CHAPTER 91

Investigations on the Role of BIM in Facility Management

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ABSTRACT

This study addresses the increasing complexity of controlling subsystems like Heating, Ventilation & Air Conditioning (HVAC) systems and electrical systems in existing facilities, where traditional approaches often fail to ensure optimal performance, predictive maintenance, and energy economy. Building Information Modeling (BIM) is revolutionizing Facilities Management (FM) by enhancing decision-making and operational efficiency throughout the asset's lifecycle. The study examines the implementation of BIM in FM, focusing on HVAC and Electrical systems. The study comprises of literature review and semi-structured interviews, resulting in analysing BIM's cutting-edge power in asset management. According to preliminary studies, interoperability issues among platforms and restricted scalability for smaller facilities exists. To address these barriers, the paper makes practical solutions for improving BIM's influence on FM procedures through success stories and case study learnings. This study demonstrates and contributes BIM's potential to transform FM processes, by providing actionable insights and concrete advantages to broaden adoption of BIM in FM.

Keywords: BIM; Facilities management; Predictive maintenance; Operational efficiency; Asset life cycle.

1.0 Introduction

The necessity for creative methods to handle facility management (FM) has been highlighted by the quick expansion of infrastructure construction in India as well as the growing complexity of contemporary structures. Reactive maintenance techniques, fragmented data, and inefficient resource allocation are common problems with the traditional facility management approaches. A revolutionary answer is offered by Building Information Modeling (BIM), a digital technology that combines operational, structural, and architectural data. By connecting the design/construction stages with the building's operating lifecycle, BIM gives facility managers access to up-to-date, precise data for preventive decision-making.

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From Bengaluru's IT parks to Mumbai's skyscrapers, India's dynamic urban geography makes this integration especially crucial for maximizing occupant comfort, sustainability, and operational efficiency. Addressing issues like energy inefficiencies, growing repair expenses, and the need for more intelligent future-ready infrastructure is made possible by the combination of BIM and FM. The study looks at how BIM is included into FM processes to pinpoint the concrete advantages of this collaboration, such as improved operational efficiency, energy management, and predictive maintenance. The study will also suggest ways to get around obstacles to BIM-FM incorporation in the Indian setting. The study looks at how BIM-driven data centralized management, presentation, and predictive analytics enhance FM outcomes. The objectives include:

- Evaluate how BIM is currently being used in FM.
- Determine and assess the possible advantages of incorporating BIM into FM procedures, particularly with a focus on HVAC and Electrical systems.

Although the study emphasizes the promise of BIM in FM, it is important to recognize several limitations. There is currently little data available on for a long time BIM-FM implementations in India. By using secondary data in the form of research papers, case studies and semi-structured interviews, the previously mentioned objectives are examined.

2.0 Literature Review

A revolutionary paradigm that presents previously unheard-of chances to maximize building lifecycle management is the incorporation of BIM in FM In order to identify gaps that guide the study's focus, this section summarizes previous research on several important topics, such as the advantages of BIM-FM integration, technical uses, sustainability, technological advancements, and sector-specific difficulties.

2.1 The basics of integrating BIM with FM

Because of its capacity to centralize data, optimize workflows, and improve decision-making, BIM has the potential to completely transform FM. Early research by Su *et al.* (2011) and Kelly *et al.* (2013) highlights the advantages of BIM over conventional 2D CAD systems, especially in terms of enhancing data accuracy, expediting work orders, and facilitating real-time asset tracking. However, obstacles including fragmented data handovers, industry reluctance to technological adoption, and problems with BIM and FM tool compatibility still exist (Patacas *et al.*, 2015; Pärn *et al.*, 2017).

2.2 Technical uses for electrical and HVAC systems

The function of BIM in managing intricate systems like electrical infrastructure and HVAC (heating, ventilation, and air conditioning) is the subject of an expanding corpus of research. Yang *et al.* (2017) proposed a BIM-based architecture that cut troubleshooting time by

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68% and identified 47 vital data requirements for HVAC maintenance. While Dahanayake *et al.* (2022) investigated IoT-BIM synergies to improve energy management and fault detection, Karimi *et al.* (2021) showed how effective BIM is at combining MEP systems into underground train stations.

2.3 Sustainability and lifecycle management

It is commonly known that BIM may help with sustainable FM practices. Potkany *et al.* (2015) support the use of BIM in lifecycle planning by relating efficient FM to lower energy use and CO2 emissions. Nical *et al.* (2016) go on to emphasize the value of BIM in energy analysis and retrofit planning, which is in line with international sustainability objectives. Studies like Liu *et al.* (2016), however, show a lack of early FM involvement throughout the design stages, which results in preventable maintenance expenditures.

