

# Real application of BIM in the engineering system design for energy management

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**Abstract.** In the article, the information modelling technology (BIM) that is gaining popularity in Russia and in the world, is considered. Its growing relevance relates to many factors: first, attention to this technology by the local and federal authorities; Secondly, with the desire to improve the quality of design documentation, to obtain the correct volumes of materials and equipment; Thirdly, with the tendency to create "smart" cities and, as a result, the rational use of energy resources. Within the framework of this article, on an example of an urban infrastructure object, the pros and cons of this technology were considered. As a facility, a local wastewater treatment plant was chosen. The stages of creating an information model on the available documentation are described: 4 main milestones that need to be implemented. In addition, further possible ways of using the model are described. Presented are the pros and cons of using this technology. Among the main advantages is the possibility of using this information model in the operation of treatment plants and further obtaining actual data for monitoring the condition of equipment and, therefore, controlling the consumable resources; At an early stage, a reduction in the number of mutual intersections of engineering systems; Obtaining the correct specifications. The results of the work described in the article can be used in the following areas: utilities, energy management, design and construction.

## 1. Introduction

The improvement of water supply and sanitation systems is not only in the application of modern operating technologies but also in the design process improvement allowing to reduce the number of design errors. One of the ways to solve this problem is the information modelling technology developing in Russia [1]. This technology has been rapidly developing with the support of major construction market players. However, it should be noted that the use of BIM for engineering facilities such as sewage treatment plants, pumping stations, water or wastewater treatment facilities is not reflected in the current realities [2-4].

What is BIM? Its role in modern Russia.

The end of the XX - the early XXI centuries associated with rapid development of information technologies were marked by the emergence of a fundamentally new approach in architectural and construction design, which consisted in creation of a new building computer model containing all information about the future object -Building Information Model (BIM). Despite the fact that the idea was first formulated in 1975 by Professor of the Georgia Institute of Technology Chuck Eastman, it is now when mass discussion and implementation of BIM technology in design and construction are carried out [5,6].

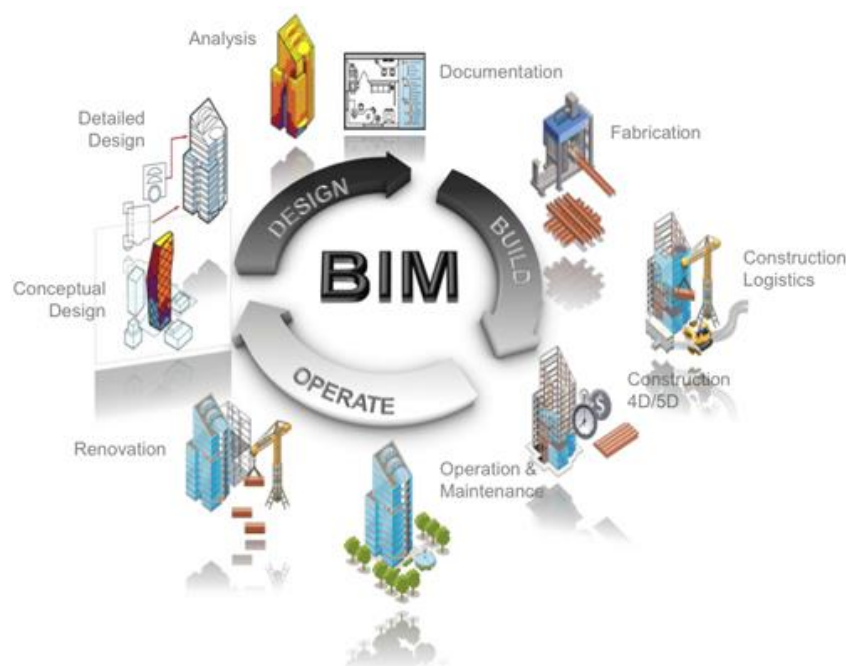
Building Information Model (BIM) is:



- Well-coordinated, coherent, and interrelated,
- Capable of being calculated and analysed,
- Geometrically linked,
- Suitable for computer use,
- Allowing necessary updates [7].

