - Screenshot presenting the web application structure[428]

The data are **exported** in the form of a table, which contains both the list of decisions made and the contents of the documentation fields. Documentation and justification of the decision are essential for achieving the desired traceability and transparency. The documentation provides for a compilation of certain information so that it can be used in the future to collect, analyze, and evaluate the information for quantitative statements. This creates an opportunity for pattern recognition and relative comparison. After the first evaluated runs, an adjustment of the accuracy should be reconsidered as well as the insertion of further choices that are still considered necessary.[429] Figure 62presents an excerpt from the export using the example of the formal test.

[428] Own illustration

[429] See Section 5.7

Level 1	Formal Review	Formal Review	Formal Review	Assignment	Assignment	Participation
Level 2	Confirmation receipt	Registry	Review of the completeness of the documents	Authorized assignment	Automated assignment	Selection of agencies of public interest and equals
Documentation Level 2	Receipt *ZS*. Feedback to applicant *ZS*	Assignment of the file number xxx *MA*.	All documents complete that are necessary for content review. (Assignment for content review may be made). *FK*		Assignment by intra-agency system - urban area x to *MA*.	
Level 3			Review of the planning documents (incl. model)	Content assignment		Mandatory selection

Figure 62 - Excerpt of an export from the web application (formal review)[430,431,432]

The web application presents the decision-maker with various **rule-specific explanations**, as depicted in Figure 63These are both the legal texts and the objectives intended by the regulations, which directly serve as the basis for decision-making. In addition, information can be provided on affected ancillary law and thus on the possible TöB to be involved. Although a delimitation of these topics has been made, the model remains open for extension. Under the item *testability in the model,* the objects in the BIM model are named that can be used for the review of the respective paragraph. In addition, an indication is given of how the objects are to be handled.[433]

Figure 63 - Screenshot of the rule-specific explanations[434]

[430] Own illustration

[431] The levels named in the export file do not correspond to the levels of the action system. They are used for structuring purposes.

[432] The columns and rows have been transposed compared with the original export.

[433] See the object catalog in Section 5.8 (Handling the BIM model)

[434] Own illustration

7.1.3 Potential further development - Scenario 3

Numerous variants can be considered for a further development of the solution approach from Section 7.1.2. One variant consists of **implementing** the web application in the software Desite md by ThinkProject. This makes it possible to handle the BIM model and the web application in parallel, as Figure 64shows.

