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Urban Wastewater Management Using BIM Method

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Abstract: Building Information Modeling (BIM) is a method that emphasizes object-based data management, communication, and collaboration among all project participants throughout the entire lifecycle of a system. It is becoming an international standard for large-scale construction and infrastructure projects. Although BIM is gaining traction in the wastewater industry, the literature on its application in this field is still limited. This research, through expert interviews and literature review, explores the extent to which BIM has been introduced in the sewage industry and the associated opportunities and challenges. Initial projects in wastewater management using BIM include the construction and development of sewage treatment plants and special structures. Planning offices are leading the way in adopting BIM, supported by catalogs of industry-specific objects, clear definitions of responsibilities, and the potential for enhanced operation of sewage systems. Some users have already recognized the benefits of BIM and adjusted their processes accordingly. BIM's object-oriented modeling improves the visualization of construction projects and processes, offering significant advantages in model-based plan derivation and mass determination. It also focuses on the collection, exchange, and storage of relevant data, which can benefit the entire wastewater industry. The research confirms that BIM adds value to wastewater management, especially since infrastructure is often difficult to access post-construction and knowledge about the systems is typically limited to those involved in the construction phase. However, to fully and effectively utilize BIM, further improvements are necessary. This requires intensive collaboration among project participants, software producers, and customers. The integration of BIM in wastewater management holds promise, but its successful implementation depends on overcoming current challenges and enhancing the method through collective effort.

Keywords: *BIM (Building Information Modeling), Wastewater, Collaboration, Data Management, Infrastructure*

1. Introduction

Innovation has always been associated with a process of change, and methods, technologies or work processes must fundamentally change over time. With the third industrial revolution at the end of the 20th century, the focus on automation and networking through electronics and information technology increased [1]. For the construction industry, this meant a shift to computer-aided design, computer-aided modeling, and the integration of sensors into IT systems [2]. Networking of digital components and efficient exchange of information between these components is part of the fourth industrial revolution [3]. The construction industry and

Power System Technology
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its previous approaches to the life cycle of a building are also changing. In the construction and infrastructure sector, Building Information Modeling (BIM) is an essential component. BIM does not replace the main tasks of planning, building and operational use of objects, but supports these activities by exchanging and digitizing project data [4]. Information management is at the heart of the BIM method. In theory, with the BIM method, all relevant information about a structure is continuously recorded, managed and exchanged or processed between people involved in the project. It works based on digital, object-based models of a structure throughout its entire life cycle. This database should be used as an integral basis for decision-making throughout the entire product life cycle [5].

The BIM method has already been implemented in large-scale international projects in building construction, structural planning and technical building services. In this regard, the United Kingdom, Finland, Singapore and the United States of America are pioneers. Urban water management researchers in Iran are also dealing with BIM. However, specialized literature on the application of BIM in wastewater management is still limited. This research tries to evaluate, by focusing on clarifying the ambiguities or disagreements, what opportunities and specific challenges exist in the introduction and application of BIM in wastewater management, and to what extent this method (or its aspects) is currently implemented. For this purpose, in addition to the qualitative content analysis of expert interviews that have already been conducted and the literature search, six more expert interviews have been conducted in 2023 and 2024. Experts who already deal with BIM method in their daily work have been selected and interviewed. In order to clarify the issue from different points of view, experts of planning, implementation and operation in the field of wastewater management have been interviewed. The results have been analyzed using qualitative methods and compared with the relevant literature. Also, an overview of the common procedure in wastewater management, digital applications used and the concept of integrated wastewater management is presented.

