Application of Building Information Modeling in Data Center design

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Abstract. The constant increase in operating costs of data centers (DC) is the driving force behind innovations to increase their efficiency. Today, one of the newest ways to improve the design and functionality of data centers is the integration of building information modeling (BIM). The aim of the work is to analyze the possibilities of increasing the efficiency of the data center design stage based on the use of BIM-technologies, and the task is to design data center systems of all levels of certification of the Uptime Institute. The integration of the capabilities of BIM-technologies during design increases the efficiency of both the general design of the facility and special design indicators of data centers. This article sets out the basics of integrating BIM and data centers, a working mechanism for their interaction when designing the required level of functionality of the Uptime Institute with the design, as well as the possibility of using BIM-data from the design stage in the subsequent stages of installation and operation.

1. Introduction
A data center is a complex engineering structure, a high-tech platform for servicing information systems and telecommunication equipment, the purpose of which is to process, store, transmit information strategically important for a particular company, and manage its information system. The data center infrastructure includes several engineering systems of a high level of reliability: air conditioning, uninterruptible power supply, fire extinguishing systems, low-current systems and access control, as well as other systems in accordance with the specifics of the facility being served.

Reliability is one of the main and combination characteristics of data centers: the reliability of the structure in which the equipment is located, uninterrupted power supply, and cold supply. All data center systems must ensure uninterrupted provision of services, access to enterprise information, and management of its business processes and maximum operation of the IT infrastructure of a company, corporation or government body.

In addition to reliability, the data center should fulfill its tasks as efficiently as possible for the data centers as a whole and specific task within the specifics of the operating company. The fundamental purpose of all data centers at any level of use is to improve the functioning of the organization and improve the quality of its services.

The existing and developing data centers, even despite the high level of development in this area, have a number of shortcomings or shortcomings that affect their functioning, and as a result, the work of the respective companies: the required reliability, the efficiency of the data center systems are not provided and the level of tasks they solve within the framework of the business process. Most of the
flaws are based on a low level of design development, lack of professionalism of service specialists and insufficient assessment of the complexity of the implementation of engineering solutions for the tasks to be solved. Therefore, today there is a problem of the efficiency of design and installation of data centers of various sizes.

One of the ways to solve this problem is a thorough study of design solutions. As a tool, the capabilities of BIM-technologies are used as a tool. Data center information modeling helps you effectively make a design decision, select equipment, make engineering calculations, and quickly analyze changes and make modifications when developing a data center concept.

Thus, the use of BIM-services and software at the stage of pre-design and design developments will help to adopt a rational version of the equipment, its location and the effective operation of all engineering systems. Reliability, operational efficiency, ease of installation and maintenance, as well as the total cost, depend on the fundamental concept of the data center.

2. Methods

2.1. Methods for improving the efficiency of data centers

Initially, the direction of increasing the efficiency of data centers was energy consumption. Customers have always sought to reduce not only design costs, but also on further operation. The main indicator of minimizing operating costs is the level of electricity consumption, as well as the costs of commissioning and monitoring. Because most of the consumption is made up of server equipment of any type of data center in conjunction with power equipment, such as switchboards, uninterruptible power supplies, batteries, generators and transformers, as well as cooling and air conditioning equipment. A lower level of consumption is characterized by low-current systems, fire safety systems and lighting.

In this area, almost all work has been reduced to improving the equipment of data centers, its characteristics, indicators of energy consumption, reliability and recovery speed in case of failures. Accordingly, a circle of specialists who can solve the tasks was significantly narrowed down to engineers for the development of equipment for data center systems and it is almost impossible to influence their decision-making processes. In addition, simplified analogues of equipment cannot be used in certain complicated concepts of data center.

Another way to increase the efficiency of data center equipment is to install additional temperature sensors and their continuous analysis, based on which operational decisions are made on the operation of specific equipment, its operating time, and interaction with other systems. However, the high cost of such temperature sensors, as well as their individuality for each specific object (i.e. the impossibility of a similar application) requires additional calculations and research, high project costs. Thus, this method does not receive sufficient distribution for implementation, and also does not cause high interest for the study and more serious developments.