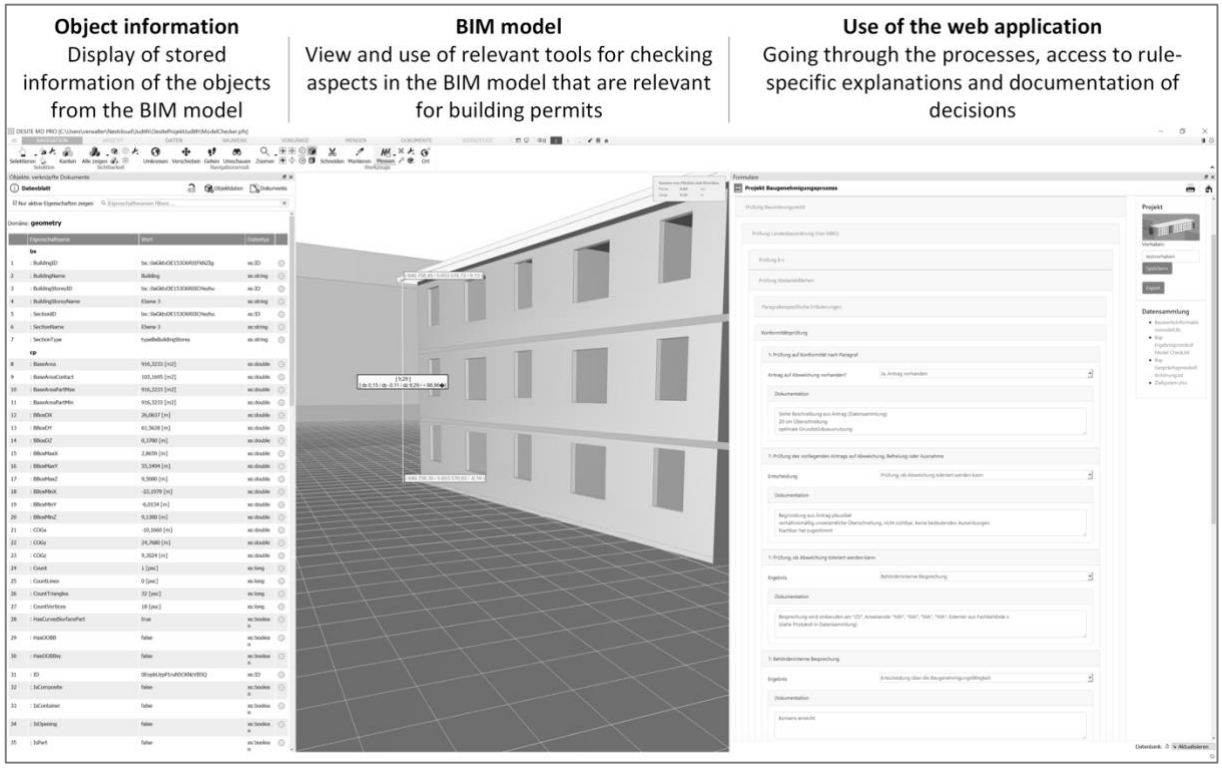

Figure 64 - Screenshot of reviewing the BIM model with the web application and Desite md[435]

7.2 Example project

To validate the model and the web application, an example was constructed. It was a fictitious constellation based on the project management approach.[436]

7.2.1 Framework conditions for validation

The project management approach includes the definition of the framework conditions. Of particular interest is the actor system. The selection of the example simulation is presented in Table 8

[435] Own illustration; created with Desite md (2020)

[436] See Section 7.1

Table 8- Framework conditions for example simulation

Elements of the actor system[437]		Selection made for the example
Organization	Internal structure	The technical building official is responsible for all processes
Instruments	Checklists	No checklists – the procedure follows the web application
	Legal texts	BauGB, MBO, MBeVO, Municipal statutes could be excluded
	Legal resources	The scope for decision-making, literature, and case law are on the basis of the individual case
	Seal authorization	Every building official is authorized to seal
	Interactions	All regular interactions are permitted and subject to the building official's specific approach to complicated issues: Invitation of affected TöB and equals
	IT use	(Proposed) web application,[438] data management system for registry
	BIM	The BIM model is submitted by the applicant and stored in the web application; quantity and quality inspection are performed manually

7.2.2 Presentation of the example model

An example BIM model was used for the validation. The project was a realized residence for trainees. Figure 65presents a schematic illustration of the project. The BIM model originated from the *DigiWertBau* research project,[439] for which a building permit consideration was not planned. The model was adapted to determine the suitability for a building permit by only retaining or adding objects relevant for this purpose. From the point of view of building law, the choice of the project was justified by the necessity of including special building regulations.

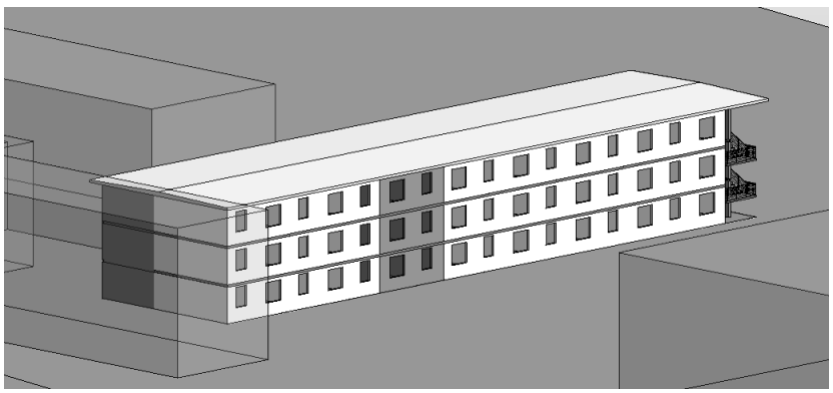

Figure 65 - Screenshot of the digital sample project[440]

7.3 Qualitative validation using a practical example

[437] See Section 6.2.2

[438] See Section 7.1.2

[439] DigiWertBau (2018)

[440] Created with Autodesk Revit (2019)

The validation was conducted on the basis of the presented construction project. It served to determine whether the previously developed model and the components of the web application were compliant with the requirements of practice. The applicability of the web application was tested in combination with a BIM model as an essential component.

