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1 Abstract

Keywords: BIM, building model, building management, laser scanning, Revit

Building Information Modelling (BIM) has brought a paradigm shift to the construction industry by offering a dynamic and collaborative approach to construction project management throughout the entire lifecycle. BIM facilitates the creation of building models that comprehensively capture both the physical and functional aspects of a project, spanning from the initial planning and design stages to the eventual construction and operation phases.

Facility Management starts after the construction of the building is done and it is handed over. It is a continuous process throughout the lifecycle of the building. The main objective is to guarantee optimal management of the asset and its content (equipment, spaces, furnishings, etc.). The building cannot function without facility management as it includes all the activities integrating business administration, asset management, maintenance, contract management, renovation, refurbishment, etc.

While there are various BIM applications available today, this research primarily focuses on Autodesk Revit as the chosen software for modeling.

The research aims to address an emerging area based on the theoretical proposition that building information generated and captured throughout the lifecycle of a building project can improve facility management. Using this thesis as a starting point, the aim of this research is to explore the challenges that affect the value of BIM and its adoption in FM applications.

The research does this through a case study, using the Materials Testing Laboratory in the MM-MG building of the Budapest University of Technology and Economics as a base. The study involves modelling the MM-MG building using Revit and then selecting a specific room for lidar scanning. The BIM model is then transformed and refined using the point cloud to meet the expectations of FM. In this context, the associated assets will be incorporated into the model based on the survey data, with the information content required for building operation.

In addition, this research will include a review of the international academic literature on the use of BIM technologies to support facilities management.

2 Introduction

2.1 BIM (Building Information Modeling)

BIM, or Building Information Modeling, represents a digital process that captures both the functional and physical attributes of a building. Its application extends far beyond this definition, encompassing a comprehensive strategy for the design, construction, operation, and maintenance of building projects through a unified digital modeling system. BIM enhances design visualization by facilitating digital simulations and practice runs for every project phase, be it design, construction, or operation.

The introduction of BIM has instigated a profound transformation in the Architecture, Engineering, and Construction (AEC) industry. It has effectively steered numerous companies toward novel approaches to design, construction, and Facility Management services. BIM fosters a more collaborative work environment among construction professionals, granting them digital management capabilities and on-demand access to information throughout the project's lifecycle.

BIM, or Building Information Modeling, empowers engineers, contractors, and architects to collaborate on projects from any location globally, consolidating vast amounts of detailed data into a manageable format. This technology simplifies the design process, streamlines team communication, and enhances maintenance in the built environment, with more advantages such as:

- Instant access to building information in real-time
- Enhanced precision in project planning
- Improved cross-team communication
- Cost estimation based on model data
- Visualizing projects during pre-construction stages
- Identifying and resolving conflicts in a proactive manner
- Enhancing project scheduling and sequencing
- Precise prefabrication of building elements
- Minimizing errors and rework efforts

Three-quarters of AEC (Architecture, Engineering, and Construction) companies employ BIM to varying degrees. According to a study conducted by Dodge Data and Analytics titled "Assessing BIM's Influence on Complex Structures," findings from AEC professionals revealed the following:

- 93% reported that BIM positively impacted the quality and functionality of the final design.
- 88% indicated that BIM contributed to a quicker project completion.
- 85% observed that BIM led to a decrease in the overall construction costs.[1]

2.2 Facility Management (FM)

the discipline responsible for coordinating all efforts related to planning, designing, and managing buildings and their systems, equipment, and furniture to enhance the organization's ability to compete successfully in a rapidly changing world" (Becker,1990).[2]

The development, coordination, and management of all of the non-core specialist services of an organization, together with the buildings and their systems, plant, IT equipment, fittings, and furnishings, with the overall aim of assisting any given organization in achieving its strategic objectives" (Moore and Finch, 2004). [2]

Facility Management commences once the construction phase is completed, and the building is officially turned over for use. It stands as an ongoing, perpetual process that extends across the entire lifespan of the structure. Its primary goal is to ensure the impeccable management of the asset, encompassing its contents such as equipment, spaces, furnishings, and more. Facility Management plays a pivotal role in sustaining the effective operation of the building, as it oversees a broad spectrum of activities that integrate aspects of business administration, asset maintenance, contract management, renovations, and refurbishments, among others. In essence, it is the linchpin that ensures a building's sustained functionality and efficiency.[3]

2.3 Principle of BIM for Facility Management

In the last ten years, numerous building owners have seamlessly integrated Building Information Modeling (BIM) into the very heart of their design and construction procedures. The natural progression for these property custodians is to extend the utilization of BIM across the entire duration of their facility's lifecycle.[3] The critical component to achieving success for facility owners lies in the development of a well-thought-out plan to implement Lifecycle BIM. While initiating a BIM plan is most effective when commenced at the project's inception, it's important to emphasize that there is significant value in initiating this plan at any juncture within the design, construction, or occupancy phases. This strategic approach ensures that the wealth of benefits BIM offers can be harnessed throughout the entire lifecycle of a facility.[4]

The plan in question should comprehensively cover three key aspects.

- First, it should delineate the specific information essential within the model to bolster building operations and facilitate strategic lifecycle planning.
- Second, the plan should clearly outline the processes and the associated responsibilities for creating and continually maintaining this crucial data.
- Furthermore, it must specify the timing for data collection and the most effective methods for populating the model, ensuring a seamless flow of information.
- Last but not least, the plan should specify the depth of model information to be incorporated into the actual model, encompassing both graphical representations and essential data components.

Ultimately, this document serves as an invaluable guide for harnessing the power of BIM in the ongoing management of building operations throughout a facility's entire lifecycle. It outlines a strategic roadmap that, when followed, can optimize efficiency and productivity across all stages of a building's existence.[4]

2.4 BIM uses for Facility Management

Lifecycle BIM is the practice of creating, maintaining and utilizing building information to manage operations and maintenance of buildings throughout their operational lifecycles. Facility managers are finding value in a number of areas of building operations that benefit from enhanced data. [4][6] Some areas of value are as follows:

- IMPROVED SPACE MANAGEMENT

By comprehending the specifics of space utilization, facility managers can decrease empty spaces and, in the end, attain significant cost savings in real estate. The data regarding rooms and areas within BIM models serve as the cornerstone for effective space management.

- STREAMLINED MAINTENANCE

The primary obstacle when creating a maintenance plan lies in inputting the necessary product and asset details for preventative maintenance. The data concerning building equipment contained within BIM models can save months of work needed to accurately populate maintenance systems.

- EFFICIENT USE OF ENERGY

BIM can streamline the assessment and contrasting of different energy options, enabling facility managers to significantly minimize environmental effects and operational expenses. By evaluating the expenditures and the potential savings associated with different enhancements and retrofits of building systems, facility managers acquire a valuable resource for enhancing building performance throughout its lifespan.

- ECONOMICAL RETROFITS AND RENOVATIONS

The as-built BIM model of a building serves as a valuable reference and foundation for future retrofitting, renovation, or refurbishment plans. BIM empowers facility managers and owners to make more informed decisions, as they have a clear understanding of the building's current condition. This simplifies the process and minimizes cost implications. BIM includes comprehensive information about every building element, reducing the complexity and cost of renovation and retrofit projects by providing precise data. This effectively eliminates the potential for interdisciplinary MEP (Mechanical, Electrical, Plumbing) conflicts, which often lead to significant damage and expenses for the building.

- ENHANCED LIFECYCLE MANAGEMENT

The lifecycle information of building components holds great significance as it is essential for predicting when replacements are needed and estimating the associated improvement expenses. BIM models incorporate data regarding the design, lifespan, and replacement costs of building elements, enabling facility managers and owners to assess the advantages of investing in materials and systems with an initial one-time cost but long-lasting benefits, ultimately yielding a better return on investment throughout the building's lifespan. Contractors and owners are equipped with valuable information about replacement costs and the expected lifespan of the materials they plan to invest in, facilitating well-informed decisions and averting unnecessary overhead expenses.[4][6][7][8]

Figure 1: BIM for Facility Management [4]

2.5 The modeling gaps between Architecture, Engineering, Construction and FM

Building owners who adopt Lifecycle BIM encounter a challenge related to the disparity between the BIM models generated during design and construction, and the BIM models required for ongoing operations. While it's possible for building data to transition seamlessly between phases with appropriate procedures, it's beneficial to categorize at least four distinct types of BIM models.[4][7][9]

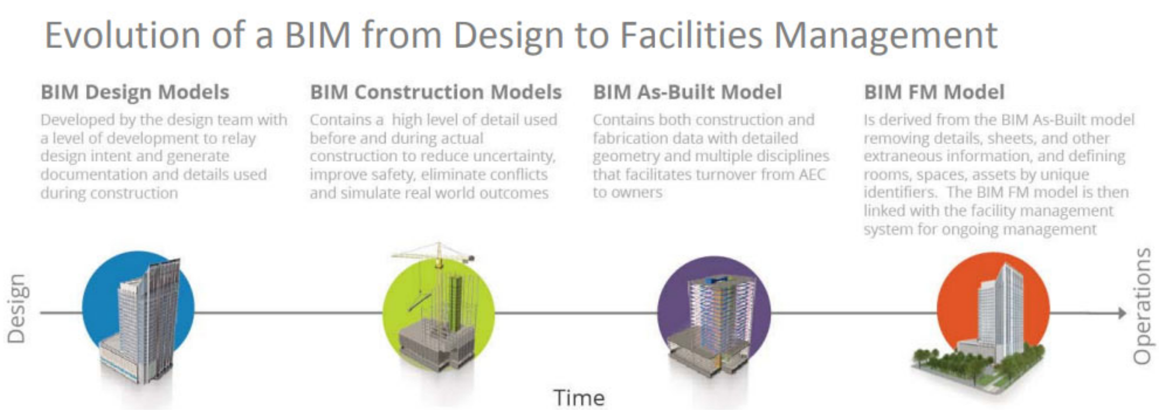


Figure 2: BIM Models from design through facility management [4]

2.5.1 BIM Design Models

These models are designed by architects and engineers with the initial goal of outlining the conceptual design and eventually generating construction documentation. Building materials and equipment are described in a non-specific manner, providing contractors the flexibility to competitively bid on and price alternative options. For instance, air handling units are outlined in terms of their general dimensions and performance criteria by the engineer, without specifying the manufacturer that will be chosen.

2.5.2 BIM Construction Models

Contractors and subcontractors will utilize these models to assist in planning and identifying potential clashes through clash detection, preventing on-site issues. They also serve for material quantity estimations and procurement. BIM Construction Models typically encompass a significant level of intricacy, employed before and during construction to minimize uncertainty in the construction process. Additional advantages encompass improved job site safety, conflict resolution, and simulating real-world scenarios.

2.5.3 BIM As Built Model

This information is typically generated by the general contractor, subcontractors, and suppliers. Traditionally, this data was presented in the form of paper working drawings, which were then annotated to incorporate change orders and field modifications. These drawings were accompanied by equipment cut sheets and shop drawings specifying the chosen equipment.

In the BIM era, this data must be re-entered into the BIM model by either the contractor or a building commissioning specialist. The BIM As-Built Model includes various elements such as details, annotations, dimensions, building sections, schedules, and elevations. It also incorporates material and equipment properties established during the construction process. The BIM standards play a crucial role in defining the necessary information. The building owner should maintain the as-built model as the authoritative source and a reference for the building in its constructed state.[4]

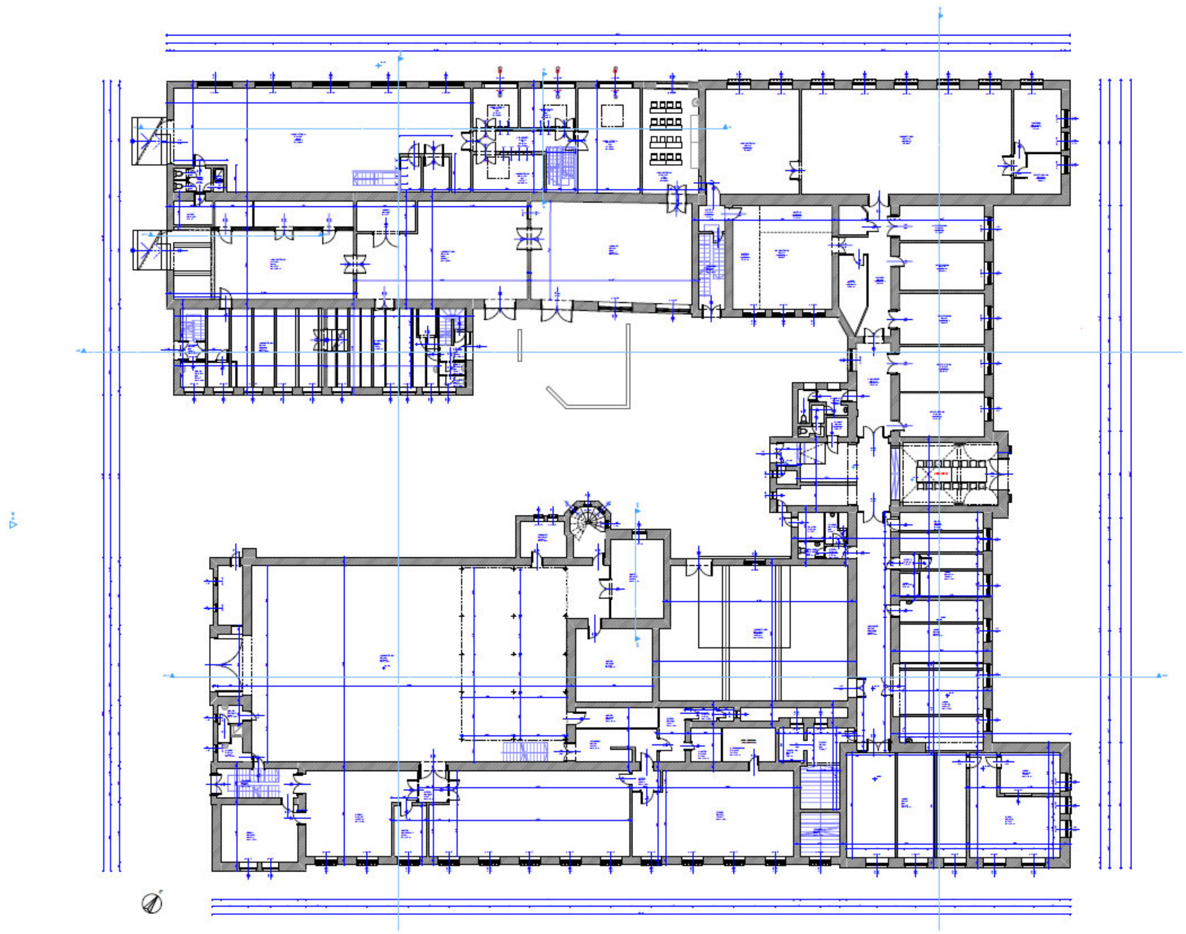


Figure 3: Floor Plan in a construction BIM model [10]

2.5.4 BIM FM Model

The BIM FM Model originates from the BIM As-Built Model, with extra details presented in section 3. The development of the BIM FM Model involves the following adjustments:

- Extraneous information is removed including construction details and working drawing sheets. This information can be obtained from the as-built model if needed, but otherwise encumbers the BIM FM Model.
- Where linked models have been used to distinctly represent building core, building shell and tenant improvements, these are merged into a single model.
- If practical, linked models representing architectural, mechanical, electrical, fire protection and specialized equipment are merged. For large buildings this may not

be practical with current technology, so there may be the need to maintain multiple models that are linked.

- Occupancy room numbers are derived from construction room numbers with numbers matching building signage.
- For office space, workstations and offices are defined separately from rooms and are numbered with an occupancy numbering system. This is key to matching office occupants to desks, cubicles and offices and is also essential for management of work orders.
- Building equipment items are numbered with unique asset ID's.
- The BIM FM Model is linked to the facility management system which tracks ongoing work orders, maintenance operations, occupancy information, equipment and material replacement costs and other data related to building operations. [4][6][11][12]

2.5.5 Integration with Facilities Management Systems

The BIM model is the authoritative source for the physical aspects of a building including the structural system, walls and doors, room finishes, lighting, power, plumbing, fire protection and HVAC systems. It is not designed to manage data for ongoing operations and occupancy; this information is best handled by a facility management system. [9][13][14] In this document, we use the general term "facility management system," but this might alternatively be known by one of the following designations:

- Computer-Aided Facility Management (CAFM) System – These are systems integrated with CAD or BIM and are used to track space and maintenance at a departmental (rather than enterprise) level.
- Computerized Maintenance Management System (CMMS) – These are systems designed to track remedial and scheduled maintenance.
- Integrated Workplace Management Systems (IWMS) – These are systems that manage space, maintenance, real estate, move management, strategic planning, project management and other facility functions and are deployed on an enterprise rather than departmental basis.[13][14]

3 SCAN to BIM

In a Scan to BIM process, a laser scanner is used to capture an accurate 3D scan of the real-world conditions on a project. The scan data is then imported into a 3D modeling environment to create either accurate as-built models or to inform the design with the real-world conditions. As defined by The B1M, Scan to BIM is

“The process of 3D laser scanning a physical space or site to create an accurate digital representation of it. This representation can then be used for designing, assessing progress or evaluating option.” (Anne-Mieke Dekker).[15]

3.1 Type of formats

1.Point Cloud Data Formats: These formats represent the 3D spatial data collected from laser scans, LiDAR, or photogrammetry.

- LAS (Lidar Binary)
- XYZ (Simple point cloud data)
- PTS (Point Cloud)
- E57 (Laser Scanning Data)
- PLY (Polygon File Format)

2.CAD and BIM Formats: These formats are used for creating or importing 3D models and BIM data.

- DWG (AutoCAD Drawing)
- DXF (Drawing Exchange Format)
- RVT (Revit Project File)
- IFC (Industry Foundation Classes)
- SKP (SketchUp)

3.Raster Image Formats: These formats are used for images generated during the scanning process.

- JPEG
- TIFF (Tagged Image File Format)
- PNG (Portable Network Graphics)

4.Mesh Formats: These formats are used for 3D surface mesh models generated from point cloud data.