2. Objectives

For an efficient BIM process, it is useful to determine in advance what added value the conversion of projects to BIM will provide for project participants. What technical foundations are there now and what challenges can those involved prepare for? For example, in building construction, there is a wealth of specialized literature, case studies, and best practices. Until today, clients, planning offices and implementing companies could not rely on such a wide range of prior information in using the BIM method in wastewater management. Currently, there are some published reports from industry pioneers, but the literature on the subject of BIM in the wastewater industry is currently still limited. Therefore, it seems reasonable to investigate the issue more deeply in the form of specialized surveys. In the first step, this research evaluates the existing set of interviews on the topic of BIM in wastewater management with 5 experts in urban water management using qualitative content analysis. The goal here is

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to identify the main issues that are of particular importance in urban water management with regard to BIM. Although only a limited number of these experts had been involved in specific BIM projects at the time of the interviews, the interviewees' well-founded knowledge of urban water management led to an appropriate assessment of the BIM topic as a baseline. The main focus of this research is to find answers to the following three questions:

1. To what extent has the BIM method or its aspects been implemented in the wastewater industry?
2. What challenges arise when introducing and implementing the BIM method in wastewater management?
3. What opportunities does the BIM method offer for wastewater management?

These research questions will be answered through the results of a series of interviews conducted, along with an in-depth review of existing research by other scholars.

3. General Principles

3.1 Digital transformation in the water industry

Current developments reflect clear efforts in many political, commercial and scientific fields to advance digitization and applications. The objectives of these efforts are based on four key aspects: the development of a digitally skilled population and highly skilled professionals, digital infrastructure, digitization of companies and public services [6]. The wastewater industry also faces challenges to adapt to changing conditions. Challenges such as urbanization, growing political and technical needs, increasing complexity or climate change are currently stimulating the development of new digital applications and tools [7]. Planning and all physicochemical processes for the protection and sustainable use of water as a resource, to meet the needs of households, industry and agriculture and to protect against water-related risks have become very important. Digitization, modeling, automation and visualization, increase cost efficiency, service quality, security and reliability in supply and disposal, as well as flood protection through the linking of departments and the integration of different processes, thereby making possible significant improvements in public services. From this work, improving the future and competitiveness of the industry, especially through automated work in smart grids. The intensified integration of information technology, sensors and applications creates opportunities to better understand the complexity and network of water management systems and integrate them into production. Also, researches emphasize the urgent need for action to introduce BIM methodology as one of the main components of digitalization in water and wastewater management [8]. In this general context, BIM is considered one of the most basic methods. The models produced in the phases of planning, execution, construction and documentation and their referenced information form a database for those who execute in the operational phase and are depicted in BIM (data). For urban water management, in digital transformation, big data analysis and the use of artificial intelligence (AI) in plant operations

Received: 06-06-2024 Revised: 15-07-2024 Accepted: 28-08-2024

and management are in the foreground [9]. The main issues for digitalization in wastewater management are defined as follows: Digitalization is seen more as a catalyst and motivation to identify opportunities to increase the effectiveness, efficiency and quality of service delivery in water management [10]. This includes the use of planning tools such as Building Information Modeling (BIM), with the corresponding requirements (software, technical know-how, etc.) for all actors involved in planning [11].

3.2 BIM in wastewater management

Building Information Modeling (BIM) has revolutionized the construction and management of infrastructure projects, including wastewater management systems. BIM facilitates the creation of digital representations of the physical and functional characteristics of facilities and enables better planning, design, construction and operation. There are two main approaches to BIM: open BIM and closed BIM. This paper examines the differences between these approaches and their implications for wastewater management. Both open BIM and closed BIM offer distinct advantages and challenges for wastewater management. Open BIM promotes collaboration, flexibility and innovation through the use of open standards and interoperability. Closed BIM, while potentially limiting collaboration, provides a controlled and integrated environment that can increase data security and stability. The choice between these approaches should be based on the specific needs and goals of each wastewater management project, taking into account factors such as cooperation requirements, security needs, and budget constraints.