7.3.1 Methodology of the validation

For the validation, the web application was reproduced in a lower building supervisory authority with a building official. An audio recording and a transcript of the conversation were created. Furthermore, the contents of the web application were filled in.

First, the example project was **introduced** and a brief explanation of the theoretical process (including the project management approach) and the web application was given. To run through a test outside of the standard case, a fictitious problematic situation was assumed in the form of an insufficient distance area.

Furthermore, the operational check was **simulated** with the help of the web application on the example project. All decisions and justifications were recorded directly in the web application.

The interviews and observations during the simulation were mainly related to

- the plausibility of the procedure and the web application,
- the correctness of the content, and
- the user-friendliness of the web application.

7.3.2 Findings and results of the simulation

Based on the conformity check,[441] Figure 66presents the process of the check in accordance with § 6 MBO distance areas. The inclusion of BIM from the example simulation is also listed.

[441] See Section 6.2.4, Figure 57

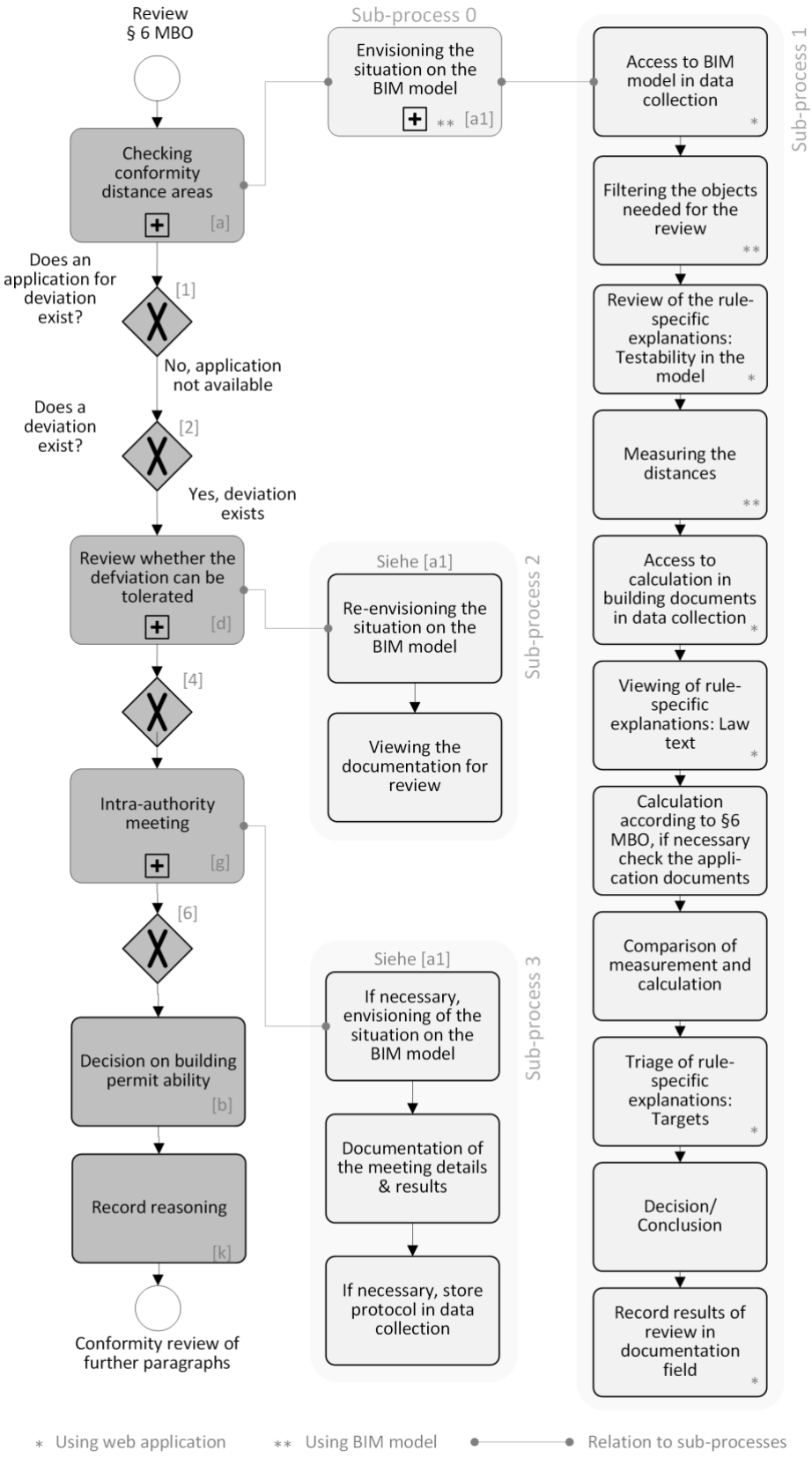

Figure 66 - Conformity check using a BIM model[442,443]

[442] The numbering is based on Figure 55 (Section 6.2.4).

[443] Subprocesses according to Section 5.8

Figure 67presents a visual documentation possibility of a deviation using the example of the distance area situation from the example simulation.