- STL (Stereolithography)
- OBJ (Wavefront OBJ)
- 3DS (3D Studio)
- VRML (Virtual Reality Modeling Language)

5.Data Exchange Formats: These formats are used for transferring and collaborating on BIM and 3D model data.

- IFC (Industry Foundation Classes)
- BCF (BIM Collaboration Format)
- COBie (Construction Operations Building Information Exchange)

6.Text and Documentation Formats: These formats are used for textual and document-based data in BIM.

- PDF (Portable Document Format)
- DOCX (Microsoft Word)
- XLSX (Microsoft Excel)
- CSV (Comma-Separated Values)

7.Metadata Formats: These formats store additional information about the scan data.

- XML (Extensible Markup Language)
- JSON (JavaScript Object Notation)

The choice of format often depends on the specific software and tools being used in the Scan to BIM workflow, as well as the requirements of the project. Converting and utilizing data in the appropriate format is crucial for accurate modeling and information exchange in the BIM process.[16]

3.2 The steps scan to BIM works

Scan to BIM (Building Information Modeling) is a process that involves using 3D laser scanning technology to capture accurate and detailed as-built data of existing physical structures or environments.[15] This data is then integrated into a BIM model, allowing for the creation of a digital representation of the real-world conditions.

1. Planning and Goal Setting:

The process begins with a clear understanding of the project's objectives. This includes defining the scope, the level of detail required, and the intended use of the BIM model. This information guides the entire Scan to BIM process.

2. Scanning the Site:

A trained technician or team is dispatched to the project site with a 3D laser scanner. The scanner emits laser beams to measure distances to various surfaces in all directions, capturing the geometry of the existing structure or environment.

3. Scanner Setup:

The technician sets up the scanner at strategic locations within the site and configures its settings, which may include scan density and the number of measurement points per scan. These settings impact the level of detail captured.

4. Data capture:

The scanner collects millions of data points, creating a point cloud. The technician moves the scanner to ensure comprehensive coverage and may take multiple scans from different positions to capture all surfaces and elements.

5. Data Transfer and Management:

After scanning, the collected data is transferred to a computer. This can be done via USB drives or uploaded to cloud-based platforms. Organizing and naming data files is essential for efficient data management.

6. Point Cloud registration:

The individual scans are registered into a unified point cloud using specialized software. This process aligns the scans to ensure accurate spatial relationships between data points.

7. Importing Data into BIM Software:

The registered point cloud data is imported into BIM modeling software, such as Autodesk Revit, Trimble SketchUp, or similar tools. The point cloud serves as a reference for modeling the existing conditions.[15][17]

3.3 The Major benefits

The big advantage of laser scanning is that data can be acquired quickly and without touching or approaching the objects to be measured. Therefore, surveys where there is only a narrow window of time or where access to the area is limited can be carried out without any problems using this technology.[4][17][18]

Typical examples are special engineering cases like complex and oversized building complexes, biologically or otherwise hazardous industrial installations, uniquely shaped or too high structures, mechanical installations, etc. [18]

Technology is also used in special areas like archaeological surveys, road or railway surveys, and, in the film industry, the documentation of spatial relations.[18]

4 Literature Review

4.1 BIM's difficulties in FM applications

The challenges associated with BIM in FM applications are multifaceted. Among the key hurdles, one prominent issue is the absence of well-defined processes for updating the initial design model with as-built information. Responsibilities for providing and maintaining this data remain unclear. Additionally, facility managers have traditionally been involved in the building lifecycle only at later stages of facility handover to clients. Design decisions are seldom scrutinized for their impact on operational costs or maintenance.[19][20]

As a consequence of these challenges, BIM data for FM often proves either insufficient or entirely absent. The traditional procurement of FM contractors, involving contract turnovers every few years, leads to suboptimal data transfer between contractors, resulting in added survey costs.[19]

A cultural resistance to embracing new technologies and processes in the FM industry further hinders BIM adoption. There's a lack of demand from clients for BIM in FM, coupled with limited collaboration between project stakeholders in modeling and utilization. The shortage of BIM skills and understanding among FM professionals exacerbates these challenges.

Interoperability between BIM technologies and existing FM systems, like Computer Aided Facility Management Systems (CAFM), remains an issue during information handover. The lack of open systems and standardized data libraries requires data re-entry into proprietary systems, incurring additional costs. The update of data presents further challenges.

Ultimately, these challenges hinder the efficient integration of BIM in FM applications, limiting its potential benefits in streamlining facility management processes and improving efficiency.[13][11][19]

4.2 Value of BIM in FM applications

Presently, most contracts necessitate the submission of physical documents that include equipment lists, product data sheets, warranties, spare part inventories, and schedules for preventive maintenance.[19][21] This information is crucial for facilitating the management of facilities by owners and facility managers. The process of transitioning information to the FM phase is predominantly manual, frequently resulting in incomplete and inaccurate data. The industry expends significant resources, both financially and in terms of manpower, recreating such information and operating with less than efficient workflows.[19][22]

Efforts to improve handover processes represent a primary incentive for the adoption of BIM in FM. Despite prevailing interoperability challenges, BIM data and information collected during the building's lifecycle can reduce the time and cost associated with assembling and establishing FM systems. For instance, digital records of spaces, systems, and finishes can be created within a BIM and do not require redundant input into downstream FM systems.[20][21] The capacity to integrate manufacturer-specific data within 3D parametric objects diminishes the need for duplicate asset information. BIM is viewed as a catalyst for enhancing data quality and reliability, ultimately leading to increased workforce efficiencies.

The capability to extract and analyze views from BIM, tailored to various needs and users, offers valuable insights for decision-making and enhancing facility delivery. For example, 3D visualization can enhance the problem-solving abilities of FM technicians by leveraging cognitive and perceptual reasoning. BIM visualization provides precise geometric data that was previously unattainable, supporting the analysis of building proposals, performance simulation, and benchmarking. Intelligent algorithms can be developed to automate decision-making in FM applications through the integration of digital data. BIM's benefits extend to various FM applications, including space management, emergency management, energy control and monitoring, and personnel training and development.[21][23][24]

Moreover, adopting BIM in FM is anticipated to encourage greater involvement of facility managers during the early design stage, allowing them to contribute to the design and construction processes.[23][19] BIM's integration in FM is expected to facilitate the management of knowledge related to building operation, which can be employed in future designs. In refurbishment projects, BIM and associated technologies, such as laser scanning, are predicted to reduce the cost of generating as-built information and enhance the accuracy and reliability of FM data. Researchers are exploring methods for integrating "scan to BIM" with advanced data collection from existing buildings, which includes non-destructive testing techniques for analyzing materials and their properties.[24][19]

4.3 Functional issues (Trends and Technologies)

The multifaceted nature of building projects, which involve various stages such as design, engineering, construction, maintenance, and potential deconstruction, results in a wide range of potential applications and necessary features for Building Information Modeling (BIM) in both buildings and infrastructure projects. The specific type of BIM required, whether it's architectural, construction-focused, or specialized in piping, electrical, structural, fabrication, or monitoring, depends on the needs of the stakeholders and the unique project requirements.[4]

These functionalities within BIM can either be integral to the core 3D, 4D, or 5D BIM dimensions, encompassing capabilities like quantity estimation, scheduling, or cost analysis, or they can be supplementary expert applications that are linked to the BIM model. These expert applications leverage the foundational BIM data to support, enhance, compute, or simulate distinct business needs, such as conducting structural assessments.[22]

The outcomes of these functionalities can be either merged back into the overarching BIM model to inform the main project dataset or reported separately. The development and deployment of these functionalities are guided by process maps, which outline the logical sequence of information and activities, as well as the roles of stakeholders within a particular functional area.[47] [48]

Example 1: of major applied or developing BIM functionalities for existing buildings

- Clash detection, spatial program validation, BIM quality assessment
- Construction progress tracking
- Cost calculation or cash flow modeling(5G) **
- Daylight simulation
- Deconstruction, Rubble management
- Deviation analysis, Quality control, Defect detection
- Documentation, Data management and visualization
- Energy/Thermal analysis and control, Carbon foot printing
- Localization of building components, Indoor navigation
- Life cycle assessment (LCA), Sustainability
- Monitoring, Performance measurement (through sensors)
- Operations and Maintenance (O&M), Facility management (FM)

- Quantity takeoff (3D)
- Retrofit/Refurbishment/Renovation planning and execution
- Risk scenario planning
- Safety, Jobsite safety, Emergency Management
- Scheduling (4D)
- Space management
- Structural analysis
- Subcontractor and supplier integration, Prefabrication (e.g., of steel, precast component, fenestration, glass fabrication) [49]

Prominent instances of inherent and expert functionalities that are actively utilized and explored in research have been identified. Presently, research predominantly directs its attention toward expert functionalities concerning new construction projects. These include tasks like energy and carbon reduction analyses, monitoring construction progress (aligning collected data with existing BIM data), analyzing deviations (ensuring quality control and detecting defects), and enhancing job site safety. [48][49][50]

In alignment with the initial use of BIM, which primarily centered around new construction, the applied functionalities have traditionally emphasized aspects like design and visualization, procurement, manufacturing, construction management, and coordination. They have not been as focused on commissioning, facility management, or deconstruction.

However, there has been a noticeable shift in recent times towards planning and handover processes that embrace the integrated project delivery (IPD) model within a collaborative framework. This transition acknowledges the significance of 'as-built' BIM data for supporting facility management, retrofitting, and the eventual deconstruction processes.

As the rates of new construction projects in developed nations plateau, the planning and execution of refurbishment and retrofit initiatives in existing buildings have gained increasing significance [20]. Various digital tools for the inspection and evaluation of buildings are at our disposal, including 2D/3D geometric drawings, tachometry, laser scanning, and automated image location. However, these tools require an elevated level of modeling and planning efforts, often carried out by skilled professionals. [52]

Existing maintenance functionalities, such as Computerized Maintenance Management Systems (CMMS) or Computer Aided Facility Management (CAFM), primarily focus on web-based data management, maintenance schedules, and the management of warranties for increasingly intricate buildings. These systems have seen considerable development, especially concerning areas like deterioration analysis and cause-effect relationships [52]. In some instances, facility management systems incorporate laser scanning of current facilities and the seamless exchange of information between Geographic Information Systems (GIS) and maintenance data. Although substantial research efforts have been dedicated to facility management and BIM-related topics, widespread industry implementation is still lacking. [13][14]

Many of the FM, renovation, and deconstruction research methodologies discussed rely on the presence of a current BIM for a recently constructed building [3]. When a BIM of the intended structure is accessible, the tasks related to planning and executing alterations, renovations, and demolitions can often be carried out with relatively minor modifications. However, in cases where only an outdated BIM or no BIM is accessible, the processes commence with an in-depth building assessment, a review of existing documentation, and analyses of past and present building characteristics. This preliminary phase aims to establish a robust foundation for subsequent planning and cost estimation. [3][52]

While digital tools for cost estimation, quantity assessment, data management, and reporting are commonly employed within the deconstruction industry, there is limited coverage in the literature regarding BIM functionalities specific to deconstruction [5]. These include aspects such as vulnerability and collapse analyses, emergency management, localization and documentation of hazardous or contaminant materials, and risk scenario planning [21][23], which are not yet extensively documented.

Additionally, various other potential BIM functionalities remain unaddressed, such as deconstruction execution planning and progress monitoring, recycling and debris management, auctions for secondary components and raw materials, logistics for recycling networks, monitoring of hazardous components, and automated reporting to relevant authorities. One possible explanation for this gap could be the limited involvement of facility managers, retrofit specialists, and deconstruction experts in the development of BIM functionalities.[53]

4.4 Precision and capability

The effectiveness of BIM functionalities relies on a specific level of accuracy, information depth, and currency of the underlying data to serve their intended purposes [6][7]. One frequently used concept to describe the depth of information within BIM objects is referred to as 'Level of Detail' or 'Level of Development' (LoD). LoD delineates the geometric and non-geometric attributes supplied by a model component [54], often linked to a specific time point, life cycle stage, or contractual obligation. To enable functionalities like analysis or scheduling, it is necessary to establish the requisite LoD for attributes and relationships of objects, including aspects such as durations, dependencies, or precedence information. Various LoD definitions can be found in the literature, as illustrated down below example 2. These definitions diverge in terms of geometric precision, the quality of information, and the comprehensiveness of semantic details.[55]

Example 2: Levels of Detail/ Levels of Development (LoD) in BIM models

+Levels of Detail

- Approximate geometry, Precise geometry,
- Fabrication level/construction documentation
- Conceptual, Approximate geometry, Precise geometry, Fabrication, As-built
- As-designed/As-planned, As-built, As-used
- Schematic design, Detailed design, Level of fabrication (shop model)

+Levels of Development

- LOD 100
- LOD 200
- LOD 300
- LOD 400
- LOD 500 [49]

In new construction projects, the Level of Detail (LoD) evolves as the project progresses through various life cycle stages, from conceptualization to actual construction, adapting to changing requirements and enhancements from initial drafts to final realization. In the literature, functionality-specific LoDs have been established for general modeling, 3D visualization, and energy performance. In the context of existing buildings, the required functionality determines the LoD, influencing the associated costs and effort required for BIM development. For maintenance purposes, the Construction Operations Building Information Exchange (COBie) standard defines an LoD for technical equipment, encompassing details like equipment type, location, manufacturer, model, serial numbers, tagging, installation date, warranty, and scheduled maintenance requirements have introduced a 2% geometric deviation standard for maintenance applications, though they do not specify an LoD for non-geometric information. As for deconstruction functionalities, including rubble management, there is currently no established LoD.[49][52][54]

In addition to LoD, numerous BIM assessment frameworks are in development, such as CMM6, CMMI, P-CMM, Object/Element Matrix, or ISO/IEC 15504 (SPICE). ISO/IEC 15504 primarily formulates the process assessment, and the Capability Maturity Model (CMM) is employed within BIM contexts to assess whether BIM projects or processes achieve the desired level of functionality. The CMM assessment framework outlines the minimum capabilities and requirements for BIM model and process maturity, with ten levels of BIM maturity identified across categories like Spatial Capability, Roles/Disciplines, Data Richness, Delivery Method, Change Management or Maturity Assessment, Business Process, Information Accuracy, Lifecycle Views, Graphical Information, Timeliness and Response, as well as Interoperability and Industry Foundation Class Support. [47[49]

Professional associations are endeavoring to define and harmonize related concepts and ratings that measure BIM's data requisites and capabilities. Nonetheless, a universally accepted assessment framework for BIM, applicable to both new and existing buildings, has yet to emerge. [56]

5 Methodology

At the beginning of this paper, we initiated a research inquiry to explore a developing field, driven by the theoretical concept that building information generated and collected during the entire lifespan of a construction project can enhance facility management. We delved deeper into the potential of BIM in Facility Management (FM) and its capacity to enhance FM practices for existing assets. We conducted a case study to scrutinize how BIM can contribute value to the management of spaces within a specific FM context.

A case study usually employs a variety of data collection methods such as archival research, interviews, surveys, and observations, with the aim of providing a comprehensive explanation and comprehension of the intricacies of a current phenomenon. Case studies are recommended as an ideal approach when a thorough, in-depth examination is required.

The primary aim of this study is to integrate all real-world assets into the BIM model, functioning as a unified system. In contrast to the past, where separate environments were required (e.g., two-dimensional floor plan drawings in DWG format and a database in MS Excel format), this approach eliminates the need for manual updates, reducing duplicated workloads. Inquiries arise within the methodology, and the resolution will be provided through the case study.

1. What are the steps of using LiDAR (Polycom) in the real life?
2. What factors influence the precision of data related to geometric details?
3. What are the key distinctions and variations between a BIM model and a point cloud, particularly when it comes to construction and architectural projects?
4. How does the process of creating a BIM model for existing conditions work (PDF plan), and what are the essential steps involved?
5. What are the main aspects and considerations when performing a comparison between a BIM model and existing plans in construction or architectural projects?
6. How can space utilization be optimized or improved in various settings? Create a schedule from the BIM.
7. What are the primary objectives and strategies for maintenance purposes in building management?
8. How to fill an asset of the element in the BIM model? Create the schedule of all the assets from the BIM model?
9. Create the schedule that includes the measurements (length and area) of the walls as well as their associated costs? In case of renovation need.
10. Create the schedule that include the amount of paint and the total cost of it? In case of renovation need.
11. Generate a schedule that outlines the life cycle and costs of all renewable assets within the room?
12. Generate a schedule the life cycle and the cost of the assets in the bathroom in case of renewable?
13. What are some of the potential applications and opportunities presented by energy modeling in the context of building design and sustainability?

Table 1: Table shows in chronological order in the adopted research

Literature review	Preliminary literature review BIM's difficulties in FM applications Value of BIM in FM applications Functional issues (Trends and Technologies) Precision and Capability
Case Study	Inquiries arise (Questions) Laser scan(Polycam) Building a BIM Model of the existing condition Space utilization and maintenance purpose of the model (3D printing room included Toilet) FM Data Requirements for As-Built BIM models Energy Analysis
Result	Examine and asses the results Draw a conclusion

6 Case Study

The case study was conducted on Building MM-MG(see figure 4 and figure 5), Budapest University of Technology and Economics located at Budapest, Bertalan Lajos u. 1, 1111. The building designed by Samu Pecz was built for the Technical Mechanics and Agricultural Machinery Laboratory (MM-MG), as can be clearly seen in the contemporary architectural plans. In the past hundred years, the world has changed a lot, there have been huge technical progress, so the faculties and departments of the University of Technology have also adapted to these changes. [25]

Figure 4: Image of MM-MG building [25]

Figure 5: Another side of MM-MG building

Video of MM-MG Buildings

https://youtu.be/0HCuAwGcDQQ

6.1 Laser scan (PolyCam)

LiDAR tools are commonly utilized to generate 3D spatial point clouds, particularly for surveying the interiors of existing buildings. They prove valuable in swiftly and accurately producing comprehensive 3D models for entire structures or specific building sections. These tools typically comprise three key components: a camera, a laser, and a GPS module.[26]

In my survey, I employed an iPhone 14 Pro Max with the Polycam application to create the point cloud. This device offers a 5-meter range and an error margin of approximately 0.5 to 1 centimeter per meter. It's essential to note that the point cloud's quality, while suitable for many applications, does not match that of professional-grade tools. Nevertheless, the LiDAR function in the iPad serves as an advancement by the manufacturer.