4. Materials and Methods

To answer the three defined research questions, the present work uses a combination of different methods: qualitative content analysis, semi-structured expert interviews and review of other researchers' researches. These were applied sequentially in three phases. In the first phase, five existing interviews with experts in urban water management were analyzed using qualitative content analysis. The aim was to identify the main issues related to the BIM method in wastewater management and use it as a basis for further expert interviews. In order to build on the existing research work and reflect the main issues identified by the experts in the first phase, a series of further interviews were conducted in the second phase with other experts who had already gained experience with the BIM method in wastewater management. The basis for creating the interview guide was the results of qualitative content analysis in the first phase. After conducting and analyzing the qualitative content of the interviews, the defined research questions were answered in the third phase based on all the available results from the interview set along with the subsequent literature research.

Power System Technology
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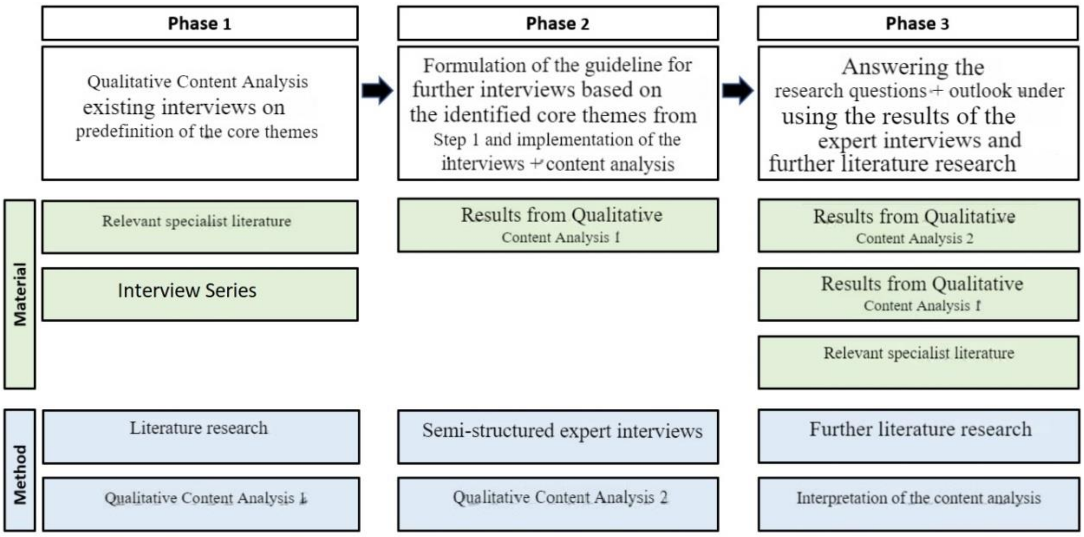

Figure 1 Flow chart of research methodology – method and materials shown over time

5. Qualitative content analysis - first phase

Qualitative content analysis focuses on the content classification of textual content and does not receive any implicit meaning from the interviewee's expression, but focuses solely on the content of the interviews [12]. The purpose of content analysis is to analyze the interview material and then draw conclusions to answer the research questions. The process of structural content analysis can be divided into different stages. This issue will be clarified below based on the actual content analysis of the first interview set. Content analysis was done manually using Excel. First of all, it was necessary to create a specific question. The interview material was analyzed considering the current state of research, relevant literature and existing theories. A classification system was identified and defined. In particular, a clear definition of defined categories is necessary in order to be able to make a clear and objective assignment of text modules to individual categories. Decision rules and "anchor patterns" were defined for individual categories. Anchor samples are selected portions of material intended to represent the relevant category area. Developed decision rules, also known as coding rules, define the conditions under which a text should be assigned to a specific category [13]. By formulating such fixed rules, one can achieve the best possible objectivity of assessment and the associated reliability, that is, the reliability of scientific measurements.