2.4 Innovations in technology and digital instruments

BIM-FM integration is changing as a result of emerging technologies like digital twins, augmented reality (AR), and the Internet of Things. While Gheisari *et al.* (2016) show how mobile AR can enhance field accessibility to BIM data, Karimi *et al.* (2021) show how digital twins allow for real-time performance monitoring. The Edge building in Amsterdam is cited by Araszkiewicz *et al.* (2017) as a model for smart FM; nonetheless, they emphasize the necessity of compatibility between BIM platforms and older systems.

2.5 Sector-specific difficulties and knowledge administration

According to Pinti *et al.* (2022), the public sector's adoption of BIM-FM is still in its infancy. They point out that nations such as the UK and Italy lack standardized methods and pilot-based deployments. Similar to this, Adetayo *et al.* (2023) highlight how technical and financial limitations cause differences in the use of BIM across regions, especially in Africa.

2.6 Future directions and human factors

Inadequate training and resistance to change continue to be major obstacles. While Lavy *et al.* (2015) support earlier BIM-COBie integration to reduce manual data entry mistakes, Aziz *et al.* (2016) attribute the underutilization of BIM with FM to organizational inertia.

2.7 Research shortcomings and inputs

Although previous research highlights the transformative potential of BIM, there are still shortages in overtime BIM-FM case studies, especially in developing nations like India. Regional issues including dispersed infrastructure expansion and the merging of HVAC and electrical systems in densely populated urban areas are not well covered in studies. To close these gaps, this study assesses how well BIM can optimize HVAC as well as electrical FM procedures in India's changing construction environment and suggests solutions for overcoming adoption hurdles.

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3.0 Semi structured Interviews

3.1 Methodology

Semi structured interviews provide comprehensive understanding on a particular topic under investigation. Professionals in the commercial, industrial, as well as educational sectors of facility management took part in semi-structured interviews about BIM in FM. The topics of discussion included ROI measurement, implementation difficulties, BIM integration, its function in HVAC as well as electrical works, and upcoming advancements.

3.2 Responses

Table 1: Respondent Details

Respondent no	Designation	Total work experience (in years)
1	Design Manager	6
2	Facility Manager	25
3	Assistant Professor	4
4	Virtual Builder	5
5	Facility Operations specialist	11
6	Assistant FM manager	9

3.3 Summary of responses

- The respondent connects assets and models using Vueops Siteline, allowing 3D representation for HVAC/electrical maintenance, even though they have no direct FM experience. Dependency on designs and the absence of trade models are obstacles. AI-driven problem identification is a trend for the future, and BIM centralization lowers staffing expenses.
- The response compares worldwide procedures with Siemens, JLL, as well as Honeywell while integrating BIM and Cam Plus One with BMS for asset monitoring. By optimizing HVAC scheduling, BIM reduces energy consumption by 30%. The incompatibility of outdated equipment is one of the challenges. Failure prediction powered by AI is a development for the future.
- The respondent oversees lab and institutional facilities and contrasts conventional FM in India with 3D BIM in the United States. BIM improves vendor data access, workstation layout, and procurement. There are obstacles to adoption of older structures. Future developments will include electrical monitoring based on sensors.
- The respondent uses Autodesk Cloud to integrate BIM in real-time for projects in Dubai. Among the advantages are 3D clash detection and lower rework expenses. Technical learning curves and stakeholder unfamiliarity are obstacles. In large, multidisciplinary projects, BIM produces a 50% return on investment.

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- In accordance with Singapore's BIM Level 2, the respondent, who managed a tech hub as well as medical facility, improved drainage systems and cut HVAC energy consumption by 18% using BIM. BIM reduced AC breakdowns by 25% and avoided 14 days of electrical rework. IoT-BIM will be used in future to monitor humidity in real time.
- The respondent, who oversaw resorts as well as commercial buildings, reduced peak energy use by 15% by optimizing electrical load distribution. BIM increased mall renovation productivity by 20% and reduced fire-alarm testing duration by 40%. Tenant resistance is one of the difficulties.

4.0 Case Studies

4.1 User-Centric BIM-Based Framework for HVAC Root-Cause Detection

A user-centric BIM-based paradigm for identifying the underlying causes of HVAC issues was presented by Alavi & Forcada (2022). Parameters such as timeliness, flexibility for integrating data from several sources, decision support capabilities, and visualization efficacy were used to evaluate the framework. The TR5 structure located at Universitat Politècnica de Catalunya was the subject of the case study. The following were the main conclusions drawn from this case study:

- The framework used Dynamo along with code written in Python to represent and depict HVAC faults by integrating information from CMMS as well as BMS systems into BIM.
- It made it possible to determine, semi-automatically, if HVAC problems were caused by insulation concerns, breakdowns in equipment (indoor and outdoor units), or an undersized system design.
- Without the need for physical equipment inspection, the facilities management team was able to diagnose issues more quickly and accurately thanks to the BIM model's user-friendly color-coded display.