2.2. Features of designing data centers based on BIM-technologies

One of the most modern areas for streamlining data centers is the use of BIM-modeling capabilities. This approach is only gaining popularity among data center designers and at the moment it is not used to 100% of its capabilities, but now you can already determine a sufficient number of advantages that facilitate, accelerate and streamline the work of a data center project for specialists of various fields: from designer to service engineer.

At the beginning of the work, on the basis of the available architectural and structural data or technical specifications, an information model is built using the selected BIM-service. Further, depending on the level of complexity of the project, the engineering part and the arrangement of the selected equipment are simultaneously or sequentially performed. At this stage, the level of detail is determined by the project team depending on the purpose, tasks, deadlines and budget.
The architectural part and the engineering part are performed by the basic tools of the BIM-service, less often the connection of additional libraries or libraries from the manufacturer is required.

The stage of equipment selection and placement is more complicated. Based on preliminary calculations and company policy, specific equipment is selected. To introduce it into the model, it is important to determine the manufacturer, model and related technical specifications. After that, you need to contact the library or the family database of the selected manufacturer and get the required model.

After all the elements have been prepared, families are loaded into the main model, the required characteristics and parameters are selected for each specific equipment, and dimensions are set if necessary. If the manufacturer does not have a model of the equipment of interest, then you will need to create a family yourself or change the analogue. Next, all equipment is placed taking into account architectural and structural limitations and technical requirements and rules.

During the arrangement, unforeseen problems or controversial issues may arise that can be quickly resolved using the existing 3D model by appropriate specialists, as well as quickly changing the equipment characteristics in the model properties if necessary.

At the end of the work, a final model of the data center will be obtained, which can be used for various purposes and perform the corresponding functions (Fig. 1). If necessary, you can add interior objects. Using the BIM-service with this model, you can manipulate and convert to other formats.

![Figure 1. BIM-model of a container-type data center (section).](image)

2.3. Designing data centers in accordance with the Uptime Institute certification system based on BIM-technologies

As a result, the mechanism for integrating BIM-systems in the design of data centers was demonstrated, and a generalized method for implementing the data center model with information modeling tools was formulated.

One of the problems that occurs at the stages of creating a data center is the lack of a single standard or a comprehensive document in Russian legislation that would regulate the design of all components of data centers and IT-infrastructure. Therefore, specialists in the field of construction and operation of data centers are guided by the classification of the Uptime Institute.

Uptime Institute is the most recognized and accepted global standard in the IT industry, and also has the rights to certify data centers in accordance with the Tier-system in the design, construction and operation of infrastructure around the world.

Today, the Uptime Institute standard is a consistent assessment of the various capabilities of data centers in terms of uptime, infrastructure efficiency or uptime. Such images there are 4 levels of Tier
data center infrastructure. Each level (Tier) establishes the requirements for power supply, cooling, maintenance and uptime. Each next level (Tier) includes the requirements of all previous levels.

Based on the classification, all levels (Tier) can be presented in the form of a comparative table according to the main criteria for assessing the data center infrastructure (Table 1).

**Table 1.** Tier classification levels of the Uptime Institute system.

| Description                              | Tier I                                    | Tier II                                 | Tier III                                | Tier IV                                      |
|------------------------------------------|-------------------------------------------|-----------------------------------------|-----------------------------------------|----------------------------------------------|
| Minimum Capacity                         | Basic infrastructure without redundancy    | Infrastructure with backup capacity      | Infrastructure that supports parallel repairs | Fault-tolerant infrastructure                |
| Components to support the IT Load        | N                                         | N+1                                     | N+1                                     | N after any Failure (N+N)                    |
| Distribution Paths – Electrical Power Backbone | 1                                         | 1                                       | 1 active and 1 alternate                | 2 simultaneously active                      |
| Critical Power Distribution              | 1                                         | 1                                       | 2 simultaneously active                 | 2 simultaneously active                      |
| Concurrently Maintainable                | No                                        | No                                      | Yes                                     | Yes                                          |
| Fault Tolerance                          | No                                        | No                                      | No                                      | Yes                                          |
| Continuous Cooling                       | No                                        | No                                      | No                                      | Yes                                          |
| Compartmentalization                     | No                                        | No                                      | No                                      | Yes                                          |