Based on this approach, by examining the set of interviews, eleven categories were initially identified as the basis of the interview guide: interfaces, standards, added value of BIM, workplace or training, feasibility and barriers, information exchange and security through models, Framework conditions, condition, operation, and safety. In order to compress the

Power System Technology
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content of the interview, the next step was to rewrite the content. This means that the statements of the interviewees have been reformulated and summarized so that all the essential content of the original text is preserved and no changes in meaning or shortening of the meaning are made [14]. The compressed text modules developed here were assigned to their respective categories using a previously developed classification system. During the content analysis and continuation of the content, the categorization system was adapted until all text modules were assigned to the same category. After adapting the classification system, the flow was repeated many times [15]. By expanding the category system, all content can be clearly assigned. Finally, the identified categories were compressed into five thematic areas that form the basis of the interview guide. The first content analysis of the set of interviews, on the one hand, identified the concerns and hopes expressed by experts regarding BIM in urban water management. On the other hand, these results were the basis for developing an interview guide for the set of interviews conducted during this work.

6. Semi-structured expert interview - second phase

Expert interview is a qualitative research method with the aim of interviewing people with specific specialized knowledge in the subject under investigation. It is necessary to emphasize that the interviewer himself must also have a certain level of specialized knowledge in the field of research [16]. Unlike structured professional interviews, semi-structured professional interviews do not require strict adherence to the exact wording and order of questions. This approach allows for a more flexible conversation, enabling a deeper exploration of the experts' individual areas of expertise relevant to the work at hand.

7. Selection of respondents

When choosing the experts to be interviewed, the goal was to interview planners and operators of the urban water management sector. Special attention was paid to the fact that the respondents were familiar with the BIM methodology and were already using BIM in practical projects. For this purpose, seven potential interview partners were selected through Internet research and participation in events on the topic of BIM, and based on that questions were asked.

The sample size is considered appropriate for the scope of the present work. The research questions can be answered with the expertise of the interviewees. The focus of the sample is the communication of the examined experts. Respondents deal with BIM methodology in practice and are also leaders or participants in international working groups on BIM in urban water management. Thanks to the expertise of experienced respondents, it is possible to cover the main areas of responsibility in wastewater management and consider all stages of the life cycle of planning, construction and operation. Achieving a statistically representative sample

Power System Technology
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at this point in time was difficult based solely on the criterion that interviewees must have prior experience with BIM in wastewater management.

8. Implementation

At the beginning of the interview, a summary of the conducted research was explained to the interviewee in a preliminary discussion. In addition, the organizational framework of the interview was clarified in the preliminary discussion. The interviewee was informed about the timing (interview duration approximately 60 minutes) and was asked if he agreed to record the conversation for further processing. In the actual part of the interview, the interviewee was first asked what he understood about BIM. This should also clarify whether there is a similar understanding of the definition of method in the rest of the interview. As mentioned earlier, there was no exact order of the questions. However, we have taken care to cover all questions. Questions were open. After the interviews, the recorded audio files were transcribed. Additional sentences and marginal items were not transcribed. The transcripts were sent to the interviewees after completion, and the interviewees' opinions were included in it. The available transcripts were then published by the interview partners. The transcripts were subsequently used as the basis for the qualitative content analysis of the second phase.

9. Qualitative content analysis - second phase

The text of the second series of interviews was re-evaluated using qualitative content analysis. The category system developed in the first content analysis was reused, and several subcategories were added during the course of the analysis, as additional themes emerged in the interviews. The focus was on the current state of BIM development in wastewater management, as well as the opportunities and challenges that experts see in this field. The evaluation then showed that the interview partners' statements about the status, opportunities and challenges of BIM implementation and application were found in several categories. For example, challenges were raised not only in the answers to the questions in the category "enablers or barriers", but also in other categories. At the same time, the opportunities were not only mentioned in the "BIM added value" category. Through content analysis, the following can be achieved:

10. Comparison of interviewees' statements

Compare statements with the current state of research

Answering research questions based on the results of analysis and further research

Further research and evaluation or interpretation of expert interviews - Phase III

In the third and final stage, the research questions were answered specifically. The answer was based on the results of expert interviews as well as more literature research, based on the results of the interviews. In order to answer the research questions and avoid repeating the

Power System Technology
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opportunities and challenges mentioned for each category, the content in presenting the results was not organized according to the categories used. Instead, the statements were assigned to the main domains of "current status" (research question 1), "challenges" (research question 2), and "opportunities" (research question 3). The main topics mentioned in these areas were presented. The previously formed categories are implicit here, but do not dictate the structure of the results for the reasons mentioned above.