In other words, BIM is a numerical description and properly organized information about the object that is used both at the design and construction stage of the building and during its operation and even demolition [8,9].

Unlike traditional computer-aided design systems creating geometric images, the result of building information modelling is usually an object-oriented digital model of both the entire object and its construction process. BIM layout is shown in figure. 1 [10].



**Figure. 1.** What BIM is.

## 2. Materials and Methods

Within the framework of this article, it was decided to build a model of a local wastewater treatment plant based on the available PD stage documentation. It should be noted that the originally proposed project was implemented in AutoCAD software package; this supposes the presence of 2D drawings in DWG format.

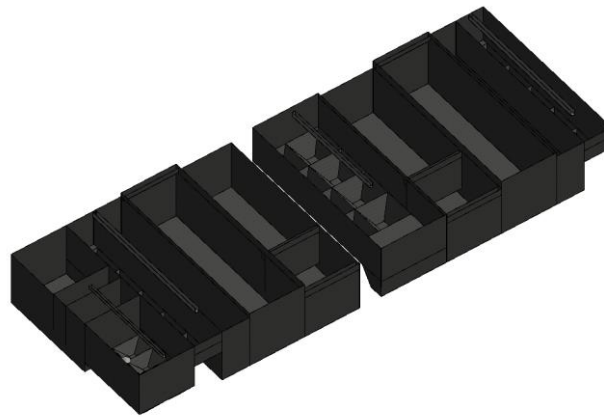
When working with the BIM model, it is necessary to clearly organize it, designate a certain order of actions, and strictly adhere to it so that the result meets expectations. That is why we identified several stages being fundamental for further work.

The zero stage was designated as a preparatory one. As part of its implementation, the analysis of existing documentation was conducted, design errors and ways of their elimination were found, a procedure for creating intermediate models was planned, a list of used equipment and elements, their sizes, and required parameters are approved. It was followed by the first stage.

The first stage implied the direct development of an architectural model, which further will be filled with engineering networks and equipment. Since within the framework of our project we considered local treatment facilities made of metal, the geometry of all structures included in the technological scheme was created. These were a regulating tank, primary settler, pre-denitrifier, denitrifier, nitrifier, secondary settler, post-treatment reactor, after-treatment filter, and aerobic sludge stabilizer. Work on

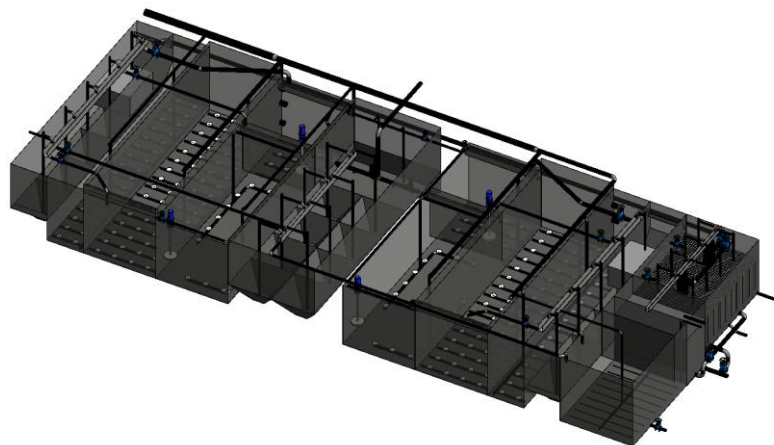
the first stage was simplified due to repetition of structures in the technological scheme and, as a consequence, due to the lack of necessity to simulate them again.

The second stage. For convenience of use, each model was created in a separate file. When the work on architectural part development was completed, the structures were merged and 'blocked' in one common file according to the adopted technological scheme for the sake of convenience in implementation of projects of related specialties. The result is shown in figure. 2. This stage did not cause any special difficulties and was in fact intermediate.