According to the results of the analysis of the classification system of the Uptime Institute, it can be seen that for each level (Tier) special equipment is not required: compliance with the level is achieved due to additional equipment of the systems in case of repair or malfunction. Thus, the same equipment can be used to implement the required level.

In the process of developing and designing a data center, it is often necessary to change the level. In addition to technological transformations, technical and economic indicators or architectural and design solutions may change. In this case, an operational adjustment of the concept or part of the project of the future object is necessary.

In order to avoid the negative effect of repeated work and additional time on it, the use of information modeling software will be rational. The integration of BIM-technologies in the design of data centers consists of several stages:

1. Building an information model using the selected BIM-service or using a container data center.
2. Designing engineering systems depending on the level of complexity of the object.
3. Calculation, selection and placement of equipment.

The basic tools of the BIM-service perform the first and second stages, less often the connection of new libraries or tools of the manufacturer is required.

The third stage is carried out on the basis of the required Tier level (company policy, preferences and capabilities of the manufacturer, architectural and structural limitations and technical requirements
are taken into account). In the final model, all previously developed entities are compiled, the required parameters are set for the equipment. If necessary, you can create a family on your own or change the analogue.

Changing the Tier level in most cases entails the repeated completion of the 3rd stage. In case of any other unforeseen problems, BIM-systems provide an operational solution using the existing 3D-model by appropriate specialists, as well as a quick change in the characteristics of the equipment in the model properties.

Thus, a method is formulated for implementing the data center model with information modeling tools taking into account the classification requirements of the Uptime Institute. Based on this approach, you can not only create various types of data centers, but also modify them. With the long work of creating models, including various Tier levels, a library of typical BIM-objects (families or components) is formed for re-use, which further reduces the time for developing the data center concept and its design, as well as adjusting and changing any character. Thus, BIM-systems provide quick creation and adaptation of the design of any data center to the required Tier level.

3. Results
As a result, the mechanism for integrating BIM-systems into the data center design process was demonstrated, and a generalized method for implementing the data center model with information modeling tools was formulated. Based on this algorithm for creating a model, it is possible to implement data centers of various scales, levels, purposes, and can also be modified and converted to similar data centers. During long-term work on the basis of the created models, a library of typical re-application BIM-projects will be formed, which in the future can reduce the time for developing the concept of data centers, for pre-design developments, for design and operational changes.

4. Discussion
Traditional approaches to design do not provide a high level of perfection of design solutions, and the duration of work is significantly higher compared to the BIM-approach. If you need to adjust the concept, when new input data appears or errors are detected, you need to recalculate or change the project. Without the use of BIM-services, this process can take quite a long time, as well as performing monotonous work. In addition, separate design actions must be performed to match the concept to the desired Tier level. In General, the traditional approach is more labor-intensive and resource-intensive.

The use of information modeling systems in the design of data centers of the required Tier level ensures the selection of a rational concept and equipment with subsequent effective operation. Therefore, the advantage of BIM-based design is obvious.

5. Conclusions
Thus, the use of BIM-services in the design of the data center provides the choice of a rational concept for the design of the data center and its subsequent effective functioning. The use of BIM tools greatly facilitates and accelerates the work of designers. As a result, the functional requirements for the data center are fulfilled: reliability and uninterrupted operation. If necessary, the model is exported for additional work in other software systems, depending on the purpose of the project. Based on the analysis of several data models of data centers, it is possible to eliminate the errors and shortcomings of previous projects, as well as improve future models. This method of development and design of data centers is the basis for their further effective functioning for many years, while ensuring the saving of technical and material resources.

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