It's crucial to recognize that LiDAR, as integrated into consumer devices, is not intended for large-scale building surveying. Moreover, its limited range means it's most effective within an 8-meter height range. High-end, multimillion-dollar devices offer considerably greater visibility range and superior data quality.

In my survey, I assessed the 3D printing room, including the bathroom within the building. The scanning process is straightforward: I held the device in front of me and, using the app, moved around the room, allowing the application to generate the point cloud.

To initiate the BIM application, I transferred the point cloud data from the Polycam application in PTS format. These files were then imported into Autodesk Recap Pro, which is compatible with a wide range of 3D object file formats. This enabled me to generate a Revit file from the PTS data. It became evident during this process that I had left a substantial overlap between each segment, which proved beneficial in reducing fitting errors caused by manual adjustments. The resulting point cloud can be seen in Figure 6, Figure 7, Figure 8, Figure 9, Figure 10.

Video of Laser-scan (Produced by Polycam)

- **3D Printing room**

https://youtu.be/FhBbR-iifjs

- **Bathroom**

https://youtu.be/ttvRFLrbRAg

Polycam LiDAR is also celebrated for the density of data it can generate, providing a wealth of information for detailed analysis and modeling. It operates effectively in all weather conditions, offering reliable performance even in adverse situations such as rain or snow. This adaptability is crucial for applications that require consistent data collection.

Additionally, Polycam LiDAR's versatility is a key asset, as it finds utility in various fields, including agriculture, forestry, archaeology, urban planning, and more. Its ability to penetrate vegetation makes it particularly valuable for applications in forestry and environmental monitoring.

LiDAR technology can be integrated with automated systems, including drones and autonomous vehicles, allowing for efficient and automated data collection. It plays a pivotal role in safety and security applications, providing obstacle detection and collision avoidance capabilities for autonomous vehicles. In the realm of infrastructure assessment, it aids in the maintenance and safety evaluation of critical structures like bridges and dams.

Figure 6: 3D printing room by Polycom

Figure 7: Section of the 3D printing room

Figure 8: Another section of the 3D printing room

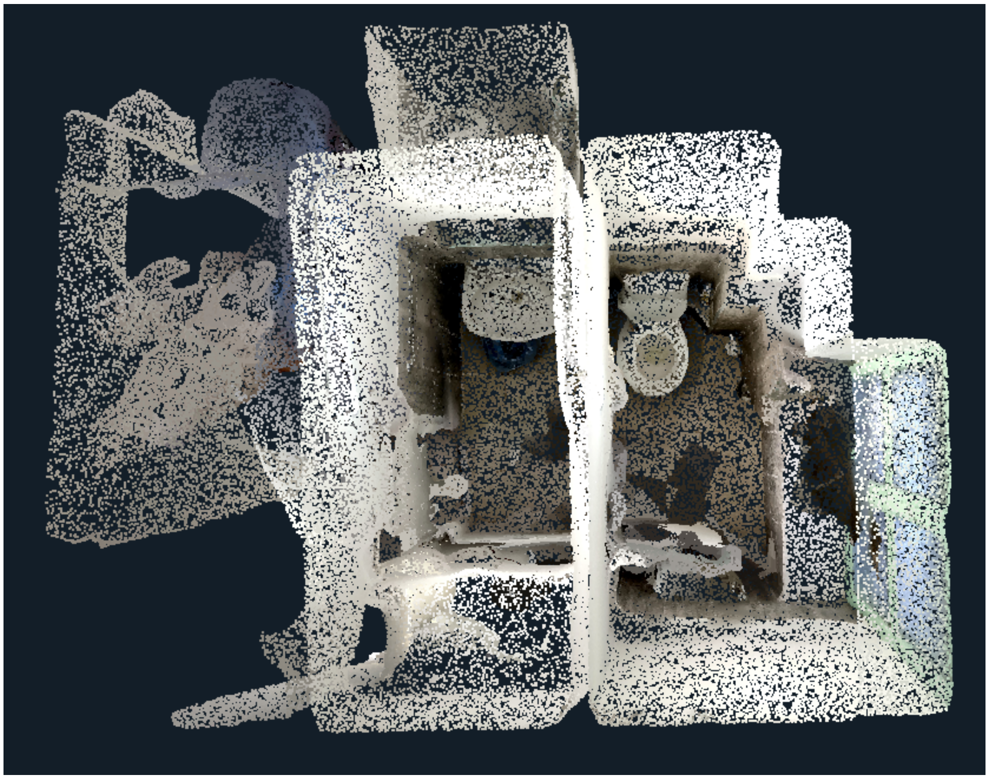


Figure 9: Toilet top view

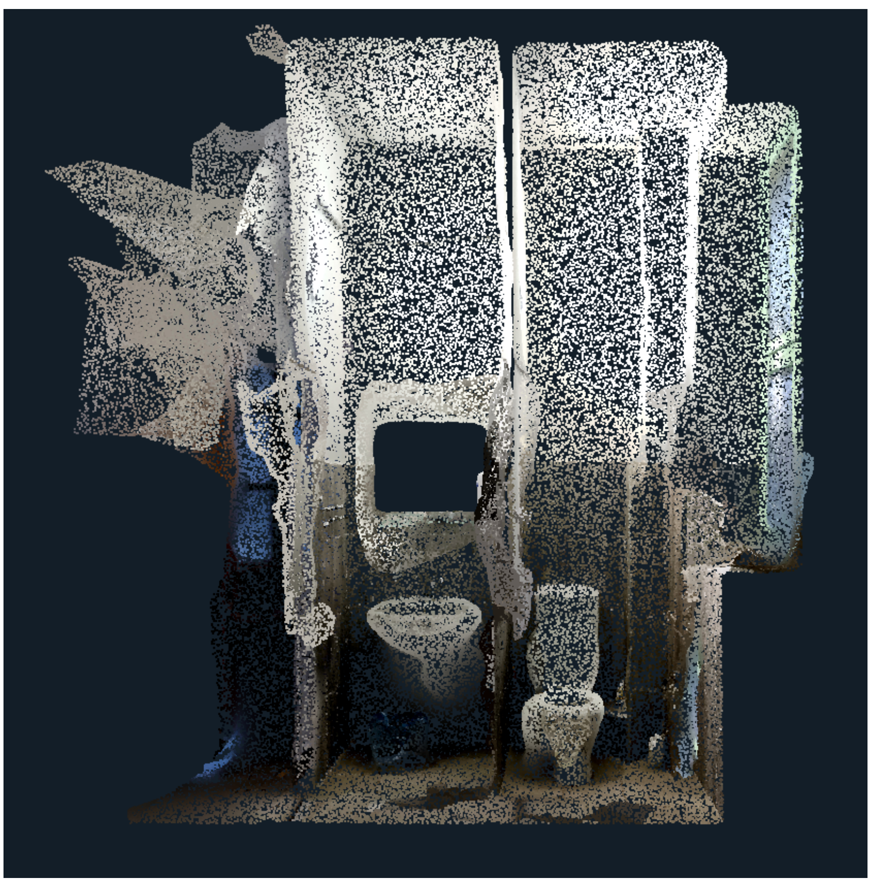


Figure 10: Section of the Toilet

6.1.1 Precision of data pertaining to geometric details

Looking at the previous images, you can observe the quality of the point cloud. The device is capable of assigning colors to the dots, making textures visible and allowing for the creation of textures on surfaces like flooring, doors, and other structures, which are clearly visible and recognizable.

What's even more important is that I compared the resulting point cloud with the existing plans provided to me by the department. Specifically, I compared the floor plan of the 3D printing room with the bathroom that was created in the 2021 survey plan drawings set to determine if any remodeling had occurred on the floor in the last 3 years. I identified a few minor differences, notably that the elevator room in that area had been removed. Apart from these minor variances, the LiDAR cloud did not yield any additional information.

In addition to these advantages, there are several noticeable flaws. The most prominent one is that some of the walls: “curve” are not parallel or perpendicular to each other. Consequently, certain areas of the floor overlap, such as restrooms and the staircase. One possible explanation for this is that during the survey, the GPS module of the equipment may have been partially obstructed.

Furthermore, the model does not perfectly align with reality because the mentioned 0.5-1-centimeter discrepancies can be found per meter. The completed point cloud is approximately 20 centimeters smaller in all dimensions than the actual building's size.

As previously explained, these sections clearly demonstrate that LiDAR technology has various advantages and disadvantages. While it may not be suitable for precise planning documentation, it can be valuable for verification surveys and interpreting specific parts of the building. The advantages and disadvantages are outlined in the table provided.

Table 2: Advantage and Disadvantage of LiDAR on iPhone

Advantage	Disadvantage
Quick data delivery	Limited visibility up to 5 meters
Recovery of colors and textures	Slight inaccuracy
Minimal plan verification	Curved walls

6.1.2 Comparisons difference between BIM model and point cloud

The process of Scan-to-BIM involves several key steps. It begins with thorough preparation, where project objectives and the scope are defined. The appropriate 3D scanning technology is selected, and the areas or structures to be scanned are identified. The actual data acquisition is the next step, during which 3D laser scanning of the physical site or structure is performed with a focus on data accuracy, completeness, and quality.

After data acquisition, the collected point cloud data is processed. This includes the registration and alignment of the scanned point clouds to create a unified 3D model. Data cleaning is carried out to remove noise, errors, or unwanted elements. The point cloud data is then converted into a format compatible with BIM software.

The next stage involves creating a 3D BIM model by importing the processed point cloud data into BIM software (e.g., Revit). The scanned data serves as a reference for the model's elements, such as walls, roofs, fixtures, and more. Information and metadata are added to these model elements for a comprehensive representation.

Validation and verification follow, where the Scan-to-BIM model is compared to the actual scanned data to ensure accuracy. Necessary adjustments and corrections are made to the BIM model to align it with the real-world conditions. Finally, the Scan-to-BIM model is integrated with existing BIM models for comprehensive facility management.

Scan vs. BIM Methodology:

The Scan vs. BIM comparison methodology is employed to verify the alignment between as-built conditions and as-designed BIM models. The process begins with the clear definition of the project's objectives, which could involve checking for design deviations or verifying construction quality.

Data acquisition is the next step, where 3D laser scanning or data collection is performed in accordance with the project scope. Data representing the as-built conditions of the site or structure is collected. A critical element in this process is obtaining the as-designed BIM model for the same site or structure, often provided by the design team.

Data alignment is the pivotal stage where the scanned data is aligned with the as-designed BIM model, ensuring proper registration and matching of corresponding elements. Following this, a detailed comparison is conducted, identifying discrepancies, deviations, or clashes between the scanned as-built data and the BIM model.

Reports are generated, documenting the discrepancies and deviations found during the Scan vs. BIM comparison. Visual representations and measurements are provided to highlight areas of concern.

Resolution and action follow, with collaboration among relevant stakeholders to address and resolve the identified issues. Necessary modifications, updates, or corrective actions are implemented in the project to rectify discrepancies.

A final verification stage may be conducted, involving rescanning or rechecking the corrected areas to ensure alignment with the as-built conditions. The Scan vs. BIM methodology ensures that the final project aligns with its design and meets the required standards and quality parameters.