11. RESULTS

Current BIM practice in wastewater management

If you compare different industries, you will see that, for example, in the aircraft or automotive industries, where production sensitive parts are produced, digitalization is already very developed [17]. For example, if there are errors in production, large costs can quickly arise. If the machine is not maintained and production stops, costs are immediately incurred. When using new technologies or methods, there is always added value that is needed and justifies the effort. In the interviews, experts were asked to assess which BIM methodology could provide added value for wastewater management projects. Respondents differentiated between the following areas:

Planning and implementation of sewer network development and renovation measures

Construction and development of new special structures and sewage treatment plants

Operation of sewage systems

In projects involving sewer network development and sewer renovation, usually only a small number of project participants are involved. In most cases, in addition to the employer and a responsible planning office, there is an executing construction company with possible subcontractors who undertake, for example, earthworks. According to experts, switching to BIM for coordination of individual transactions is not necessary now due to low complexity.

BIM in the construction and development of special structures and sewage treatment plants

Experts estimated the potential of BIM in the construction and development of special structures and sewage treatment plants. According to the surveyors, more transactions, more order volume and more complex construction processing are the main reasons for using BIM in this field of wastewater management. In fact, it turns out that some clients and planners understand the added value of improving coordination and collaboration and use this method in projects [18]. According to experts, many of the benefits of BIM applications can be used in these wastewater management projects, which also add value in other areas of the construction industry where BIM is now more widely used. takes, offers. These BIM applications include:

Power System Technology
ISSN:1000-3673
Received: 06-06-2024 Revised: 15-07-2024 Accepted: 28-08-2024

Visualization

Design derivation from the model

Linking the model with features

Coordination

Piping flow diagram and instrumentation

Determination of quantity and cost

Review feedback

Data exchange and model control

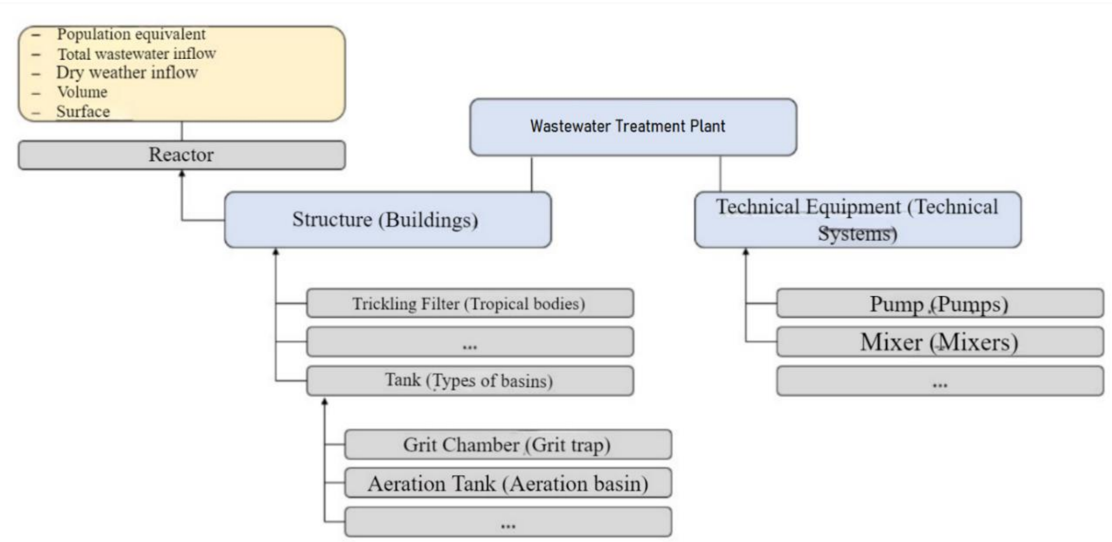

Figure 2 An excerpt from the semantic model class diagram for wastewater treatment plants