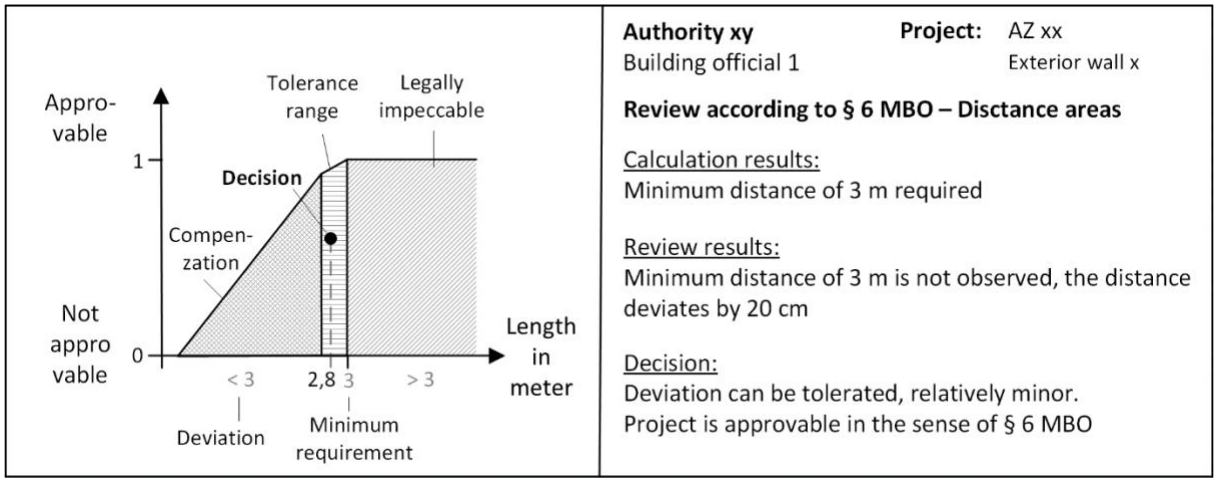

Figure 67 - Documentation possibility using the example of a deviation

Improvements to the application after the interview were only necessary to a minor extent. They mainly concerned notes and additions for improved comprehensibility and were incorporated into the programming after the interview. Overall, the simulation was perceived as positive, and the web application was described as useful. Furthermore, the rule-specific explanations in connection with the indication of the legislative objectives were considered particularly helpful. The interface of the web application was found to be user-friendly. The structured sequence can be expected to increase transparency and efficiency. It was mentioned, for example, that still inexperienced building officials could be effectively introduced to their tasks with the help of the web application. The use of the presented model is conceivable, also with regard to a phased deployment of a BIM model. The complete simulation can be understood by the screenshots deposited in Appendix H. In addition, the data and results set (export) of the example simulation can be found in Appendix I.

7.4 Conclusion on practicality

In this section, the practicality of the model using the web application (scenario 2) is considered from different perspectives.

Added value is generated for the **individual building official** by strengthening his or her decision-making confidence. Decisions are made conscious through the presentation of alternative courses of action, which is expected to reduce susceptibility to errors.