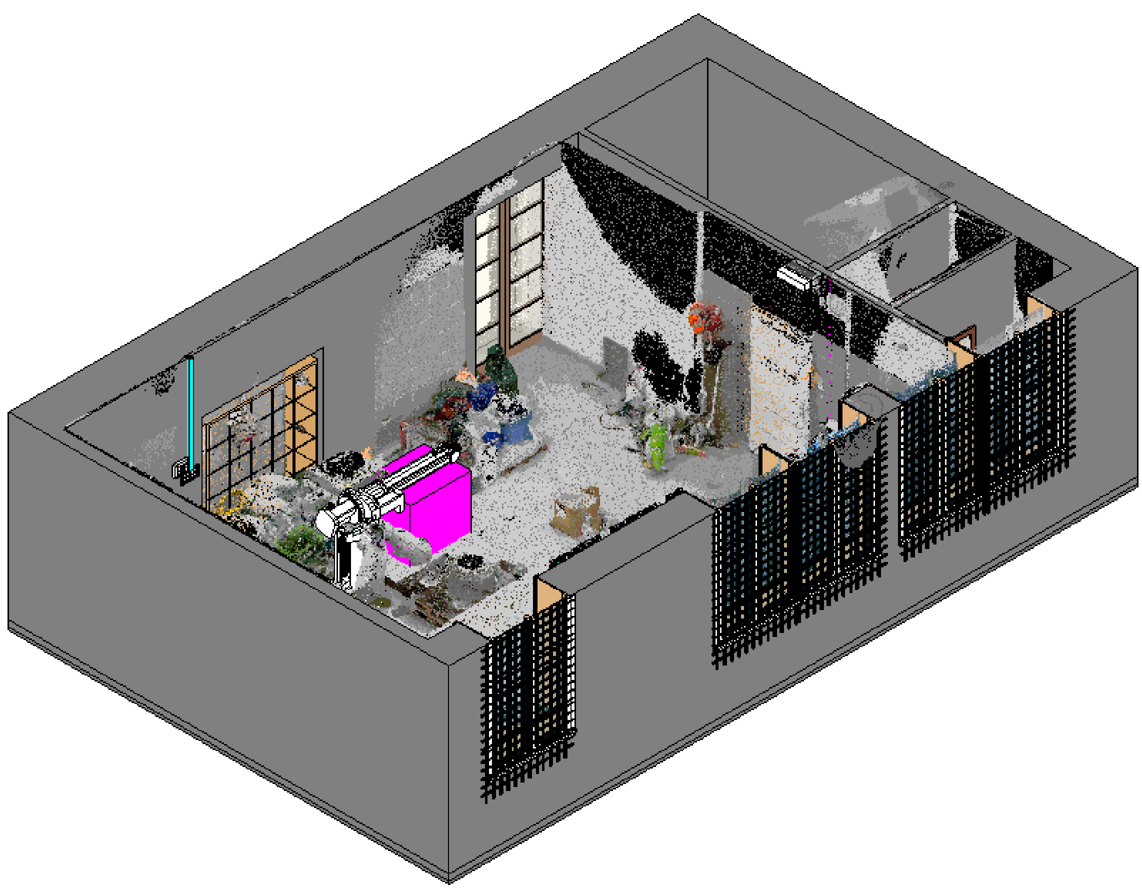


Figure 11: 3D view Register Point Cloud on BIM model

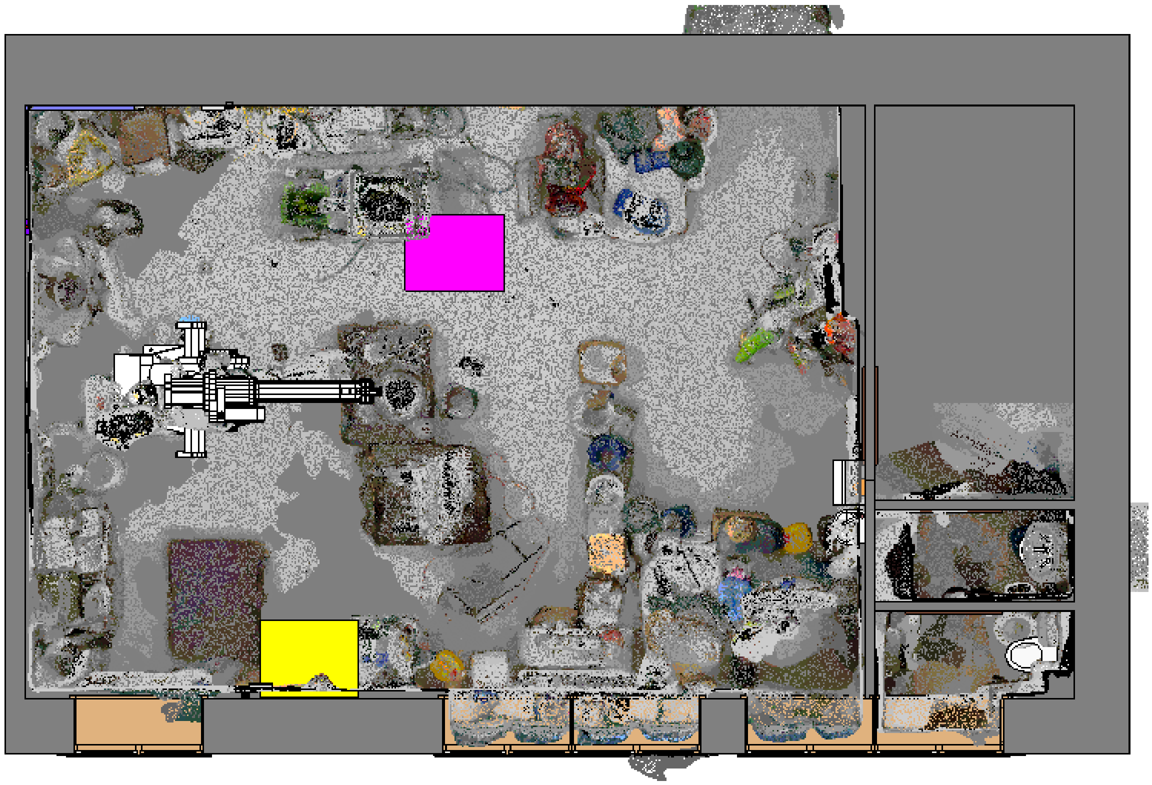


Figure 12: Top view Register Point Cloud on BIM model

Figure 13: Section A-A Register Point Cloud on BIM model

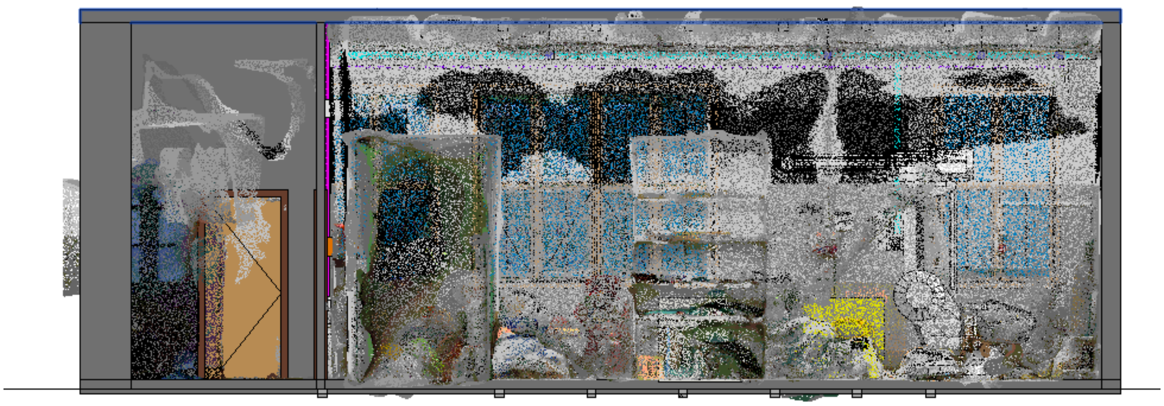


Figure 14: Another Section Register Point Cloud on BIM model

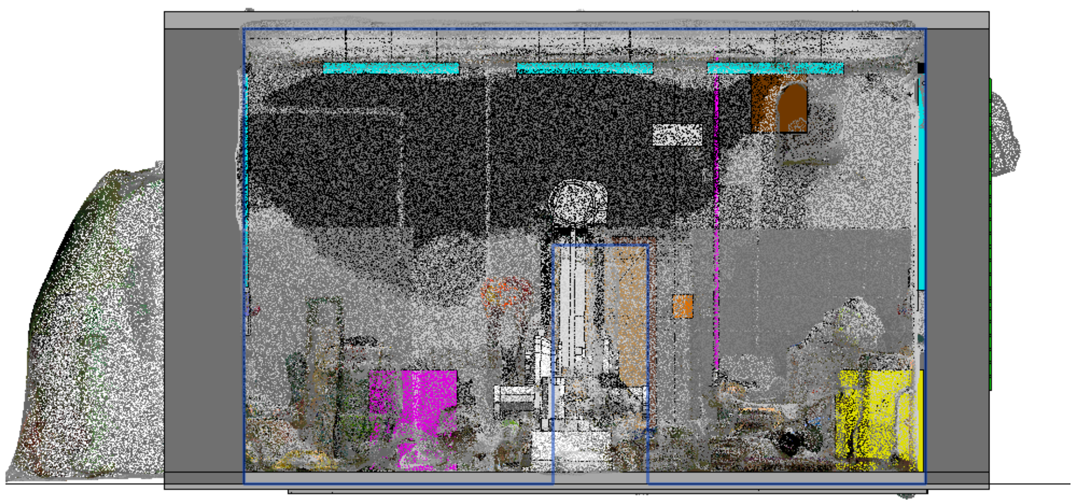


Figure 15: Section B-B Register Point Cloud on BIM model

BIM entails the creation and management of digital representations that capture both the physical and operational aspects of a building or infrastructure. It encompasses the use of 3D models, general data, and workflows to support various phases of a project, from design and construction to post-construction. The adoption of BIM on its own already leads to improved project efficiency, but this advantage can be further amplified when BIM is combined with emerging technologies like virtual reality to enhance design comprehension, laser scanning to acquire as-built data, or autonomous systems for automated monitoring. Nevertheless, the integration of BIM with other technologies remains a complex task due to challenges related to data transfer and interoperability. Therefore, this section aims to tackle the primary practical issues and offer solutions for the effective integration of BIM with other technologies, with a particular focus on point clouds.

6.2 Building a BIM model of the existing condition

I've already explained the concept of BIM, its evolution, and related terms in previous paragraphs. To create the model for the existing condition, I used the previous plans and survey results. For Modeling, I chose Autodesk Revit software family. This software has been developed for BIM processes right from the beginning.

I began the modeling process by creating a model space that included rasters and elevation data. I did this with the intention of being able to assign models to them, reducing the need for manual data and thereby minimizing the possibility of errors. Next, I generated the appropriate 3D objects, such as pillars, walls, ceilings, and opening, using these elements, I constructed the building model floor by floor, segment by segment. Obviously, there were details that had to be created layer by layer, such as the façade, after completing the model, I thoroughly reviewed it, search for errors, and architecturally corrected to the nodes. As a result, the model was created.

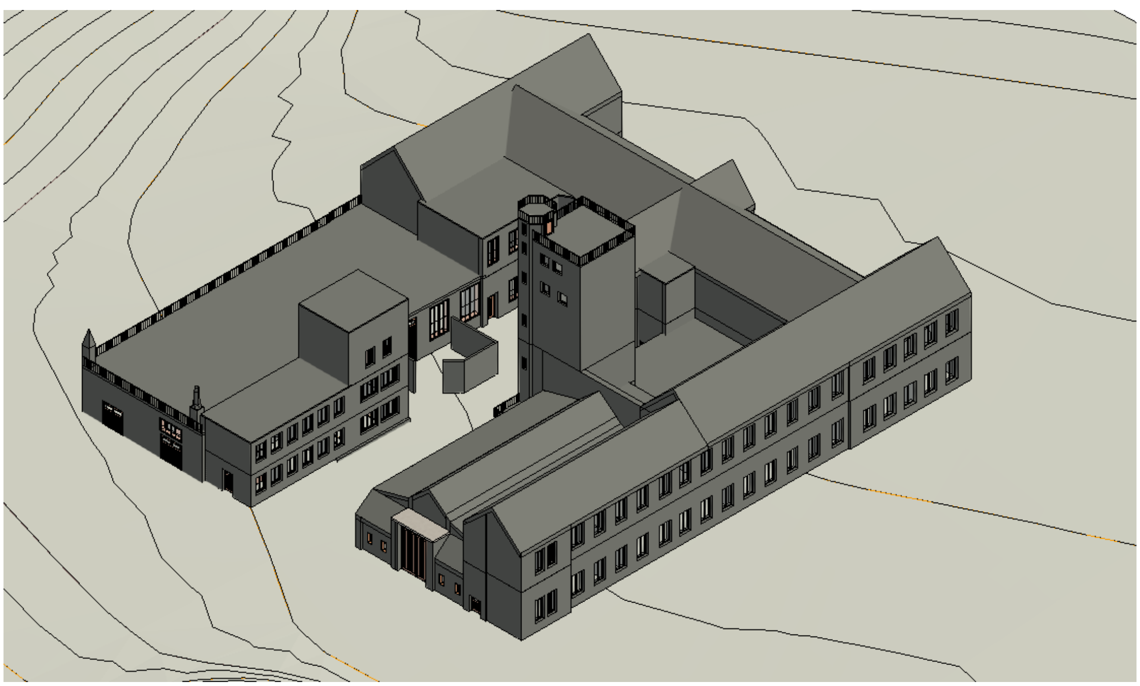


Figure 16: BIM model for existing condition (Building MM-MG)

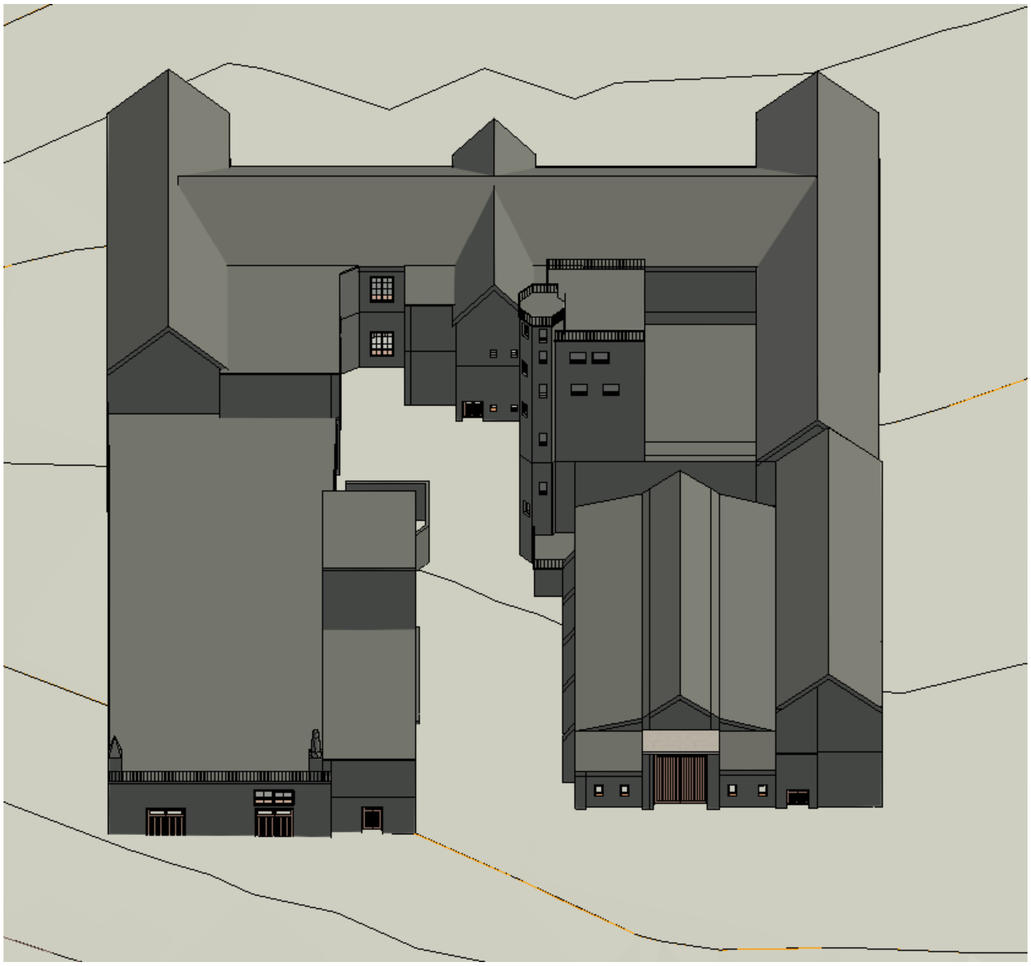


Figure 17: BIM model Building MM-MG – Top View

Video of Revit Model (Whole MM-MG Building)

https://youtu.be/InHwM8oR2f8

The plans generated from the model are far from perfect; they require post-processing work because it is software intended for the international market, so it cannot be expected to include the unique drafting (coding, material designation style), door, and other equipment labeling specific to each country in the format typically used in the domestic system.

6.2.1 Comparison of BIM model and existing plans

It is advisable to compare the BIM model that I created with the older plans. This can effectively illustrate that from the new 3D object-based design, the previous plans can be recovered and regenerated.

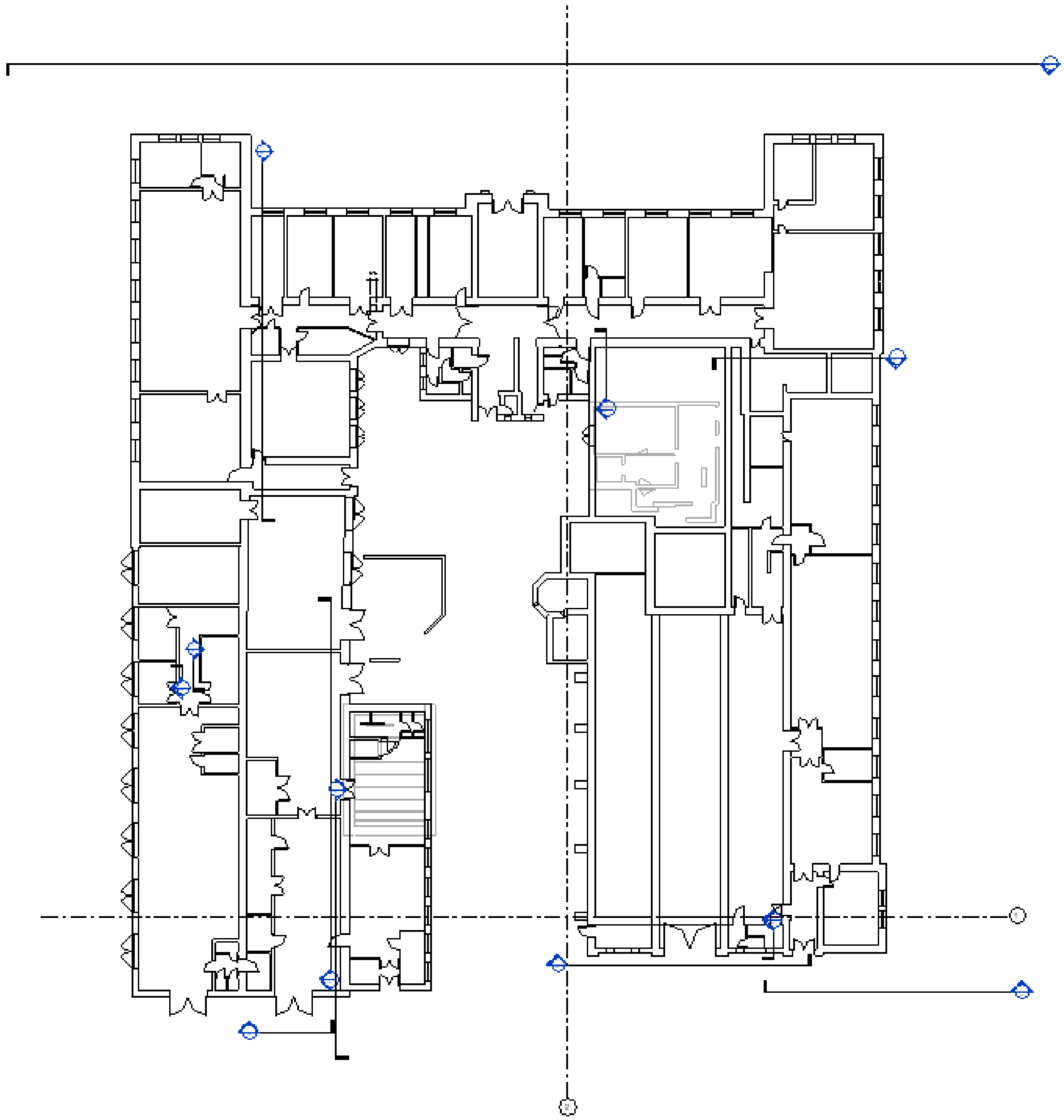


Figure 18: Floor Plan generate from BIM model (Revit)

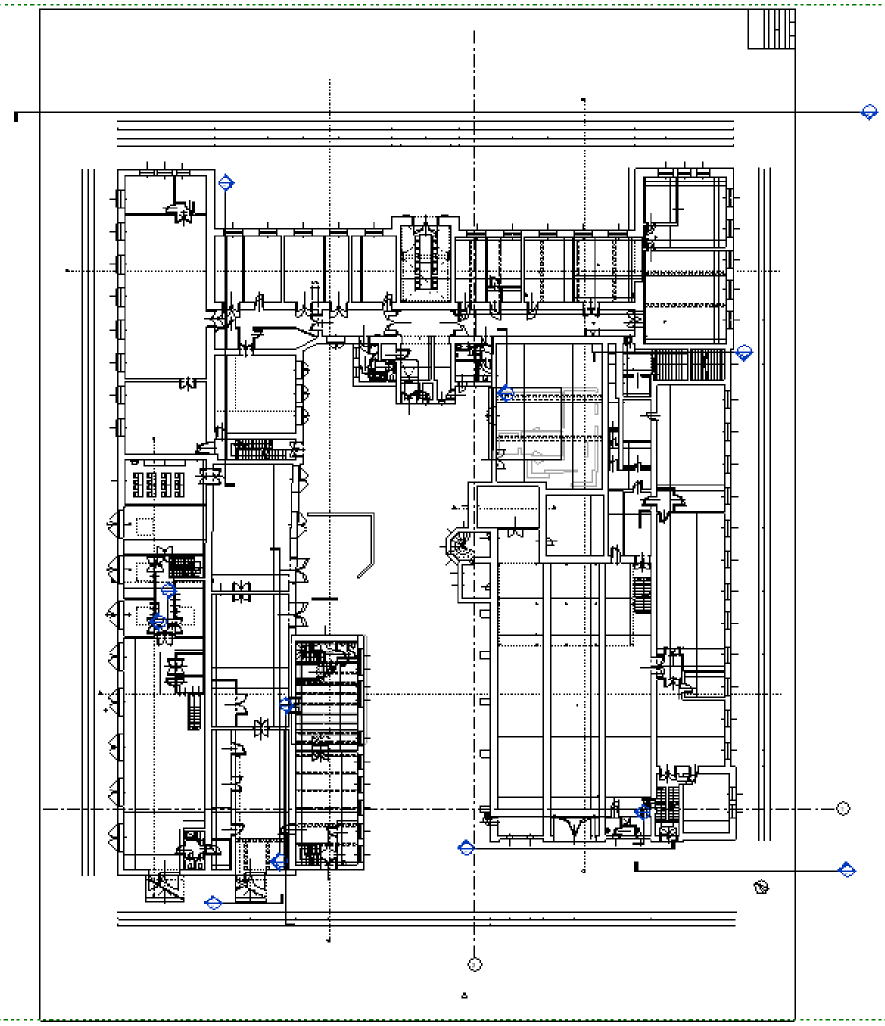


Figure 19: Comparison of floor plan PDF drawing 2021 and extracted floor plan from the BIM Model

The PDF illustrate well that plans extracted from a carefully prepared model closely match the previous ones. Of course, labels, codings, and layering are still missing, but these can be easily added. Furthermore, it is visible that colors and textures have been associated with the model elements, aided by the LiDAR point cloud, allowing for an expansion of the model in this regard compared to the older plans.