Challenges of introducing and implementing BIM in wastewater management

BIM fundamentally changes the way planning and execution processes are carried out [19]. With the BIM method, work processes are completely changed. This creates opportunities and challenges for both contractors and clients. Table 7 shows the challenges raised about BIM in the interviews. According to the table below, moving towards BIM in urban water management is "an important challenge in the field of digitization." To date, digitization has often been limited to correspondence and data storage. Until now, digitization has been mainly archival and not very efficient in practice. The process of using BIM in the wastewater industry is happening slowly.

Power System Technology
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Table 1 The results of the interviews about the challenges of implementing and using BIM

Challenges of BIM in wastewater management
Transition of processes New working methods for clients and contractors Engineering offices are currently still making advance payments Clear definitions of loads and duties (AIA and BAP specific to the Municipal water management are missing) Subcontractors, suppliers, and specialist planners must adopt new working methods
Working with the model Industry-specific object catalogs for wastewater are not yet freely available Effort for planning derivation in 2D Questions regarding data management and exchange Organization of open and closed formats Limited computing power
Full BIM potentials in municipal water management are not yet implementable Model-based tenders in the wastewater industry are hardly implemented Lack of standardized performance descriptions for automated Tenders BIM potential for operations in wastewater management has not yet been fully utilized
Data quality Incorrect inventory plans and varying data quality Lack of consistent updating of databases Decentralized data collection from other service providers
In political decisions, investment costs often take priority Responsibility of the state for the path to digitizing wastewater management not yet sufficiently clarified Wastewater management is often not in the focus of politics Dependence on political decisions

Power System Technology
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12. Processes

The results show that the wastewater industry faces similar problems when implementing and using BIM that have already been addressed in case studies for projects in other areas of the construction industry. However, the initial additional effort is currently exacerbated when used in the wastewater industry, as IFC data structures must be expanded or BIM objects created for wastewater industry-specific structures and system components [20]. Currently there is only very limited access to the experience of existing projects. Employees usually do not have the necessary prior knowledge and need to familiarize themselves with the use of BIM software. In addition to additional time and financial costs, this also means the risk of not completing projects on time or without profit for contractors [21]. If a company decides to plan using the BIM method, the first step should be to evaluate the appropriate software and train its employees in the relevant programs [22]. The issue of user acceptance also plays a role. Companies that are currently working with BIM in the wastewater sector pay in advance. This means that companies incur an additional amount that they do not get reimbursed [23]. However, clients are only forced to switch to BIM when there is minimal long-term added value compared to conventional project management [24]. Municipalities and associations need to assess which use cases are relevant for them and to what extent it creates the relevant added value [25].

Processes must be changed by all involved [26]. For clients, the shift to BIM also means they have to formulate their needs earlier and much more precisely. This initial definition of requirements is essential for the successful implementation of BIM in projects. The sooner and more precisely they are defined, the better the method will help meet the requirements. In this way, BIM creates a clear added value during the life cycle of projects [26].

Urban water management researchers who have already worked with BIM methodology are currently working on developing client information requirements tailored to urban water management and the corresponding BIM implementation plan. This helps clients to clearly define their project needs at an early stage. The problem is that currently available information is particularly related to construction projects and is not suitable for the water industry [27].

