Modern Civil Engineering (ISSN 2470-4180)
June 2025, Volume 5, No. 4-6, pp. 60-67
Doi:10.15341/mce(2470-4180)/04-06.05.2025/002
Academic Star Publishing Company, 2025
www.academicstar.us

Application of BIM Methodology in Buildings Projects: Challenges and Limitations of Its Implementation

Wellington Vinícius da Silva
Polytechnic University IPS – ESTB, Portugal

Abstract: Building Information Modeling (BIM) has emerged as a transformative methodology in the Architecture, Engineering, and Construction (AEC) sector, offering significant benefits such as improved collaboration, cost optimization, and enhanced project quality. Despite these advantages, many professionals remain resistant to moving away from traditional design methods, often due to a lack of awareness and understanding of BIM tools and processes. Although some segments of the industry are beginning to adopt BIM standards, its implementation is still fragmented, with many teams underutilizing BIM-capable software. This results in isolated data and coordination challenges. To fully leverage BIM's potential, a cultural shift is needed one that embraces digital workflows, promotes ongoing training, and fosters integrated project development. Only through comprehensive adoption can the AEC industry meet the demands of increasingly complex and interconnected projects.

Key words: AEC, BIM, building information modeling, software, technology

1. Introduction

1.1 What is BIM?

Building Information Modeling (BIM) is a collaborative work processes and methodologies designed to create and manage data throughout the entire life cycle of a development project, including its ongoing maintenance.

At its core, BIM revolves around three key and interconnected elements: technology, people, and processes. As shown in Fig. 1, these components are closely linked, and their convergence gives rise to new terminologies and approaches that reflect the evolving nature of BIM practices.

In the context of Building Information Modeling (BIM), people represent a fundamental pillar. They bring experience, intuition, and the development of essential human skills to the table. When individuals operate within a well-structured and aligned organization, collaboration is enhanced, fostering an environment conducive to co-creation. Ultimately, it is people who make critical decisions, conduct analyses, and approve project proposals.

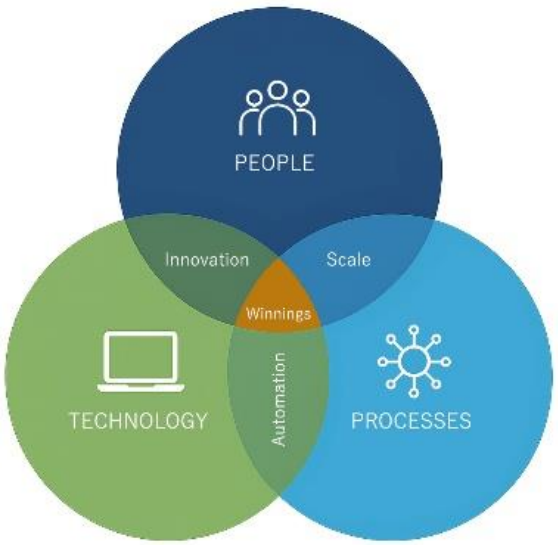

Fig. 1 Three pillars of the BIM methodology [1].

Corresponding author: Wellington Vinícius da Silva, Master in Civil Engineering and Master in Architecture; research areas: architecture, civil engineering. E-mail: silvawellington.eng@gmail.com.

Processes contribute by enhancing operational efficiency and enabling the reallocation of resources to strategic activities. The evolution of project development methods through BIM provides an opportunity to break away from the constraints of traditional systems, paving the way for more dynamic and responsive workflows.

Technology, meanwhile, has redefined the way design information is created and shared. The shift from paper-based drawings to digital environments has transformed communication and design practices. This technological shift not only facilitates the realization of ideas but also enables instant, global access to project data and intellectual content.

BIM's ability to store vast quantities of data presents both an advantage and a challenge. The true value lies in how this information is organized and utilized to streamline processes and make BIM methodologies more accessible and practical. The interplay between people and technology creates a fertile ground for innovation, encouraging creativity and supporting the development of transformative solutions.

From the intersection of BIM's core pillar people, processes, and technology three important sub-concepts emerge: innovation, scale, and automation.

- Innovation arises from the synergy between human insight and technological capability, enabling companies to remain competitive in an evolving industry;
- Scale is achieved through efficient processes and collaborative teamwork;
- Automation simplifies routine tasks, freeing up time and resources for higher-value activities.

Together, these elements drive substantial benefits across the project lifecycle, with positive impacts on both internal project teams and external stakeholders.