**Figure. 2.** The result of work at the stage 2.

The third stage. After completing the work on the second stage, it became necessary to create families of the equipment used in the project. If the issue with pipelines and shaped elements was solved by internal capabilities of the program, such elements as aerators, latches, and pumps had to be modelled from scratch since there are no manufacturers in the Russian market that provide ready-made equipment models. After completion of the preparatory works, the stage for laying of engineering systems began. The main difficulty was the interconnection of elements. For example, very often there was a situation when pipe marks on a 2D plan differ but not enough for their free passage without crossing each other. Or another situation, when the valve on a 2D drawing was shown in conventional and / or inaccurate dimensions, and when placed in the model it rested against the wall, or the valve stroke was limited by neighbouring elements. In addition, it was revealed a lot of things when equipment fastenings, sufficient distances for placing fittings and other elements were not considered.



**Figure. 3.** The result of work at the stage 3.

The fourth stage. After design of all adjacent sections, a visual model analysis was carried out, some corrections were made, and visual materials for demonstration were prepared. In the future, it is planned to execute a machine room model with the arrangement of large-sized equipment and the layout of pipeline systems inside this building, and to perform siting of the station.

### 3. Results and discussions

As the performed work showed, the modern tendency towards the increased design speed cannot fail to affect the number of made errors regardless of the control level by CPE and CPA organizations. It is a poor quality of design documentation when designing in a classical way that became one of the fundamental factors forcing the industry to start using BIM [11,12]. Most of the errors are related to engineering systems and the interaction of several adjacent sections. Among the most frequent errors that occur in design of engineering systems, the following points can be emphasized:

- Intersection of different systems. For example, sewage pipes with cable trays, main lines of water supply systems with air ducts, etc.
- Difficulty in performing mounting works due to impossibility to correctly determine the location of engineering systems. (Binding to unfinished structures).
- Passage of pipelines of engineering systems through the load-bearing structures and the necessity of their location adjustment.
- Possibility to lose drawings and further difficulties with identification of the type of engineering systems, and as a consequence - operation problems.
- Lack of space for correct system installation and use of incorrect connectors
- Limiting or impeding normal functioning of the elements

### 4. Conclusions

Based on the results of work with this model, we can identify several sectors where it could be useful and describe a couple of use cases.

#### 4.1. BIM for testing and design

3D model use allows not only to check the accuracy of design decisions but also to link them with other sections, to check the correctness of location of adjacent equipment and elements. In addition, the receipt of various specifications is greatly accelerated, which means the nullification of human factor and complete elimination of errors in calculation.

The obtained model allowed to determine such drawbacks of the documentation created in 2D as:

- Absence of openings for utilities and pipelines
- Intersection of engineering systems
- Inconvenient places for maintenance and installation
- Overestimated number of pipelines and fittings

It is also worth highlighting one more possibility of the BIM model relating to the design. A designer can very quickly change the material of pipes, equipment, change the overall dimensions of terminals, and all these changes are automatically displayed not only in working form but also updated in all working drawings containing this element. Thus, it eliminates another problem when the designer changes, for example, one type of aerators to another in one form and forgets to change them in the others. The result is an error and waste of time for project documentation adjustment [13].

#### 4.2. BIM for operation

The application of BIM technologies has many advantages not only for the construction process, reducing the number of design errors, but also significantly facilitates further operation of the facility or structure. The main difference between BIM and simple 3D is that each element has a certain set of properties, and not just some visual display. Hence, there are the following advantages:

- Using of real equipment with real dimensions and indicators by a designer

- The operation service can use this model and see not only how any equipment is displayed but also use its basic properties for repair or proper operation.

#### 4.3. BIM for construction

The application of information modelling technology does not end solely in obtaining a fine 3D picture. The resulting model can be used to form estimates, calendar and network planning, to create 4D and 5D graphs (depicting the change of the model in time (4D) and change of the amount of spent resources, including material ones to create a specific object) [14,15]. In addition, these models are used for comparison between the model state according to the schedule and the current state of affairs on the construction site.

### 5. Results

The result of this article is a proven coordinated model of a wastewater treatment plant; with a constructive section that reflects the overall concept and with combined engineering section for troubleshooting during design.

The key conclusions are that not only a designer but also the state should gradually implement this technology. This, as it was said earlier, should stimulate the use of information modelling at all stages of the object's life cycle.

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