6.3 Space Utilization and Maintenance of the model

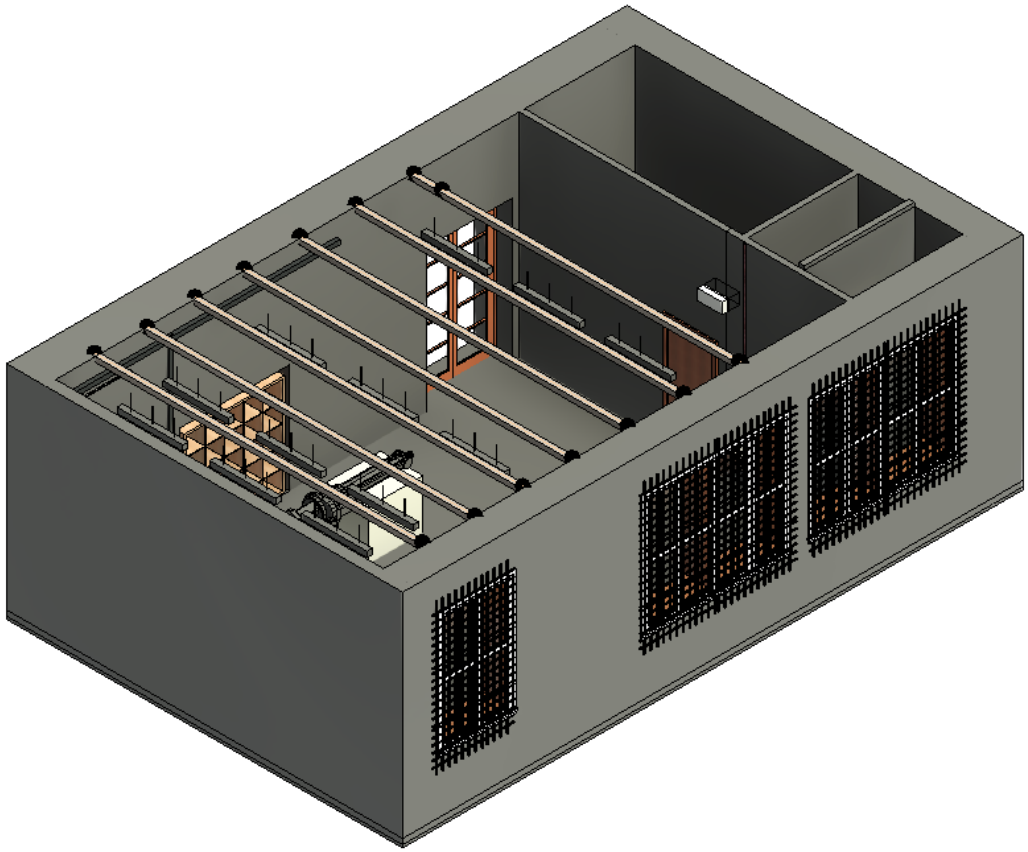


Figure 20: 3D view of the chosen room in the Revit

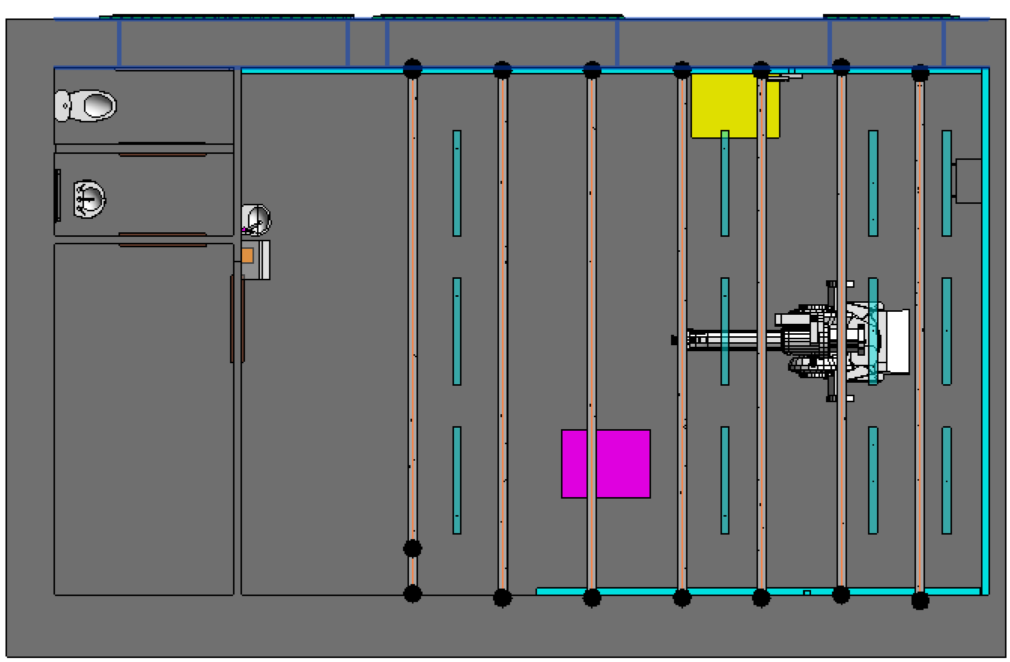


Figure 21: Top View of the chosen room in Revit

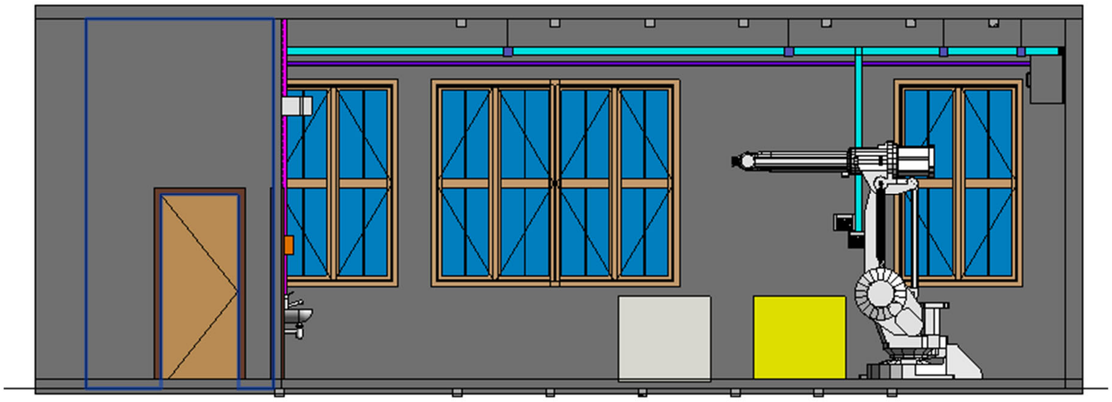


Figure 22: Section View of the chosen room in Revit

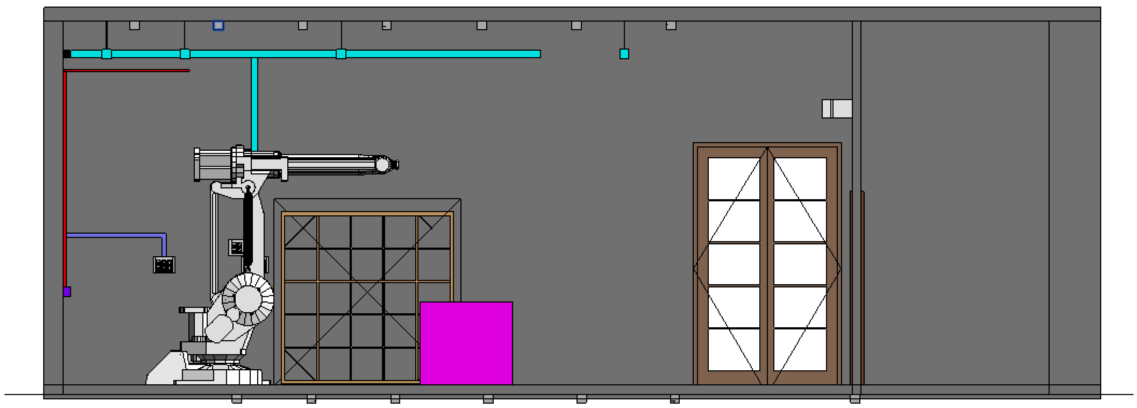


Figure 23: Another Section View of the chosen room in Revit

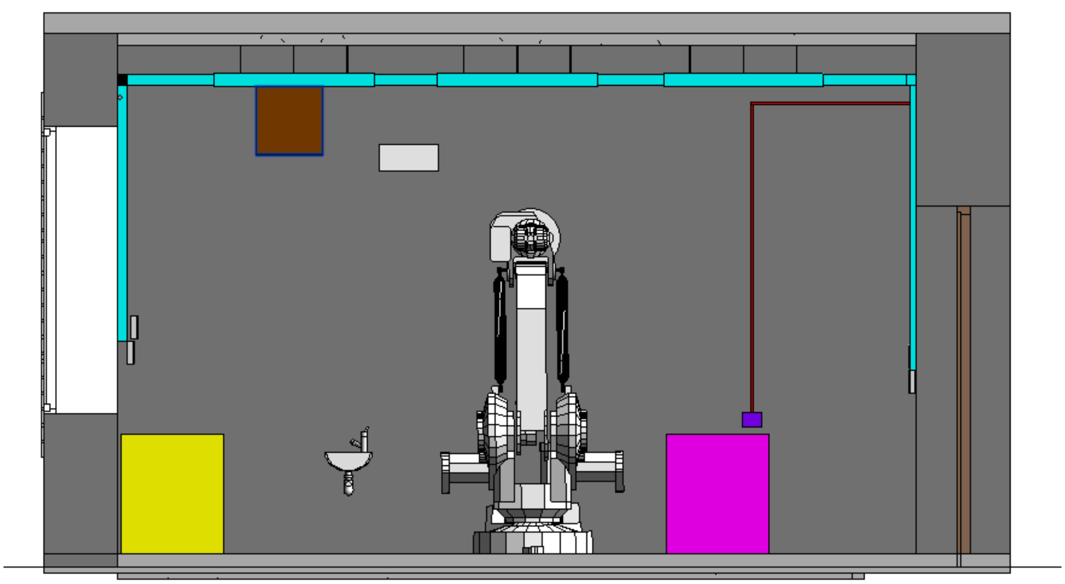


Figure 24: Front Section view of the chosen room Revit

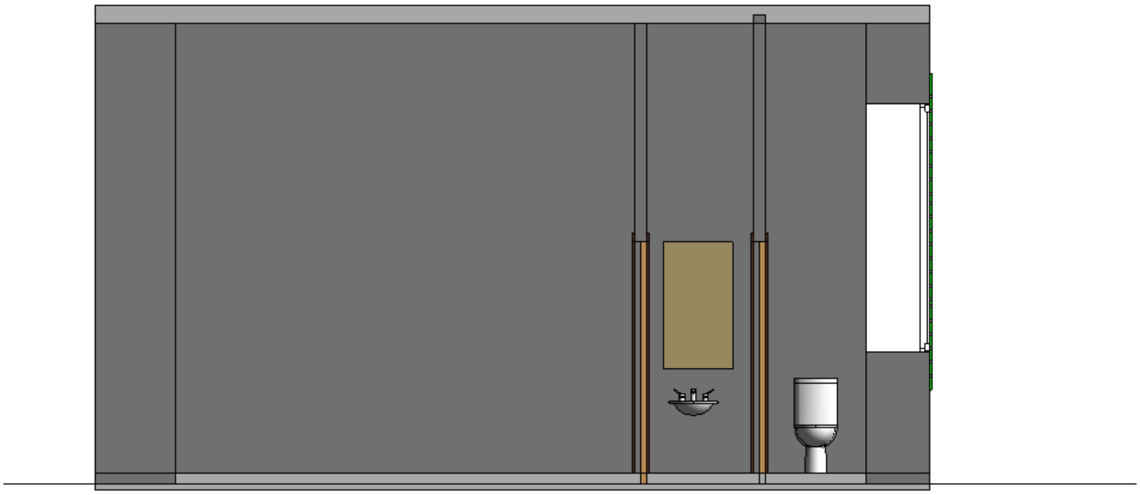


Figure 25: Section of the Toilet in Revit

I modeled the selected room, which is the 3D printing room with a toilet, with the help of the point cloud (polycam) and drawings provided by the Department.

Video of 3D printing room model in Revit

https://youtu.be/c9wNOLxuB3k

Creating a model of an existing building in Revit offers a multitude of advantages for professionals in the architecture, engineering, and construction industry, as well as for facility managers and preservationists. One of the primary benefits is the ability to generate precise and comprehensive as-built documentation, capturing the current state of the structure with remarkable accuracy. This documentation forms the foundation for efficient renovation and retrofit planning, as the 3D model enables stakeholders to visualize proposed changes and assess their impact on the existing structure before actual construction begins. Additionally, Revit facilitates the seamless coordination of new and existing building elements, ensuring a harmonious integration of components. The software's capacity to integrate various data sources, including point cloud scans and existing CAD drawings, streamlines the modeling process and enhances data accuracy. This model is invaluable for cost estimation, allowing for accurate budget planning and cost control. It also supports space management, aiding in the assessment of space utilization and facilitating planning for reconfigurations. Moreover, the model serves as a crucial asset for maintenance and facility management, as it offers a comprehensive understanding of building systems and components. It can be used for energy analysis, helping identify opportunities for energy efficiency improvements. In historical preservation efforts, Revit models document architectural details, contributing to the preservation of heritage buildings. Lastly, the model is a valuable tool for assessing code compliance, supporting adaptive reuse projects, promoting collaboration among stakeholders, and aiding in effective visualization for decision-making and client presentations. In essence, modeling existing buildings in Revit is a versatile and powerful approach that enhances efficiency, accuracy, and collaboration in various aspects of building management, from renovation and retrofit to space utilization and energy analysis.

6.3.1 Space Utilization

Due to the numerous rooms in the building serving various functions, my supervisor opted to select the 3D printing room, which includes a bathroom, for further analysis. This room is situated on the ground floor in Building. The point cloud of the room can be seen in the figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Videos.

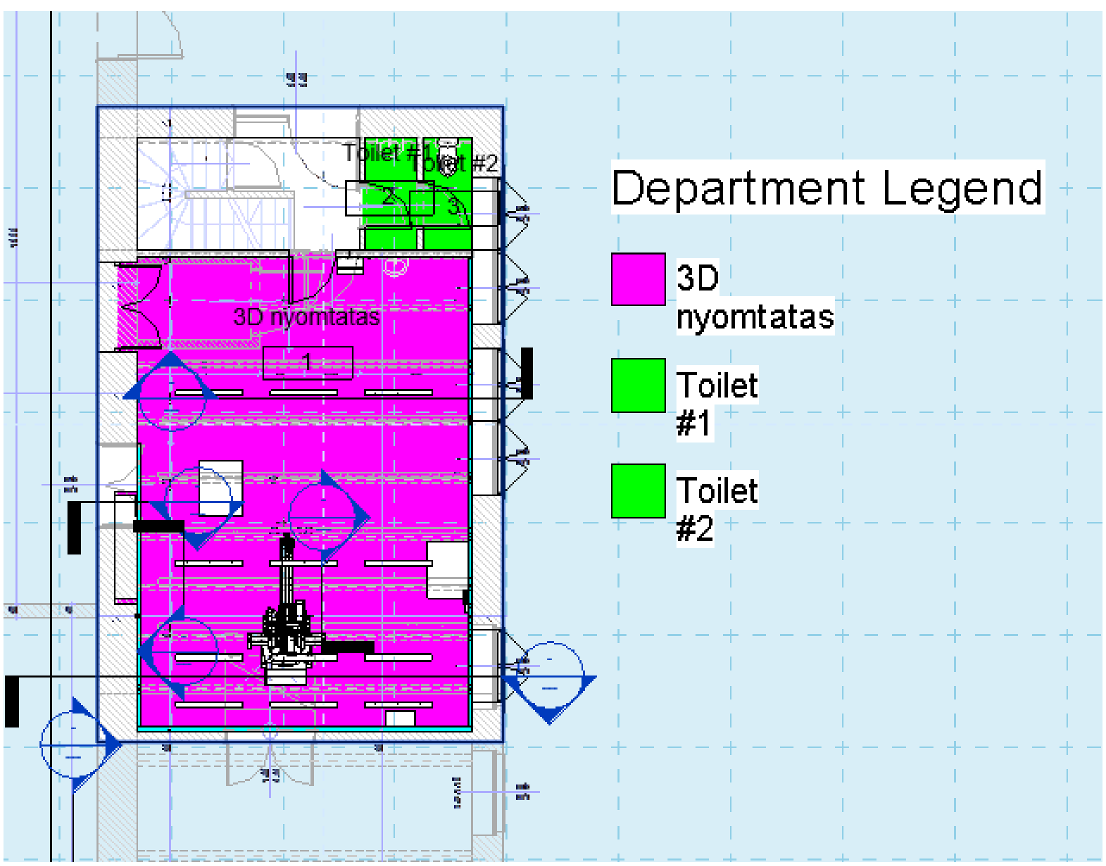


Figure 26: Department Legend

It's worth noting that the BIM model can provide information about the room's area along with other important attributes in the model, including its elevation, assigned space, room condition (heated/unheated), floor finishes, ceiling finish, number of windows and doors in that room.