BIM tools facilitate close interdisciplinary collaboration by enabling the use of a shared, centralized database. This shared environment supports the development of comprehensive three-dimensional (3D) models that contain detailed information about each building component ranging from brands and materials to dimensions and performance metrics. These models allow stakeholders to visualize and analyze buildings in real time, long before construction begins [2].

By embracing advanced technologies and integrating BIM into their workflows, companies in the Architecture, Engineering, and Construction (AEC) sector can achieve new levels of efficiency and responsiveness, positioning themselves to meet the growing demands of the contemporary market.

2. BIM as a Catalyst for Multidisciplinary Collaboration in Construction

By embracing advanced technologies and effectively integrating Building Information Modeling (BIM) into their workflows, companies in the Architecture, Engineering, and Construction (AEC) sector can unlock higher levels of efficiency, agility, and coordination positioning themselves to better respond to the evolving demands of today's competitive and fast-paced market [3].

Building Information Modeling (BIM) has transformed the way construction projects are conceived, developed, and managed. One of its most significant contributions lies in fostering direct, real-time collaboration among all project stakeholders. In this context, collaboration means not only working together but actively contributing effective, integrated solutions toward a shared objective leveraging the unique expertise of each professional involved.

While cooperation entails joint effort toward a common goal by aligning individual contributions, collaboration in BIM goes a step further by unifying workflows and decision-making processes. This distinction is critical in today's increasingly interconnected and globalized construction environment, where multidisciplinary integration is both a necessity and a challenge.

To meet this challenge, information must be managed in a way that ensures clarity, accessibility, and consistency across all disciplines. Effective coordination between architecture and specialized areas such as structural engineering, HVAC, electrical systems, telecommunications, fire safety, gas distribution, water supply, and sewage remains a major hurdle in traditional workflows.

BIM addresses this complexity by providing a centralized, data-rich platform that supports accurate, real-time information exchange. It facilitates better decision-making and enhances coordination throughout all phases of the project, ensuring that the specific requirements and interdependencies of each discipline are efficiently managed.

In this way, BIM emerges as a powerful solution for overcoming the fragmentation of traditional project delivery methods supporting the phasing, integration, and execution of increasingly complex construction projects.

3. Impacts of BIM on the AEC Sector

To fully grasp the potential of Building Information Modeling (BIM), it is essential to understand how to operate the software tools that support this methodology. As a transformative technology in the construction sector, BIM stands out as a means of improving project quality, efficiency, and coordination. Despite its promise, significant challenges remain particularly regarding resistance to change and the absence of comprehensive, standardized regulations for its implementation.

Although BIM represents a fundamental shift in how projects are designed and managed, these ongoing challenges underscore the importance of refining, disseminating, and standardizing the methodology. Interoperability the ability for different software platforms to work seamlessly together remains a pressing issue, as does the global alignment of standards to ensure consistency and reliability in project execution.

At present, a notable degree of reluctance still exists within the industry to move away from traditional methods. Many design firms encounter barriers when attempting to fully coordinate all project information within a BIM-based framework. Additionally, the task of managing multidisciplinary teams under this new methodology presents operational and cultural hurdles that have yet to be fully resolved.

In this context, MacLeamy's Curve (2004), illustrated in Fig. 2, offers a compelling visualization of BIM's potential advantages for the AEC industry which includes four key curves: (1) A curve representing the impact of decisions on cost and functionality throughout the project lifecycle highlighting the importance of early planning; (2) A curve illustrating the cost of design changes, which increase significantly in later stages of a project; (3) A curve showing the traditional distribution of design effort over time, typically peaking during later phases; (4) A curve representing the BIM-based distribution of design effort, which emphasizes front-loaded planning and design activities.

These curves collectively demonstrate how BIM can shift the effort to earlier stages of the project, enabling better-informed decisions, reducing rework, and minimizing cost escalations as the project progresses.

The curve primarily illustrates that BIM emphasizes addressing project impacts in the early stages of development, thereby aiming to reduce costs and rework in later phases. The key benefits of BIM are closely tied to the enhancement of information quality throughout the project lifecycle, which in turn supports more informed and efficient decision-making at every stage [4].

While BIM-based projects typically demand greater effort in the early phases particularly due to the need for extensive data input and model development this front-loaded approach leads to significantly lower effort and risk when implementing changes later in the project, especially when compared to traditional CAD tools.