These advantages would be reflected in an equivalent manner throughout the **entire authority.** During hearings or meetings, a uniform structure can be used, which also serves as a basis for discussion and

decision-making. With regard to **BIM,** the developed model offers the possibility of a gradual and individual introduction of a BIM model into the building permit process. The presented web application enables a software-neutral platform for a structured review process.

The decisions of a public authority are made in a manner that is as **safe** from legal action as possible and can be challenged in court if necessary. The transparent documentation of decisions provides a solid argumentation aid.

It can be assumed that satisfaction will be increased by the model and its transparency. Due to the public accessibility of the standardized model, **architects and developers** can provide the right information in a target- and process-oriented manner, which can be expected to save time and reduce the susceptibility to errors in the building application documents (e.g., with regard to missing applications for deviation). Especially for planners and project developers who are not familiar with the area, the model can simplify the permit planning if they are not or hardly familiar with the local building regulations and official processes.

8 Concluding remarks

8.1 Conclusion

The examination of building permissibility often occurs in secret for the applicants. The processes are not transparent. Therefore, meaningful data on the processes in practice were collected and evaluated in this study. The variety of organizational forms and processes as well as their interdependencies are only one aspect of the complexity involved in determining whether to grant a building permit. This is because building permit processes are a complex and incompletely defined web of processes, particularly due to the wording of the law not always being objective, the individual approach in the administration, the necessary interpretation of individual cases, and the formation of network-like connections between private and public participants.

A not insignificant proportion of building regulations cannot be objectively represented from today's perspective. At the same time, building permit processes are intended to ensure case-by-case justice in building regulations.

The examination of building regulations will continue to be a semi-automated process. For this reason, the principles that are actually necessary for optimizing the building permit process were examined in order to map them in a model. With the help of elements of systems theory, project management, and decision theory, issues related to the determination of building permissibility were investigated to place a manual BIM-oriented building permit determination on a solid fundament.

To make a decision, all possible alternative actions, external influences, information, and targets for the construction project must be known. Based on this, a model was developed that consisted of the following four subsystems: action system, actor system, target system, and product system. Action alternatives are represented in the form of processes and are part of the action system. The objectives of the building regulations are represented in a target system. The action system represents general external factors. These include the existing official organization and instruments that are not without influence in the determination of the building permissibility. Examples are the objects in the BIM model. The product system represents the basis from the building project, property, and environment. The theoretical model was transferred to web-based programming and tested in practice using an example.

In summary, the model was able to map all of the processes and external factors relevant to construction approval in one structure. It thus offers a process-oriented decision-making model for practice and simultaneously strengthens the transparency and intersubjectivity between the parties involved. The model closes a gap between the conventional, manual, and often non-transparent building permit processes and the automated examination of the building permit, which until now have been neither legally secure nor feasible in engineering terms. The model can be flexibly adapted to conditions in other countries.

8.2 Outlook

The previous **limitations of the developed model** and thus the **perspectives of further research** are described in this section.

One possibility is to **further enrich** and evaluate the collected **data** with the aim of extending the analysis to other parts of the building permit phase (e.g., preliminary building application).

An **extension to other countries** and the transfer of the presented model there could also be profitable (e.g., to the USA).

Specific data collections can be **generated** with the help of the model, such as through the coordinated use of the web application in several authorities. Among other things, this could lead to improved protocol templates as decision-making aids as well as provide indications for the verification of quantities by model checkers. This could also test whether the model, in addition to improving transparency, also enables a reduction in processing or turnaround time.

With regard to the **digital implementation**, it is foreseeable that the web application will be used as a plug-in for BIM software or offered as a separate software tool. Specifically, this concerns, for example, the linking of the web application directly with IFC objects or with a model checker, and also a user-friendly programming of the project management approach. With a larger data basis, targeted selection options could be generated in this area to control each project individually and in a way that is specific to the authority or building official.

Under the condition of a comprehensive documentation collection, the approach of **artificial intelligence** should also be considered. This offers great potential in connection with the developed model. The model could automatically generate assistance for the user regarding processes, decisions, and documentation (e.g., through keywords) or identify cases of hardship.

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Appendix (separate document)