Table 3: Space Utilization #1

<Space Utilization Summary>

A	B	C	D	E	F	G	H	I
Level	Number	Department	Name	Comments	Floor Finish	Ceiling Finish	Height	Area
F-02 CAD - 0 Floor	1	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	3D nyomtatas	HEATED	Concrete	Board and batten Ceiling	4000	50.79 m²
F-02 CAD - 0 Floor	2	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	Toilet #1	HEATED	Ceramic tiles	Board and batten Ceiling	4000	1.88 m²
F-02 CAD - 0 Floor	3	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	Toilet #2	HEATED	Ceramic tiles	Board and batten Ceiling	4000	1.78 m²
Grand total: 3								54.45 m²

Table 4: Space Utilization #2

<Space Utilization>

A	B	C	D	E	F	G	H	I	J
Level	Number	Department	Name	Comments	Floor Finish	Ceiling Finish	WINDOW	DOOR	Area
F-02 CAD - 0 Floor	1	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	3D nyomtatas	HEATED	Concrete	Board and batten Ceiling	4	1	51 m²
F-02 CAD - 0 Floor	2	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	Toilet #1	HEATED	Ceramic tiles	Board and batten Ceiling	0	1	2 m²
F-02 CAD - 0 Floor	3	ÉPÍTŐANYAGOK ÉS MAGASÉPÍTÉS TANSZÉK	Toilet #2	HEATED	Ceramic tiles	Board and batten Ceiling	1	1	2 m²
							5	3	54 m²

6.3.2 Maintenance purpose

To enhance facility efficiency, it is crucial to consider the room layout when reorganizing it with new equipment. This includes accounting for factors like window and door openings. Therefore, if the new equipment doesn't fit through the door, it may be necessary to transport it through the window. It's important to note that the window presents a challenge, as it only partially opens (as shown in the figure 16) and is obstructed by a steel bar. Should the need arise to move new equipment through the window, it will be necessary to remove both the steel bar and the window.[4][14]

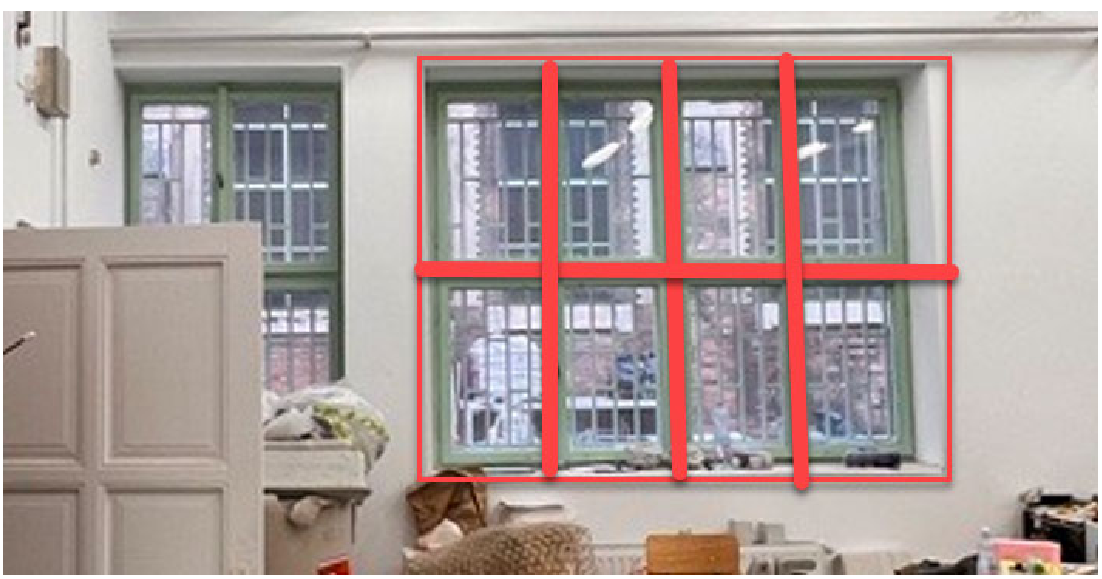


Figure 27: Reality window of the 3D printing room

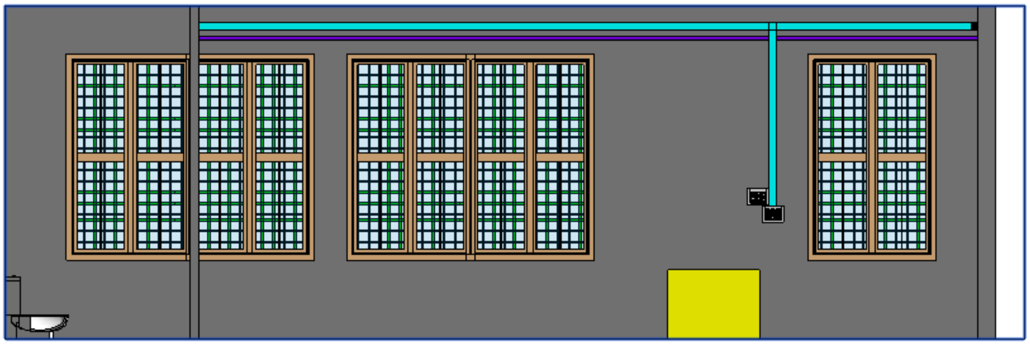


Figure 28: window from the BIM model

6.4 FM Data Requirements for As-Built BIM Models

6.4.1 Work Efficiency and Workflows

+The purpose of the As-Built Model:

The As-Built BIM model has three primary functions:

- It acts as the foundational data source for constructing the BIM FM Model.
- It serves as the official record for the building, making it a go-to resource for any repair or replacement needs for materials or equipment during the building's lifecycle.
- Certain sections of the model may also serve as crucial reference data for upcoming renovation and expansion projects.[27]

+Data requirements for Assets:

The document outlining the specific data requirements for each asset type. The following guidelines are recommended:

- Maintain consistent naming conventions for all facility information, encompassing file names and object attribute names. This ensures uniformity, scalability across software platforms, and precise reporting. Model and drawing file names should follow this format: production number - year - discipline designations.
- At a minimum, all assets should include manufacturer, description, model, and serial number information.
- Each asset should be accompanied by its relevant specification sheets, installation manuals, and O&M manuals in PDF format.
- Ensure that all assets are positioned with dimensional accuracy. Assets not directly associated with a room should be linked to the nearest room's area boundary.[4][9][21]

This is the way how to fill an asset of each element of chosen room. It is important to note that BIM model can stored information data in the model. Instead, the manual update, it is require creating duplicate of workload. Photographs and scanned elevations and sections from the original drawing sheets are used to verify specific details. [9][14][19]

This is lengthy task requiring the lots of technicians such as creation of geometric information and list of elements that store in the facility in separate folder which means the facilities and the model aren't linking each other.[19][20][23]

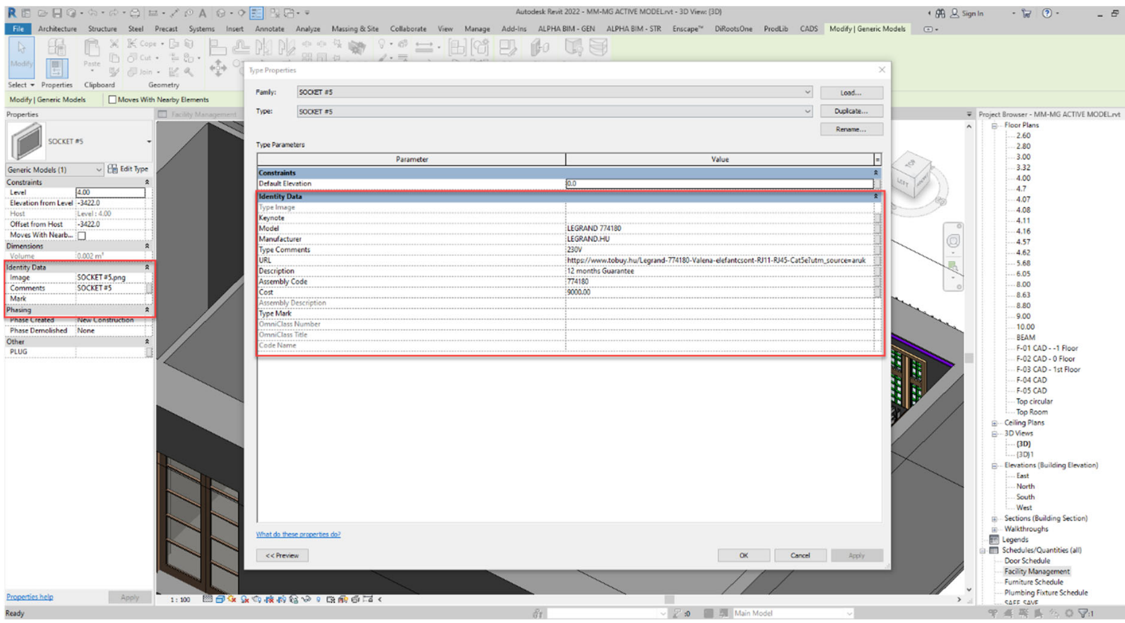


Figure 29: Filling Asset in the MM-MG Building BIM Model

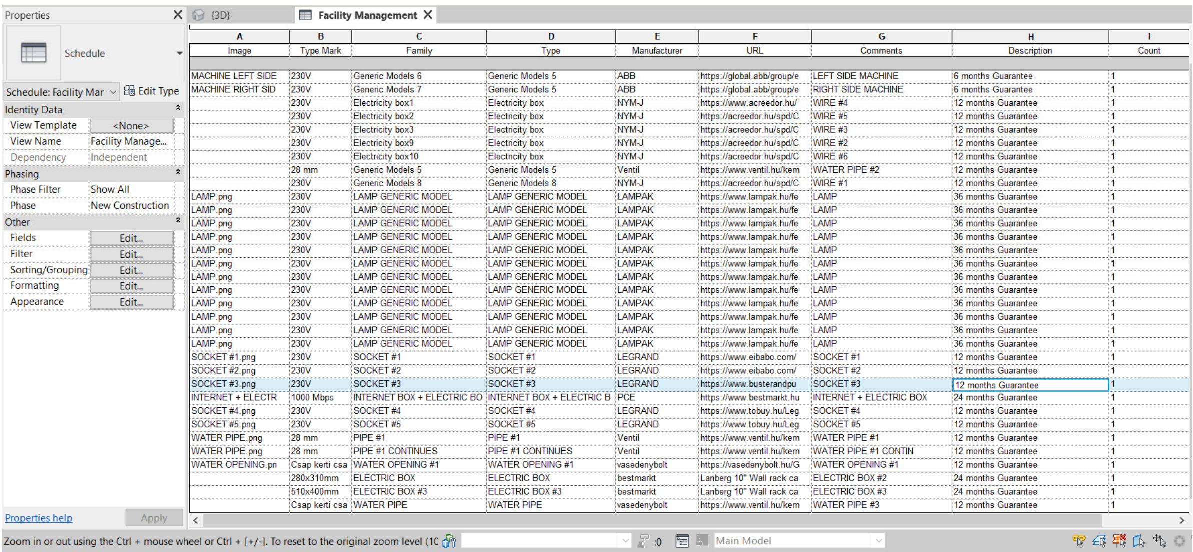
Using BIM for FM, the creation of geometric information and the inclusion of specific FM information allows automatic updating of the required schedules; producing instant sections, sections, elevations, three dimensional visuals and renders, and generating drawing sheets from a single integrated environment can be seen in Figure 11 and Figure 12.

This provided efficiency gains that have not been possible to achieve with current processes and technologies utilized by the FM team. It was estimated that this will reduce the need a full time CAD technician and provide cumulative savings from improved efficiencies in future work order over the years. [14][21][28]

Moreover, the estate department staff identified that BIM for FM models, with the augmentation of available BIM functionalities, can enhance key FM services such as room finding, fault reporting, development and refurbishment option generation, and assessment of building performance. Such services lead to reduction in response times, with detailed campus knowledge assigned to specific buildings, levels, rooms, etc. For example, with each request to replace a light bulb on the campus, the maintenance staff could check in real time the bulb type and manufacturer using the FM model before carrying out the task. Another example could be to check the paint colour code for a room where the wall finish has been damaged, thus saving staff time and material resources. [28][29]

All Assets of each element can be found [31][32][33][34][35][36][37][38][39][40][41][42][43]

Table 5: All Assets of each element in the 3D printing room



A Image	B Type Mark	C Family	D Type	E Manufacturer	F URL	G Comments	H Description	I Count
MACHINE LEFT SIDE	230V	Generic Models 6	Generic Models 5	ABB	https://global.abb/group/e	LEFT SIDE MACHINE	6 months Guarantee	1
MACHINE RIGHT SID	230V	Generic Models 7	Generic Models 5	ABB	https://global.abb/group/e	RIGHT SIDE MACHINE	6 months Guarantee	1
	230V	Electricity box1	Electricity box	NYM-J	https://www.acreedor.hu/	WIRE #4	12 months Guarantee	1
	230V	Electricity box2	Electricity box	NYM-J	https://acreedor.hu/spd/C	WIRE #5	12 months Guarantee	1
	230V	Electricity box3	Electricity box	NYM-J	https://acreedor.hu/spd/C	WIRE #3	12 months Guarantee	1
	230V	Electricity box9	Electricity box	NYM-J	https://acreedor.hu/spd/C	WIRE #2	12 months Guarantee	1
	230V	Electricity box10	Electricity box	NYM-J	https://acreedor.hu/spd/C	WIRE #6	12 months Guarantee	1
	28 mm	Generic Models 5	Generic Models 5	Ventil	https://www.ventil.hu/kem	WATER PIPE #2	12 months Guarantee	1
	230V	Generic Models 8	Generic Models 8	NYM-J	https://acreedor.hu/spd/C	WIRE #1	12 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
LAMP.png	230V	LAMP GENERIC MODEL	LAMP GENERIC MODEL	LAMPAK	https://www.lampak.hu/fe	LAMP	36 months Guarantee	1
SOCKET #1.png	230V	SOCKET #1	SOCKET #1	LEGRAND	https://www.eibabo.com/	SOCKET #1	12 months Guarantee	1
SOCKET #2.png	230V	SOCKET #2	SOCKET #2	LEGRAND	https://www.eibabo.com/	SOCKET #2	12 months Guarantee	1
SOCKET #3.png	230V	SOCKET #3	SOCKET #3	LEGRAND	https://www.busterandpu	SOCKET #3	12 months Guarantee	1
INTERNET + ELECTR	1000 Mbps	INTERNET BOX + ELECTRIC BO	INTERNET BOX + ELECTRIC B	PCE	https://www.bestmarkt.hu	INTERNET + ELECTRIC BOX	24 months Guarantee	1
SOCKET #4.png	230V	SOCKET #4	SOCKET #4	LEGRAND	https://www.tobuy.hu/Leg	SOCKET #4	12 months Guarantee	1
SOCKET #5.png	230V	SOCKET #5	SOCKET #5	LEGRAND	https://www.tobuy.hu/Leg	SOCKET #5	12 months Guarantee	1
WATER PIPE.png	28 mm	PIPE #1	PIPE #1	Ventil	https://www.ventil.hu/kem	WATER PIPE #1	12 months Guarantee	1
WATER PIPE.png	28 mm	PIPE #1 CONTINUES	PIPE #1 CONTINUES	Ventil	https://www.ventil.hu/kem	WATER PIPE #1 CONTIN	12 months Guarantee	1
WATER OPENING.pn	Csap kerti csa	WATER OPENING #1	WATER OPENING #1	vasedenybolt	https://vasedenybolt.hu/G	WATER OPENING #1	12 months Guarantee	1
	280x310mm	ELECTRIC BOX	ELECTRIC BOX	bestmarkt	Lanberg 10" Wall rack ca	ELECTRIC BOX #2	24 months Guarantee	1
	510x400mm	ELECTRIC BOX #3	ELECTRIC BOX #3	bestmarkt	Lanberg 10" Wall rack ca	ELECTRIC BOX #3	24 months Guarantee	1
	Csap kerti csa	WATER PIPE	WATER PIPE	vasedenybolt	https://www.ventil.hu/kem	WATER PIPE #3	12 months Guarantee	1

The developed BIMs for FM were used to trial option appraisal for redevelopment and refurbishment as phased plans, sections, elevations and 3D rendered views that could be quickly displayed and assessed. Such functionalities provide time and costs efficiency in future FM option appraisal and represent a platform for more accurate strategic decision making from a management perspective.

6.4.2 Cost Scheduling, lifecycle and Maintenance

6.4.2.1 Wall

Scheduling for walls is crucial in construction and project management for several reasons. It aids in effective time management, resource allocation, and budget control, ensuring that the project progresses according to the planned timeline and optimized resource usage. Additionally, wall scheduling helps in sequencing construction activities and coordinating work among various teams and subcontractors, reducing conflicts and rework. It also allows for a focus on quality assurance, meeting client expectations, and proactive risk management, while ensuring compliance with legal and regulatory requirements. Overall, scheduling for walls is a fundamental component of construction project management, guaranteeing that the project adheres to timelines, budgets, and quality and safety standards.[28][29]

Table 6: Schedule Amount of Cost in case of Renovation

<Wall Schedule>

A	B	C	D	E	F	G	H	I
Material Name	Comments	Length	Area	Base Constraint	Top Constraint	Cost (Forints)	Count	Cost per Area
Concrete Masonry	WALL	2345	6 m²	F-02 CAD - 0 Floor	Up to level: 4.00	15000.00	1	94866 m²
Concrete Masonry	WALL	2345	6 m²	F-02 CAD - 0 Floor	Up to level: 4.00	15000.00	1	94866 m²
94866 m²: 2		4690				30000.00		189732 m²
2345: 2		4690				30000.00		189732 m²
Concrete Masonry	WALL	2485	9 m²	F-02 CAD - 0 Floor	Up to level: 4.00	15000.00	1	132600 m²
132600 m²: 1		2485				15000.00		132600 m²
2485: 1		2485				15000.00		132600 m²
Brick, Common	WALL	6618	26 m²	F-02 CAD - 0 Floor	Up to level: 4.00	10000.00	1	261720 m²
261720 m²: 1		6618				10000.00		261720 m²
Brick, Common	WALL	6618	29 m²	F-02 CAD - 0 Floor	Up to level: 4.00	10000.00	1	289720 m²
289720 m²: 1		6618				10000.00		289720 m²
Concrete Masonry	WALL	6618	22 m²	F-02 CAD - 0 Floor	Up to level: 4.00	15000.00	1	333247 m²
333247 m²: 1		6618				15000.00		333247 m²
6618: 3		19854				35000.00		884687 m²
Brick, Common	WALL	10970	28 m²	F-02 CAD - 0 Floor	Up to level: 4.00	10000.00	1	284065 m²
284065 m²: 1		10970				10000.00		284065 m²
Brick, Common	WALL	10970	39 m²	F-02 CAD - 0 Floor	Up to level: 4.00	20000.00	1	777985 m²
777985 m²: 1		10970				20000.00		777985 m²
10970: 2		21941				30000.00		1062050 m²

+Amount of Painting Area

According to Pratiker, the cost of paint 700 ft/ Liter. [30]

Table 7: Table of Amount of Paint needed

<Paint Wall Schedule>

A	B	C	D	E	F	G	H	I	J
Material Name	Comments	Length	Area	Base Constraint	Top Constraint	Count	Area of Paint	Quantity of Paint (L)	Cost of Paint (Forints)
Concrete Masonry	WALL	2345	6 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	9 m²	0.12	83.782697
Concrete Masonry	WALL	2345	6 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	9 m²	0.12	83.782697
2345: 2		4690					19 m²	0.24	167.565394
Concrete Masonry	WALL	2485	9 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	10 m²	0.17	117.108099
2485: 1		2485					10 m²	0.17	117.108099
Brick, Common	WALL	6618	26 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	26 m²	0.50	346.7141
Concrete Masonry	WALL	6618	22 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	26 m²	0.42	294.312289
Brick, Common	WALL	6618	29 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	26 m²	0.55	383.8071
6618: 3		19854					79 m²	1.46	1024.833488
Brick, Common	WALL	10970	39 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	44 m²	0.74	515.318054
Brick, Common	WALL	10970	28 m²	F-02 CAD - 0 Floor	Up to level: 4.00	1	44 m²	0.54	376.314686
10970: 2		21941					88 m²	1.27	891.632741