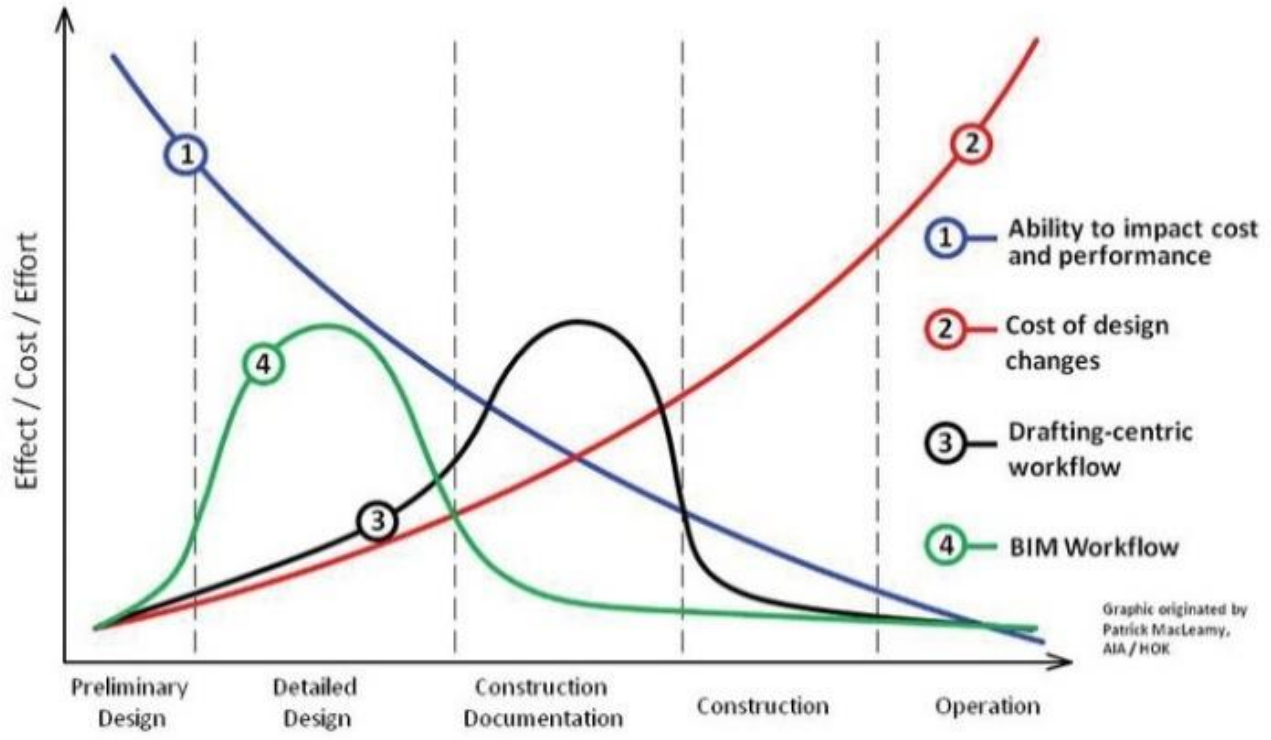

Fig. 2 The MacLeamy Curve [5].

Beyond the immediate financial advantages during design and construction, BIM introduces qualitative benefits that enhance the overall project workflow and stakeholder engagement. These include:

- Enhanced collaboration across multidisciplinary teams;
- Greater client involvement during the design phase, as 3D visualizations provide a clearer understanding of the final product;
- Advanced visualization and simulation tools, including performance analysis for energy efficiency and sustainability;
- Clash detection and conflict resolution, minimizing design discrepancies by integrating data from various disciplines and eliminating redundancies;
- Centralized data and document management, encompassing material specifications, quantities, costs, and performance data;
- Automated generation of technical documentation, such as floor plans, sections, and material schedules;
- Greater efficiency and sustainability, through accurate budgeting and resource optimization, helping reduce waste and unnecessary expenditures;
- Improved productivity and communication, leading to higher quality deliverables;
- Automated cost estimation and budgeting, streamlining project planning and procurement.

In the operational phase, BIM proves essential for Facilities Management (FM) a discipline focused on the efficient maintenance and administration of buildings and infrastructure. BIM supports FM by ensuring that all building data is prepared, organized, and accessible for long-term use.