Working with models

The efficiency of creating a BIM model depends greatly on how extensive the available catalog of BIM objects (such as pipes, valves, pumps, etc.) is [28]. Designers in building construction have catalogs of ready objects at their disposal. However, there is still no specific and free catalog for wastewater management. The individual development of such catalogs currently means spending considerable money and time for companies [29]. The fact that the corresponding BIM objects are not currently available for free and offices cannot freely access them certainly prevents some offices from taking the first steps with BIM. It is not implemented

Received: 06-06-2024 Revised: 15-07-2024 Accepted: 28-08-2024

homogeneously in projects, currently in the wastewater industry it is often necessary to provide conventional 2D plans to suppliers or individual specialist planners.

The full potential of BIM has not yet been implemented in urban water management, and model-based tenders are rarely implemented in the wastewater industry. According to experts, despite the spread of BIM, tenders are still routinely conducted. However, the potential of BIM for operations has not yet been fully exploited in the wastewater industry [30].

On the one hand, the operational phase is the longest phase of a building, and on the other hand, it has the greatest potential for using a building model that was created using it. The BIM method The interviews showed that the BIM method in wastewater management is currently only used for the planning and construction phase [31]. Operational benefits are not currently considered at the project planning stage. According to [32], this is especially due to the fact that there are no clear instructions from operators in this field. The implementation of BIM methodology for any company in the implementation phase creates effort without revenue. However, for operators, this effort will cost quickly in the life cycle. However, as mentioned above, life cycle costs are often not considered [33].

Opportunities to introduce and implement BIM in wastewater management

In addition to the challenges that currently exist in the implementation and application of BIM in wastewater management, according to the respondents, significant opportunities can already be identified. Table 2 summarizes the respondents’ statements.

Table 2 The results of the interviews conducted regarding the opportunities in the application of BIM

Opportunities for BIM in Wastewater Management
Model-Based Visualization • Persuasion through Visualization • Illustration of Construction Processes • As-Built Model for Training Purposes and Transfer of Subjective Knowledge • Model-Based Collision Detection
Future Competitive Advantage • Significant Knowledge Advantage • New Processes Already Implemented in the Future • External Impact of the Company • Attractiveness for New Personnel
Transparency and Data Management

Power System Technology
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• Changes in the Project are Traceable • Collaboration and Coordination of Individual Trades • Model-Based Quantity Takeoff • Consistent Adoption of Changes in the Model • Standardization of Data Transmission
Collection of Relevant Data for the Entire Lifecycle of a Facility • Foundation for Digital Twin • Data from Planning to Operation • Planning Based on Current Data from Operations • Digital Planning / Implementation of Variants Before Decisions

13. DISCUSSION AND CONCLUSION

The results show that there are still significant challenges when introducing BIM in the wastewater industry. These challenges are related to the transformation of processes, working with models, data management and data exchange, data quality, the role of politics in digital transformation and the lack of feasibility of all BIM potentials for urban water management. These challenges often outweigh the expected added value. Larger engineering offices in particular are now starting to use this method on selected projects. However, interviews show that companies are currently still making advance payments. Therefore, introduction in smaller companies is often not conceivable at this stage from a purely economic point of view. BIM process management frameworks are currently not yet designed for the wastewater industry. Likewise, there are currently no sets for modeling industry-specific objects. When modeling existing buildings, officials often face limitations in their work due to the low quality of existing documents. Despite early BIM projects in the construction and development of wastewater treatment plants and special structures, the application is usually limited to the planning and implementation phase. The potential of BIM in the operational phase has not yet been exhausted in wastewater management projects. The customer or operator must determine which information is important to the company.