6.4.2.2 Internal Assets in the room (Wire, Pipe)

In these system categories, assets consist of equipment such as air handling units, chillers, and pumps. Maintenance technicians are responsible for carrying out both scheduled preventive maintenance and corrective maintenance when components experience malfunctions. During the maintenance process, various details are gathered for each asset, including its maintenance history, warranty status, and the potential need for asset replacement if it exceeds its expected lifespan.[4][19][28][29]

Not all equipment possesses moving components or necessitates regular maintenance, but it may still require information beyond its physical location. For instance, an electrical disconnect safeguarded by fuses for over-current protection might only demand attention when a fuse malfunctions. Immediate access to details like the fuse type and size for that disconnect, as well as the equipment it safeguards, can not only save time but also potentially reduce costs. Another instance of non-moving equipment could be a ball valve used for shutting off domestic water to a building section. This type of equipment may not require maintenance, but it's crucial to record its location in a BIM for Facility Management model. To accurately classify equipment for maintenance and other purposes, Facility Managers need to comprehend the necessary data for populating the BIM, which can be used within an asset and maintenance solution. Various sources of information for equipment are available, such as manufacturer cut sheets, equipment submittal packages, recommended maintenance schedules, and nameplate data, among others, as detailed below.[4][29]

The asset descriptions, including manufacturer details, warranty information, installation date, expected lifespan, and estimated replacement cost, are based on approximate values derived from daily market prices. More specific information regarding market prices can be found. [30][31][32][33][34][35][36][37][38][39][40][41][42][43]

These assets are essential elements that contribute to the room's functionality, comfort, and overall performance. Internal assets can encompass a wide range of components

It enables them to assess spatial requirements, plan for efficient systems integration, ensure code compliance, and create a comprehensive representation of the room. Revit's capabilities allow for the detailed modeling and management of these internal assets, contributing to the success of a building project from conception to completion. [44]

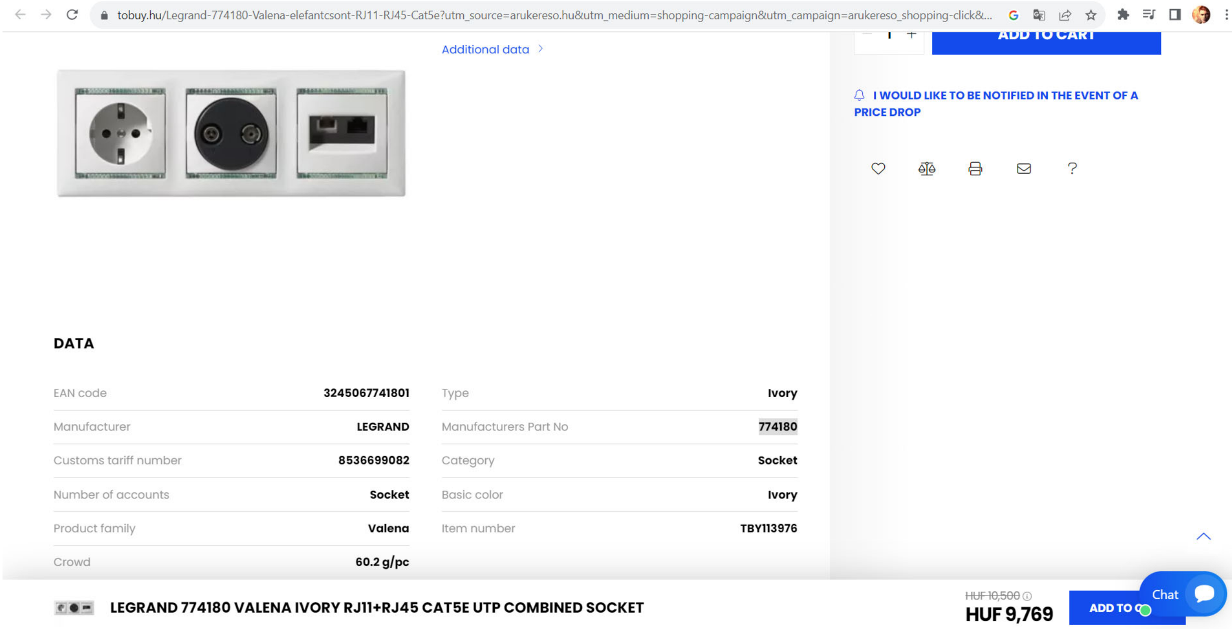


Figure 30: Asset data from daily market price [32]

Table 8: Life Cycle of the Assets in the Room

Family	Type Mark	Comments	Manufacturer	Description	Count	Installation Year	Life Cycle	Cost of Replacement (Forints)
Generic Models 6	230V	LEFT SIDE MACHINE	ABB	6 months Guarantee	1	2020	6 years	3000000
Generic Models 7	230V	RIGHT SIDE MACHINE	ABB	6 months Guarantee	1	2020	6 years	5000000
Electricity box1	230V	WIRE #4	NYM-J	12 months Guarantee	1	2015	10 years	50000
Electricity box2	230V	WIRE #5	NYM-J	12 months Guarantee	1	2015	10 years	50000
Electricity box3	230V	WIRE #3	NYM-J	12 months Guarantee	1	2015	10 years	50000
Electricity box9	230V	WIRE #2	NYM-J	12 months Guarantee	1	2015	10 years	30000
Electricity box10	230V	WIRE #6	NYM-J	12 months Guarantee	1	2015	10 years	30000
Generic Models 5	28 mm	WATER PIPE #2	Ventil	12 months Guarantee	1	2015	10 years	80000
Generic Models 8	230V	WIRE #1	NYM-J	12 months Guarantee	1	2015	10 years	30000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
LAMP GENERIC MODEL	230V	LAMP	LAMPAK	36 months Guarantee	1	2015	10 years	120000
SOCKET #1	230V	SOCKET #1	LEGRAND	12 months Guarantee	1	2014	12 years	60000
SOCKET #2	230V	SOCKET #2	LEGRAND	12 months Guarantee	1	2014	12 years	60000
SOCKET #3	230V	SOCKET #3	LEGRAND	12 months Guarantee	1	2014	12 years	60000
INTERNET BOX + ELECTRIC BO	1000 Mbps	INTERNET + ELECTRIC B	PCE	24 months Guarantee	1	2013	12 years	200000
SOCKET #4	230V	SOCKET #4	LEGRAND	12 months Guarantee	1	2014	12 years	60000
SOCKET #5	230V	SOCKET #5	LEGRAND	12 months Guarantee	1	2014	12 years	50000
PIPE #1	28 mm	WATER PIPE #1	Ventil	12 months Guarantee	1	2015	10 years	80000
PIPE #1 CONTINUES	28 mm	WATER PIPE #1 CONTIN	Ventil	12 months Guarantee	1	2015	10 years	80000
WATER OPENING #1	Csap kerti csap 3/4 k	WATER OPENING #1	vasedenybolt	12 months Guarantee	1	2015	13 years	40000
ELECTRIC BOX	280x310mm	ELECTRIC BOX #2	bestmarkt	24 months Guarantee	1	2013	12 years	100000
ELECTRIC BOX #3	510x400mm	ELECTRIC BOX #3	bestmarkt	24 months Guarantee	1	2014	12 years	100000
WATER PIPE	Csap kerti csap 3/4 k	WATER PIPE #3	vasedenybolt	12 months Guarantee	1	2015	10 years	50000
Grand total: 33								10700000

6.4.2.3 Plumbing Fixtures

Plumbing fixtures include sinks, toilets, faucets, showers, and other water-related components.

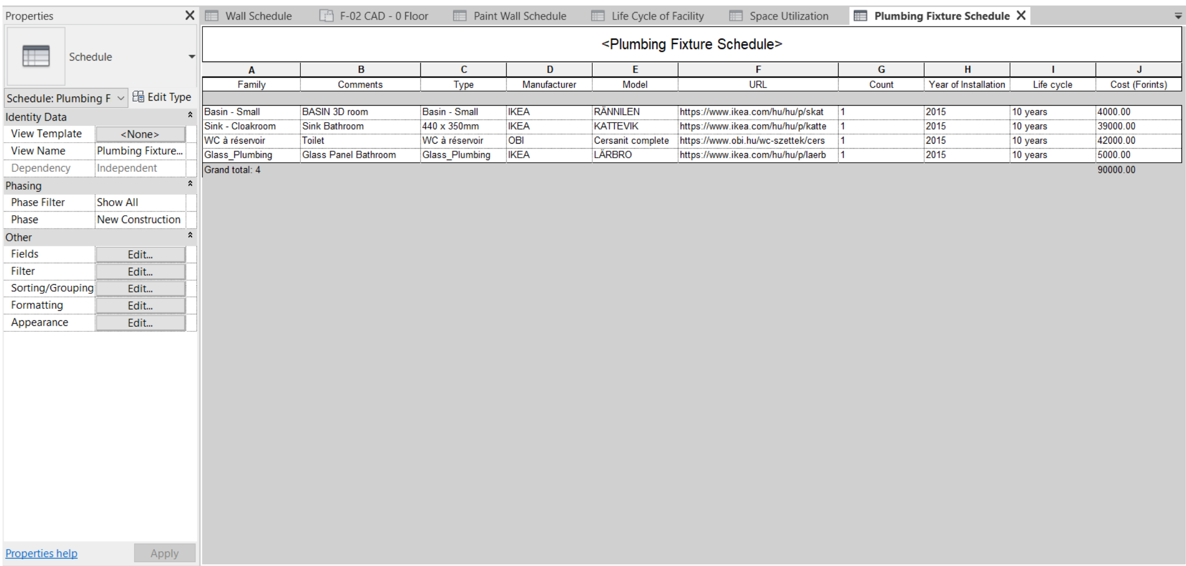
In a BIM model, plumbing fixtures are represented in 3D with accurate dimensions and specifications.

BIM allows for the integration of plumbing fixture data, including manufacturer details, product codes, installation requirements, and maintenance schedules.

Plumbing fixtures in BIM models help in spatial planning, ensuring proper placement and connections within the building's plumbing system.

They aid in clash detection, identifying conflicts between plumbing fixtures and other building elements.

Table 9: Plumbing Fixture



<Plumbing Fixture Schedule>

A	B	C	D	E	F	G	H	I	J
Family	Comments	Type	Manufacturer	Model	URL	Count	Year of Installation	Life cycle	Cost (Forints)
Basin - Small	BASIN 3D room	Basin - Small	IKEA	RÄNNILEN	https://www.ikea.com/hu/hu/p/skat	1	2015	10 years	4000.00
Sink - Cloakroom	Sink Bathroom	440 x 350mm	IKEA	KATTEVIK	https://www.ikea.com/hu/hu/p/katte	1	2015	10 years	39000.00
WC à réservoir	Toilet	WC à réservoir	OBI	Cersanit complete	https://www.obi.hu/wc-szettek/cers	1	2015	10 years	42000.00
Glass_Plumbing	Glass Panel Bathroom	Glass_Plumbing	IKEA	LÄRBRO	https://www.ikea.com/hu/hu/p/laerb	1	2015	10 years	5000.00
Grand total: 4									90000.00

6.5 Energy Analysis

Energy analysis in Building Information Modeling (BIM) refers to the process of using BIM data and models to assess and analyze the energy performance of a building. This analysis provides valuable insights into a building's energy consumption, efficiency, and sustainability. [44][45]

6.5.1 Energy modeling is a showcase of possibilities

Energy modeling within a Revit model is a versatile and powerful tool with a wide array of capabilities. It empowers users to conduct detailed analyses and simulations of a building's energy performance, providing invaluable insights for various stages, from design and construction to operational management. Key possibilities and advantages of energy modeling in a Revit model include assessing energy efficiency, optimizing design, evaluating environmental impact, ensuring code compliance, integrating renewable energy sources, analyzing daylight and natural ventilation effects, performing life cycle cost assessments, finetuning building operations, real-time energy monitoring, effective visualization and communication, simulating retrofit projects, and generating compliance documentation. In summary, energy modeling in a Revit model transcends basic energy calculations and serves as a comprehensive platform for scrutinizing, enhancing, and visualizing a building's energy performance, thereby advancing sustainability and well-informed decision-making across the building's lifecycle.

Before starting the simulation, I had to set the energy parameters for the building. The building's purpose was defined as 'School or University.' When selecting the heating type, there was no option for district heating, only conventional central heating with a connected radiator system. Furthermore, in the indoor layout, I could specify for various units to consider room by room or indoor area by indoor area. I provided the building's ventilation rate using the value previously determined in Autodesk Revit Energetic.[45]

I set the material for the wall, door, and window in order to perform the analysis in Revit.