Ensuring that data is properly structured and stored during design and construction phases is crucial for supporting lifecycle management. This includes

maintaining up-to-date documentation that reflects all modifications made during the building's lifespan.

The adoption of Building Information Modeling has significantly influenced how AEC projects are conceived and executed. By centralizing data in a single digital environment, BIM enhances communication and reduces traditional coordination challenges, fostering a more integrated approach among stakeholders.

Moreover, BIM is increasingly intersecting with emerging technologies such as Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), and the Internet of Things (IoT). This convergence empowers the AEC sector to design and manage smarter, more sustainable, and technologically advanced buildings, aligning with global innovation trends.

Projects already executed using BIM clearly demonstrate the methodology's ability to navigate complexity, improve interdisciplinary coordination, and optimize performance. As the industry continues to evolve, BIM remains a central force in shaping a more connected, innovative, and competitive construction landscape.

4. Implementing BIM Methodology

The BIM work methodology is grounded in the concept of the "Common Data Environment" (CDE), which serves as a centralized platform enabling real-time access to project information. The CDE connects all activities carried out during the project lifecycle, including modifications and edits made by different stakeholders. By continuously incorporating updates, it becomes a dynamic and reliable source of truth for all project participants. This evolving environment ensures consistency, transparency, and traceability of information, as illustrated in Fig. 3.

In the BIM workflow, each project stage follows a sequential and validated process, ensuring that the consistency and integrity of the digital model are maintained throughout development. Each step must undergo formal verification before progression to the next phase. Additionally, the workflow is characterized by interdependencies among stakeholders, requiring timely communication and resolution of discipline-specific issues before advancing. Once validated, all project data is stored in a centralized, constantly updated repository, reinforcing the model's role as a single source of truth.

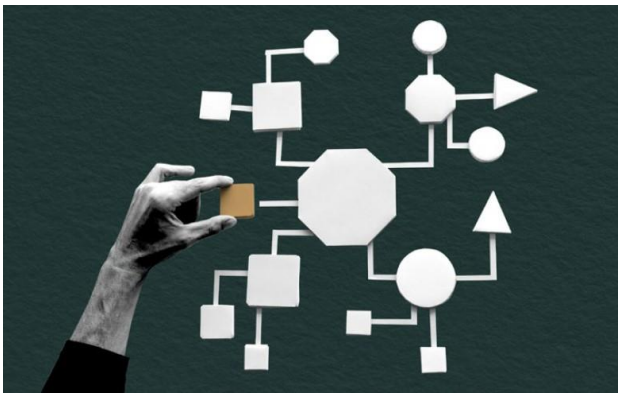

Fig. 3 Concept of common data environment (CDE) [6].

To ensure seamless collaboration, it is essential to implement effective communication strategies that facilitate the integration of all involved parties. This collaborative environment supports multidisciplinary coordination and minimizes the disruptions associated with the transition from traditional design methods to BIM-based workflows.

When selecting BIM-authoring tools and information management systems, teams must consider compatibility with existing infrastructure and software ecosystems. Due to the dynamic nature of BIM, ongoing professional training is crucial to keep pace with technological advancements, system upgrades, and evolving industry standards.

As the methodology continues to mature, broader adoption is anticipated, particularly among design professionals who are increasingly focused on improving workflow quality and project outcomes. The ability to generate highly detailed, interactive digital models fosters deeper analysis and clearer communication among stakeholders, contributing to more rigorous and informed project development.

5. BIM MEP

BIM represents a comprehensive and collaborative methodology that spans all sectors of the construction process. Within this framework, MEP (Mechanical, Electrical, and Plumbing) constitutes a specialized domain focused on the coordination of building service systems.

While BIM integrates detailed MEP models covering mechanical, electrical, and plumbing installations into the overall digital representation of a building. These systems are modeled in conjunction with architectural and structural elements to enable clash detection, performance simulations, and construction sequencing.

As such, MEP can be viewed as a subset within the broader BIM ecosystem, working in tandem with other disciplines to form a cohesive and information-rich model. This integration ensures that MEP systems are fully coordinated with the rest of the building design, improving accuracy, reducing on-site conflicts, and supporting a more efficient and sustainable construction process [7]. This concept is illustrated by the editorial team at Biblus, as depicted in Fig. 4.