If you look at the added value of BIM use cases, it is clear that there is a lot of potential here for tasks in wastewater management with regard to existing information systems in wastewater management [34]. In practice, systems corresponding to master data and status data about the installed infrastructure are currently mostly used as an information system and a basis for planning [35]. In most cases, project management and communication between people involved in the project are not done through appropriate platforms. Following a BIM workflow-based approach can bring significant progress here. The question arises as to how far the findings from the implementation of the BIM method can be applied to common practices in

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network expansion, renovation and exploitation. Improve the sewage management system. Software manufacturers are now offering the first applications that use a single platform to exchange between planners, clients and implementing companies. This is particularly interesting for the wastewater industry in the field of wastewater rehabilitation, as the focus of future actions will be on the renovation of wastewater systems [36]. This means that the developed processes can also be used in the future for the expansion of the sewer network and the renovation of the sewers. However, it needs to be evaluated to what extent aspects of the BIM methodology, especially transparent and platform-based collaboration, can improve these processes.

In addition, managed information systems on wastewater infrastructure can be used in the future together with dynamic data collection. In connection with the evaluation of real-time data in the sewer network, the performance of a system can be improved, and longer time series of measurement data can also provide a good planning basis for planners [37]. However, this requires optimal data management. A standardized process can also help convey information about the implementation of sewer rehabilitation and network expansion. In order to provide a clear framework for this, specific use cases must be defined and subsequently specified:

Which data is required for this task,

How relevant data can be collected,

At what depth of information, the data should be available and

How often should the data be updated?

In order to be fair in the added value in the operational phase, these considerations should be done in the initial phase of the project. It is also important to involve the people who will subsequently operate the relevant system. The BIM method inevitably requires a review and restructuring in the way of data management and exchange. In the wastewater industry, there are systems for managing and documenting building information and measuring relevant parameters. Many dynamic data (e.g. measurement of flow, water level, water temperature, etc.) are currently being collected, especially in measurement, control and regulation technology. However, the management of collected data is usually done in statistical databases. This means that information is organized in different systems and is often not interchangeable or combined. Furthermore, in their current form they are often not easily usable and shared, or it is generally not clear which data is actually available. The problem of separate storage and management of project and building information in the life cycle of a building also covers other areas of the construction industry. By reorganizing the exchange, management and analysis of information in the respective specialized models of individual project participants, BIM promises to resolve this separation by integrating individual specialized models at specific

Power System Technology
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times in the project. In this way, information loss can be avoided by removing interruptions in the flow of information [38].

Wastewater management is currently being implemented, what added value can be seen and what challenges this method currently creates. The results of the conducted interviews show somewhat similar opportunities and challenges to those described in the literature on BIM application in other areas of the construction industry. Despite the similarities, the results show a more accurate picture of the issues that the wastewater industry is concerned with, especially in relation to the introduction of BIM. By scrutinizing the BIM method with experts in the field, it is also possible to assess where aspects of this method are used in addition to the conventional use of BIM, especially in new construction and expansion of special structures and wastewater treatment plants. Finally, the results of this research are summarized as follows:

In the future, there will be a need for a low-threshold introduction to the topic of BIM for both large and small companies (even a slightly closed BIM approach can provide great added value depending on the respective use cases).

Exchange of information between potential users and pioneers of this field should be increased.

For already established practices in wastewater management, where aspects of the BIM methodology are already applied, it is necessary to examine how this approach can be further improved.

In the future, the technical and legal framework in the wastewater industry will change, as a result, among other things, data management in the wastewater industry will become more important. It is important to define which system data is relevant in relation to the entire life cycle and how data is collected. Defining industry-specific use cases and managing tailored data can be of great benefit here.

14. SUGGESTIONS

In order to work with the added value of the method for industry in more detail in the future, additional quantitative research approaches can be used in further research work. For example, through a survey on the relevance of defined BIM use cases in the planning, implementation and operation of wastewater systems. It also makes sense to support pilot projects with regular interviews or empirical reports so that we can really evaluate the development. This should be done in partnership with customers as well as software providers.

In addition, data quality analysis of wastewater management inventory and operational data would be beneficial. This can be used to assess the industry's progress in information management and how data is collected and used. However, the focus of future research work should be a practical investigation of BIM and digital divides in wastewater management.

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