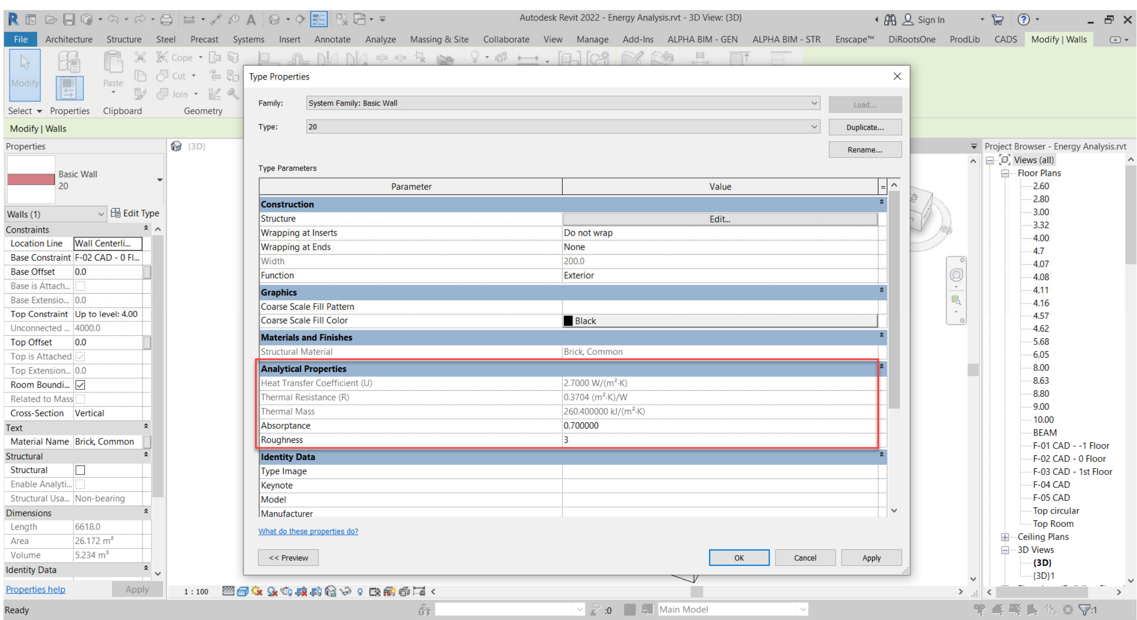


Figure 31: Basic Wall for the Energy analysis in the BIM software

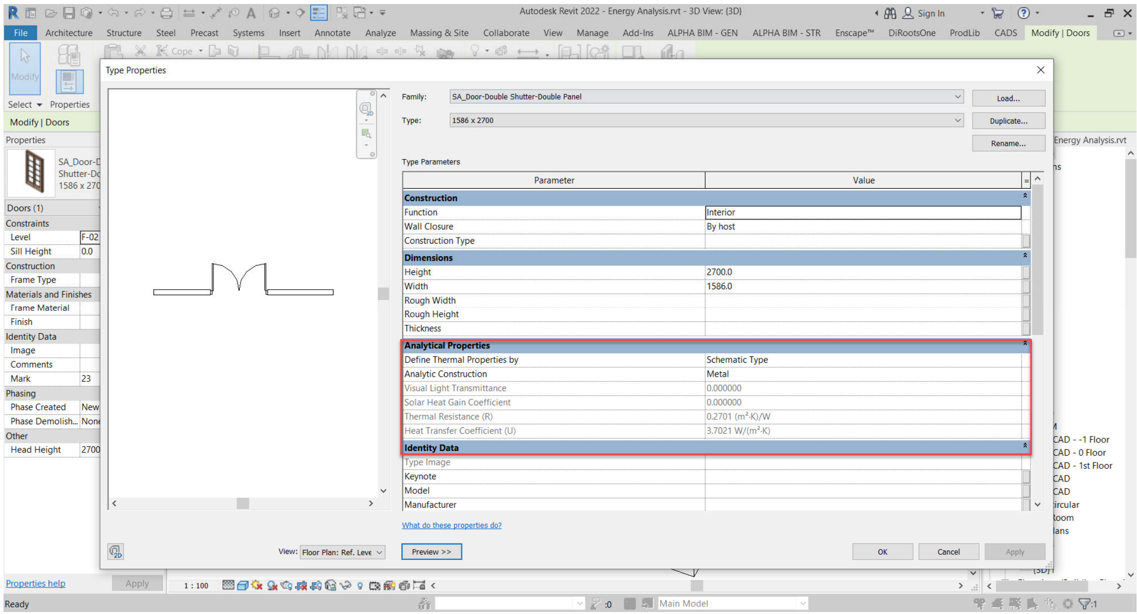


Figure 32: Door for the Energy analysis in the BIM software

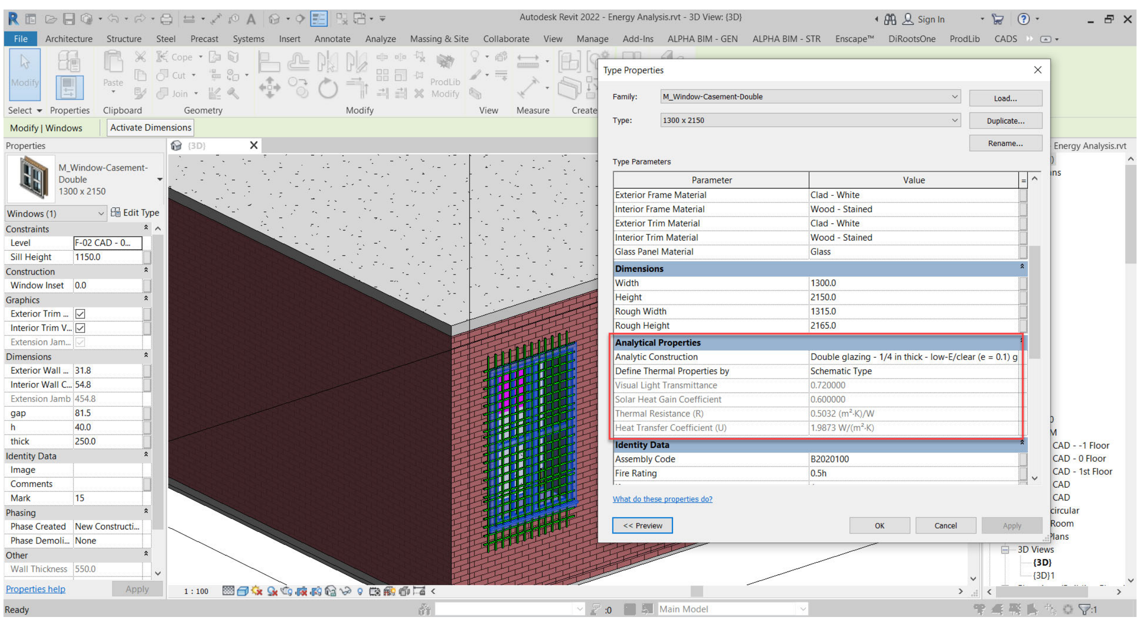


Figure 33: Window for the Energy Analysis in BIM software

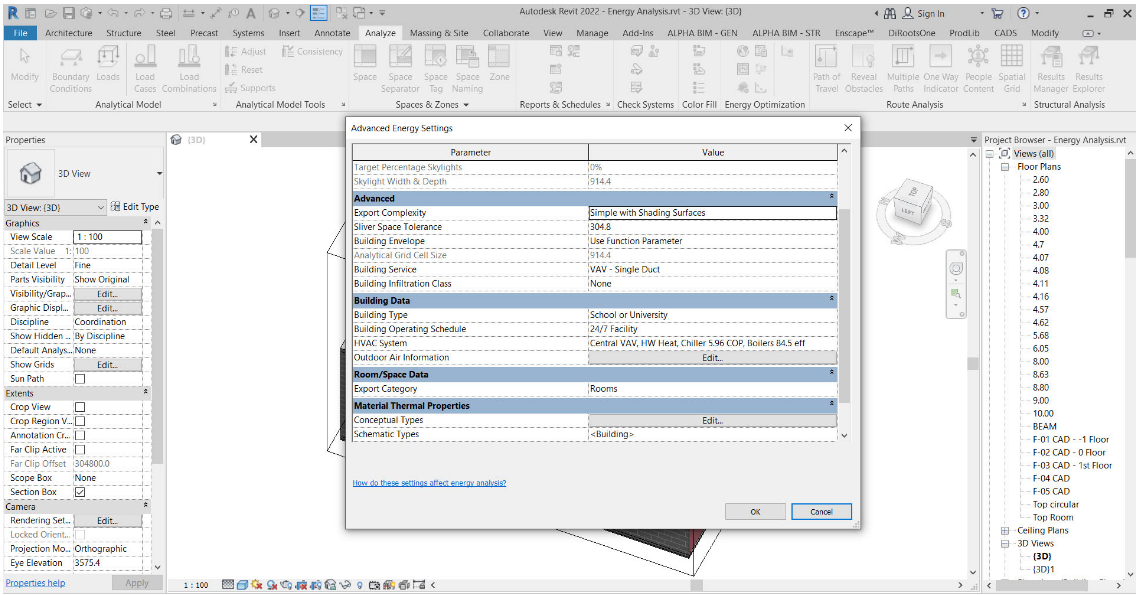


Figure 34: Model for the Energy analysis Setting

Following this, the software generated the building's analytical model. This model no longer includes any 3D objects; it only contains their background data, which can be exported to various analysis software.

I exported this analytical model to the software called Autodesk Insight360. This is a web-based energy analysis software, so it was sufficient to upload the model without the need for conversion to other file formats.

Once the upload was complete, I refined the settings on the Insight360 web interface, for example, specifying that the windows have double glazing without shading or reflective layers. I set the share of renewable energy to zero. Since I provided detailed operational data in Revit and the ratio of the building's openings was automatically calculated, I did not make any changes to these settings.

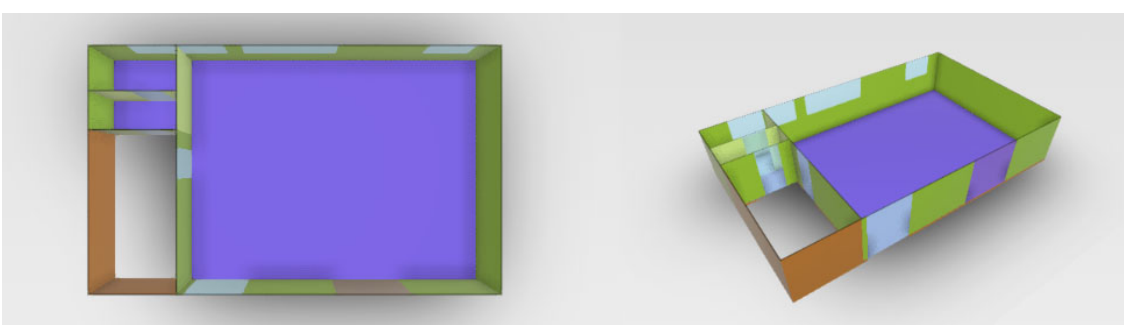


Figure 35: Analytical model of building in Insight360

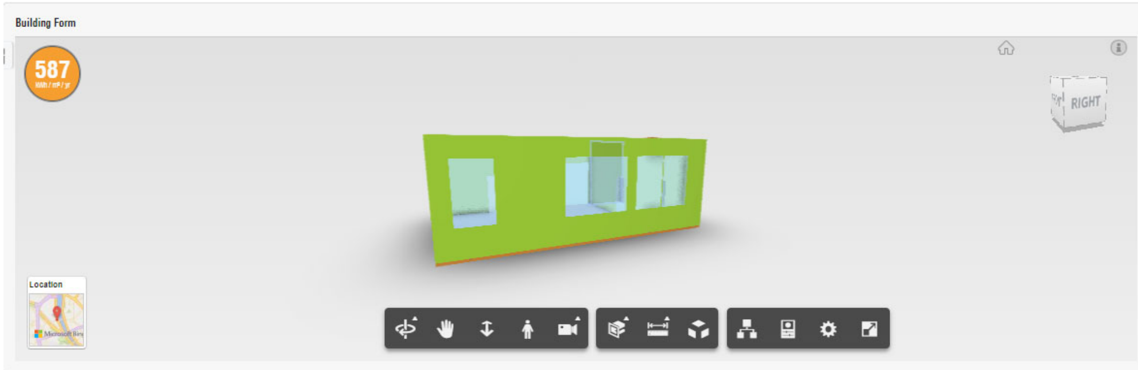


Figure 36: Benchmark comparison

It can be seen that there is a minimal variation between the result and that is 587 kWh/m^2. Energy analysis in Revit offers a holistic approach to designing energy-efficient buildings by integrating analysis tools with the design process. This can lead to better-informed decisions, cost savings, compliance with regulations, and a reduced environmental impact.

Figure 37: Utility of usage by Autodesk Insight

energy analysis tools provide a wide range of utilities, from energy performance assessment and design optimization to environmental impact estimation and real-time monitoring. These utilities empower design and engineering professionals to make informed decisions that enhance energy efficiency and sustainability in building projects.

Energy estimate by the BIM application

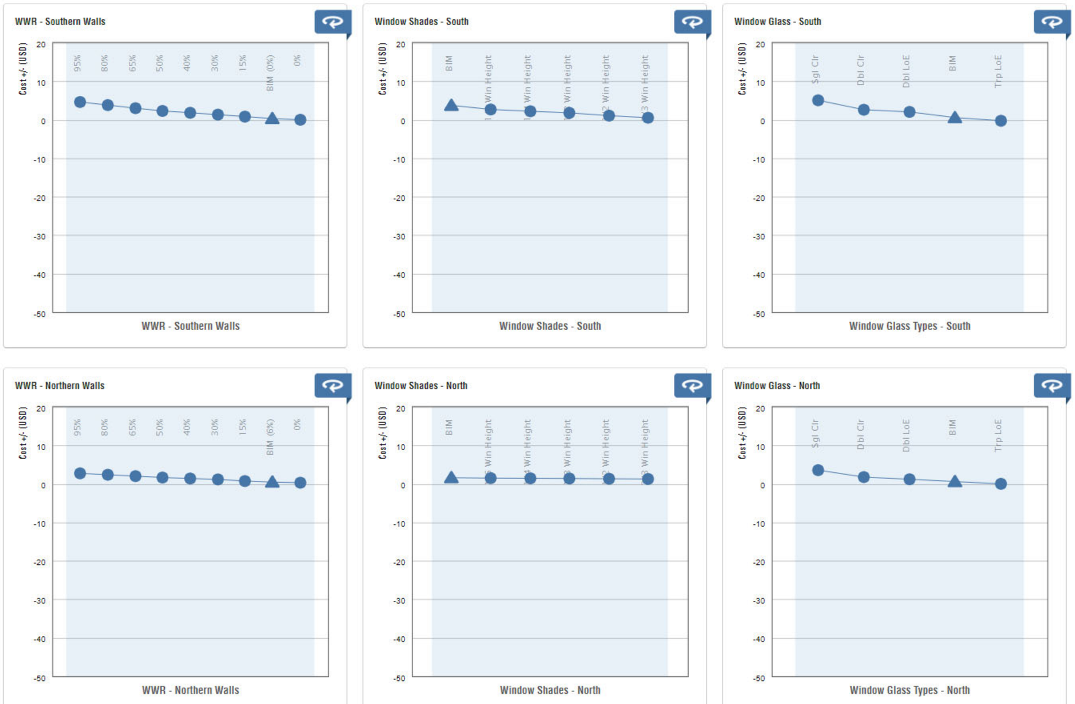


Figure 38: Window Data Set in Autodesk Insight

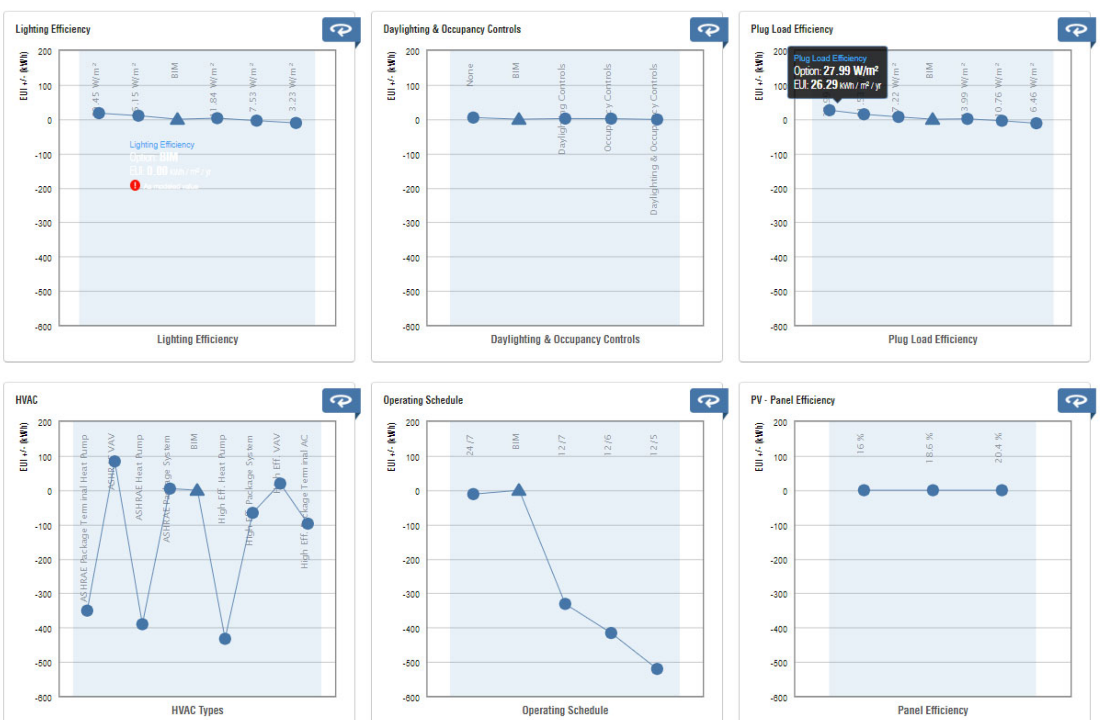


Figure 39: Operating schedule by Autodesk Insight

7 Discussion and conclusion

We are currently in the early stages of applying BIM throughout a building's entire lifecycle. The industry has much to discover, and it will require time for optimal practices to develop. However, the imperative to enhance the management of building lifecycles is evident. Ineffectively managed buildings result in resource and financial wastage, failing to reach their full potential. This detriment affects not only building owners but also occupants and society at large. There is room for improvement, and BIM stands as a vital technology for unlocking the complete potential of our constructed environment. By collaborating, we can commence realizing the pledges of Lifecycle BIM.

The results presented substantiated a consensus regarding the worth and potential of BIM in Facility Management (FM). This value primarily arises from:

- Enhancing existing manual information handover procedures.
- Enhancing the precision of Facility Management (FM) data.
- Boosting the efficiency of work order execution, including speed, data access, and intervention location. This value stems from BIM's capacity to offer a data-rich, integrated visual environment.
- Improving the accessibility of FM data contained within the model.
- Increasing efficiency in generating customized plans, elevations, and visual representations from a single model.
- Enabling the inclusion of legislative and statutory compliance data that can be generated and scheduled from a unified model.
- Exploring the potential for room identification and precise fault reporting through model analysis.
- Empowering scenario planning for renovation projects within a 3D environment.

However, there are obstacles impeding the effective utilization of BIM in Facility Management (FM). The primary challenges include:

- Absence of methodologies that substantiate the concrete advantages of BIM in FM, leading to a limited demand for BIM in FM from clients and operators.
- The necessity for stringent BIM specifications concerning modeling prerequisites.
- Issues related to interoperability between BIM and FM technologies and disparities in their lifespans.

- Limited awareness of the prerequisites for implementing BIM in FM, including what information needs to be provided, when, and by whom.
- A lack of open systems and standardized data libraries that could serve as a bridge between BIM and Computer-Aided Facility Management (CAFM) technologies.
- A proliferation of dissimilar operational systems managing the same building.
- A deficiency of well-defined roles, responsibilities, contractual frameworks, and liability structures.
- A shortage of BIM expertise within the FM industry.
- The industry's entrenched and inflexible cultural approach to adopting new processes and technologies.

The results from the case study demonstrated with practical examples how BIM can add benefits to the space utilization, maintenance purposes, work efficiencies, cost scheduling and the lifecycle of the Facility.

It is widely acknowledged that BIM gives a numerous advantage while the value of BIM in facility management (FM) is still waiting for clear demonstration. An effective BIM for FM should align with the specific needs of building owners. This implies that clients must comprehensively define their BIM requirements, specifying the required level of detail. The varying lifespans of technologies and buildings underscore the need for open-source standards to ensure the continued usability of models.

This thesis represents a significant contribution to the field, with its emphasis on the novel and cutting-edge aspects of Building Information Modeling (BIM)-based operations. The study underscores the innovative nature of the research conducted and its potential to address critical challenges in the construction and architectural industries. It is important to highlight that BIM-based operations are still not widely adopted, not only within our country but also globally, making this work particularly pertinent and forward-looking.

The novelty of this thesis lies in its exploration of BIM's practical applications, showcasing how it can revolutionize the way we plan, design, construct, and manage infrastructure and buildings. By presenting real-world examples and demonstrating the advantages of a BIM-based approach, this research lays the groundwork for the future of the construction industry. It goes beyond mere theoretical discussions to provide practical solutions that can be implemented across various sectors, both in our country and on a global scale.

While traditional construction methods remain prevalent, the potential for BIM to enhance efficiency, reduce costs, and improve project outcomes is evident. It is essential to recognize that the global construction and architectural community is in the early stages of recognizing the transformative power of BIM-based operations. The lack of widespread adoption in our country and around the world signifies a significant gap between the current industry practices and the innovations offered by BIM. This thesis addresses this gap by shedding light on the untapped potential and providing a roadmap for future development.

In conclusion, this thesis's novelty is a testament to its forward-thinking approach, exploring uncharted territories within the realm of BIM-based operations. As it challenges the status quo and paves the way for a more efficient, cost-effective, and sustainable construction industry, it stands as a beacon of innovation that has the potential to reshape the landscape not only in our country but also across the globe. By embracing BIM, we have the opportunity to propel the construction and architectural sectors into a new era of unprecedented success and productivity.

7.1 Future Research Direction and Initiatives

The usability of BIM for facility management is a transformative development for professionals. Its efficiency in data management, visual representation, integrated information, maintenance planning, energy efficiency, space management, cost analysis, collaboration, compliance management, and user experience improvement provides a comprehensive set of tools for effective facility management. The demonstrated possibilities of BIM-supported facility management applications are compelling reasons for professionals to embrace this technology, as it promises to enhance their ability to maintain and manage facilities more efficiently and effectively, leading to improved operational performance and cost savings.

It is valuable that BIM in facility management plays a significant role in both future construction planning and the management of existing buildings.

For example: It is exciting that MOL Campus, which stands as the tallest new building in Budapest, Hungary, also employs BIM in facility management for its operations.

MOL CAMPUS also started experiencing with using BIM-based Facility Management operations to analyze the possibilities and to implement real time sensor data of the buildings.

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