The "El Sol Insurance Building" (1996), modeled by the Grid Studio team and coordinated by Architect Rainer Huaranca (Fig. 5), serves as a representative example of BIM MEP application. Developed as part of a BIM MEP training course certification, the project utilized Revit 2021 to consolidate all disciplines into a unified working model, enabling a comprehensive visualization of the building's systems and equipment in real time. Despite the density of information within the model, the platform allows for selective isolation of individual elements or systems, facilitating clearer analysis and targeted review.

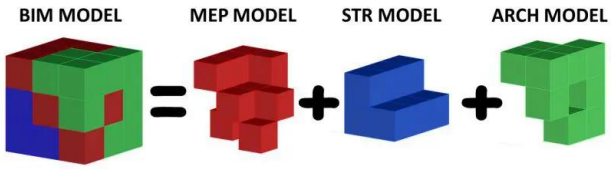

Fig. 4 BIM integration process [8].

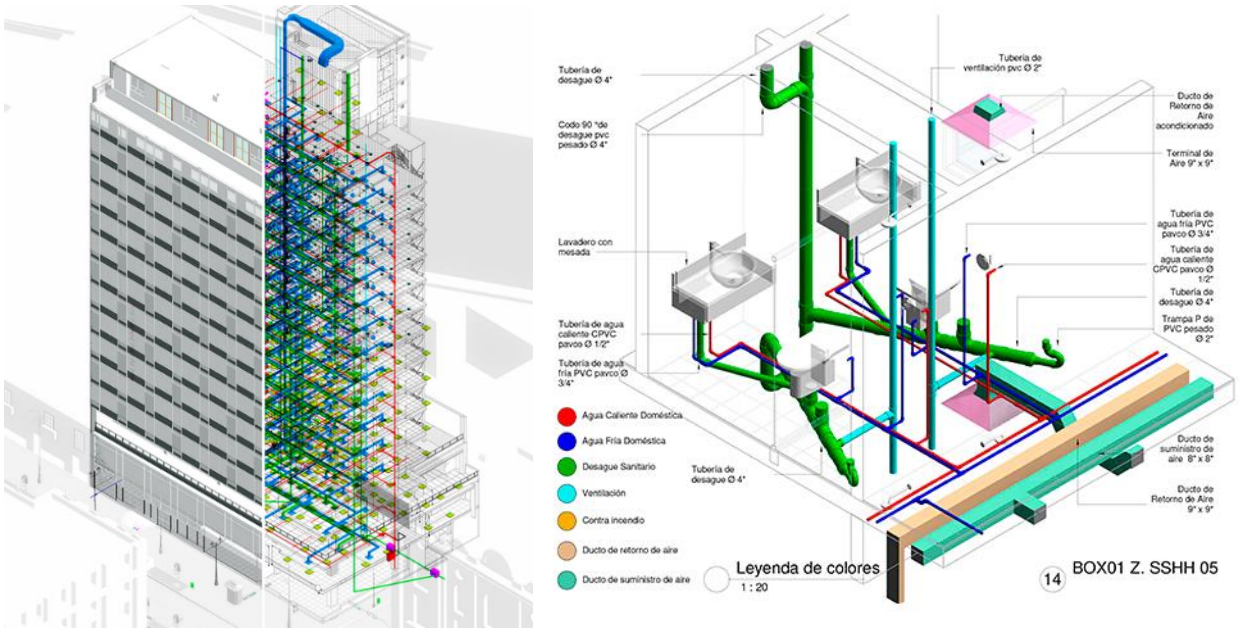

Fig. 5 BIM modeling process [9].

The BIM methodology applied to building services network design offers a broad set of tools that enhance the realism and precision of hydraulic and other system representations. It enables the manipulation of component properties, aiding in accurate modeling and improved coordination across disciplines.

Additionally, BIM supports the creation of a detailed execution plan, outlining the full construction phasing process, thereby optimizing organization and reducing preparation time prior to execution.

Moreover, the approach provides advanced capabilities for conflict detection, allowing for early identification of clashes between installations and the application of corrective measures during the design phase. The methodology supports the generation of plan views, sections, elevations, and 3D visualizations, while also enabling the extraction of critical data such as material properties and component specifications. This integrated and information-rich environment significantly improves decision-making and enhances overall project performance.

When applied to building services (MEP), BIM facilitates the creation of detailed, intelligent 3D models that support precise analysis and visualization. This enables early detection of clashes between networks and other installations, minimizing rework and construction delays. BIM tools also allow for advanced performance simulations that guide decisions on materials, equipment, and technical solutions.

6. Conclusion

In the construction industry, fostering a culture of innovation and continuous learning is essential to sustaining technological progress. Implementing a new collaboration policy supported by tools that facilitate efficient information exchange is vital for organizations aiming to thrive in an evolving landscape.

The integration of Building Information Modeling (BIM) into project development represents a critical step toward creating a resilient and adaptable future. The COVID-19 pandemic further underscored the industry's reliance on technology, revealing the feasibility and advantages of remote work. BIM directly responds to this shift, offering a collaborative environment that supports seamless remote interaction, provided that its implementation is strategically planned.

Although BIM introduces a promising paradigm shift for civil engineering delivering clear benefits in efficiency, accuracy, sustainability, and project quality successful adoption hinges on investment in technological infrastructure and internal process transformation. One of the major hurdles lies in the resistance to change, accompanied by the need for consistent regulation and standardization to ensure smooth implementation.

The interoperability promoted by BIM standards enhances transparency and information quality across the AEC sector. Nevertheless, its deployment demands upfront investment in hardware, software, and workforce training requiring commitment and coordinated effort from all stakeholders.

From a sustainability perspective, BIM contributes significantly to environmental performance. By facilitating accurate resource management and minimizing material waste, it supports efficient execution and reduces environmental impact. The methodology also aids in facility and infrastructure management, through enhanced preventive maintenance planning and cost control mechanisms.

Despite its many advantages, BIM adoption presents a steep learning curve. For successful implementation, it is imperative to establish general standards and adopt a phased approach that minimizes disruptions during the transition from traditional practices.

Technological training should be prioritized, not only to overcome implementation barriers but also to prepare professionals for the long-term benefits that far outweigh initial challenges. Companies that invest in BIM will be better positioned to compete in a market increasingly defined by digital integration and complex demands.

BIM also enhances conflict resolution by streamlining data exchange and reducing the need for face-to-face validation meetings. While the benefits

become fully apparent over the medium to long term, the process requires persistent dedication and a collective mindset shift.

Ultimately, BIM is not just a technological evolution but also a cultural transformation in the AEC sector. Its adoption promotes integrated, collaborative work throughout the entire building lifecycle from design to maintenance. Among its many benefits are improved coordination, cost management, conflict reduction, and overall project quality.

Working with BIM requires more than software knowledge; it involves understanding the entire methodology, from individual processes to collaborative workflows. A practical way to implement BIM is through a pilot project preferably a simple, new build designed to explore software capabilities and foster team adaptation. This pilot can then inform broader implementation strategies.

Once a project team embraces BIM from design through execution, the methodology's full potential becomes apparent. As confidence grows, teams can tackle more complex initiatives, including urban rehabilitation and large-scale developments.

BIM continues to gain momentum and solidify its role within the AEC sector. While current challenges persist, the pace of technological advancement suggests these will be overcome, paving the way for new innovations and raising new questions. By committing to BIM, professionals and companies alike position themselves at the forefront of a more efficient, collaborative, and sustainable future in construction.

References

[1] Available online at: https://www.vimansca.com.br/blog/pessoas-processos-tecnologia.

[2] Grupo, A. J., O que é o BIM?, available online at: https://grupoajbim.com/2024/03/18/o-que-e-bim/.

[3] Castro, L. C. L. B., BIM 360º - Um panorama multidisciplinar sobre o estado do BIM, available online at: https://info.e-zigurat.com/hubfs/MBIM/ebookbim360/BIM%20360%20-Um%20panorama%20multidisciplinar%20sobre%20o%20estado%20do%20BIM.pdf.

[4] T. F. G. J. R. M. S. S. F. M. C. D. Campestrini, Entendendo BIM, Paraná, 2015., available online at: http://www.gpsustentavel.ufba.br/documentos/livro_entendendo_bim.pdf.

[5] Available online at: http://www.gpsustentavel.ufba.br/documentos/livro_entendendo_bim.pdf.

[6] Available online at: https://www.designingbuildings.co.uk/wiki/Common_data_environment_CDE.

[7] Biblus, Conheça as diferenças entre BIM e MEP, available online at: https://biblus.accasoftware.com/ptb/conheca-as-diferencas-entre-bim-e-mep/.

[8] Available online at: https://biblus.accasoftware.com/ptb/conheca-as-diferencas-entre-bim-e-mep/.

[9] Available online at: https://gridstudio.myportfolio.com/mep-de-edificio-de-seguros-el-sol.