4.2 Bim-energy simulation approach for detecting building spaces with faults and problematic behaviour

A BIM-based methodology for identifying spaces in buildings with HVAC system issues and troublesome behavior was given by Shalabi & Turkan (2020). The assessment was predicated on factors including impact on maintenance planning, detection accuracy, visualization efficiency, and integration capability. To illustrate the use of the framework, a case study of the King Pavilion, an educational facility was carried out. The following were the case study's main conclusions:

- Within the BIM context, the framework combined information from building energy management systems (BEMS), computerized maintenance management systems (CMMS) and energy simulations.
- Facility managers were able to identify areas with unusual patterns (inactive, exaggerated, or inadequate HVAC activity) by comparing simulated and real heating/cooling loads.

- The framework pointed out that while BEMS can identify alarms, it frequently overlooks concealed HVAC inefficiencies. This technique revealed these inefficiencies, allowing for predictive maintenance and less energy waste.

4.3 Using a retro BIM workflow: Case studies on energy driven retrofit projects

A 25,000 square foot mixed-use building located at 1204 Mason St. in San Francisco was the subject of a case study on energy retrofitting with BIM assistance by Skripac & Bergman (2012).

- The study's main objectives were data collecting effectiveness, simulation tool interaction, retrofit accuracy, and decision-making support. Time was saved by streamlining data collecting with a 3D laser scan. When energy simulations were calibrated using actual electricity bills, they showed that inefficient mechanical systems, uninsulated walls, and single-pane windows caused significant losses.
- Energy-Efficiency Measures (EEMs) like DHW improvements, more efficient insulation, steam-to-hydronic boiler utilization, as well as enhanced lighting/ refrigeration were prioritized with the aid of BIM visualization.
- For occupant comfort, daylight simulation insights were obtained through combining Revit and DesignBuilder along with Ecotect. Suggestions for incentive funding were communicated to PG&E's Saving by Design program.

5.0 Conclusion

BIM has shown revolutionary potential when included into FM especially when it comes to HVAC and electrical system optimization. The following are the findings of the study:

5.1 Important takeaways from semi structured interviews

- Practical viewpoints on the current application of BIM in FM across a range of industries, especially commercial, institutional, as well as industrial projects, were offered by Real-World Insights.
- Outlined important obstacles such exorbitant installation costs, challenges integrating with previous systems, and a shortage of qualified staff.
- Highlighted benefits prove how BIM can increase energy efficiency, lower operating costs, and facilitate predictive maintenance by using asset monitoring and 3D visualization.
- Shared perspectives on return on investment (ROI) indicate that while smaller projects necessitate a longer-term cost-benefit analysis, larger ventures yield a quicker ROI.
- New trends were identified, including the usage of digital twins for sophisticated facility management, IoT-BIM interface for real-time monitoring, and AI-driven predictive Maintenance.

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5.2 Usage of BIM in FM from case studies

In FM, BIM is actively used to improve sustainability and operational efficiency. Important uses consist of:

- As-Built Modeling: Accurate digital copies of existing facilities are made possible by scanning with lasers and 3D point cloud information, which is essential for retrofits (Case study 3).
- Energy Simulation: In order to discover inefficiencies, BIM is combined with tools such as EnergyPlus and DesignBuilder to model HVAC effectiveness, daylighting, and electrical consumption (Case Studies 1–3).
- Interoperability: BIM and FM technologies (CMMS, BEMS) work together to centralize data, facilitating quicker maintenance workflows and root-cause identification of HVAC issues (Case Studies 1-2).
- Retrofit Planning: In accordance with energy efficiency objectives, BIM-driven analytics direct HVAC modernization and envelope improvements (such as window replacements and insulation) (Case Study 3).

5.3 Advantages of BIM for FM for electrical and HVAC systems

The case studies demonstrate quantifiable benefits of using BIM:

- Cost and energy savings
  - By improving insulation, HVAC retrofits were able to lower heating loads by as much as 18.58% (Case Study 3).
  - Opportunities to reduce lighting consumption by 35–50% were found through daylighting simulations (Case Study 3).
  - Utility costs were decreased and operational disruptions were minimized by proactive maintenance (Case Studies 1-2).
- Preventive maintenance
  - Rapid fault identification (such as refrigerant leaks and valve malfunctions) was made possible by the combination of BIM with CMMS, which reduced downtime (Case Studies 1-2).
  - HVAC response times were improved by using color-coded BIM visuals to prioritize repairs (Case Study 1).
- Improved ability to make decisions
  - Hidden inefficiencies like old boilers and inadequate ventilation were discovered through data-driven comparisons between simulated and real energy use (Case Studies 2–3).
  - BIM-assisted electrical system audits identified expensive equipment (such as café refrigeration units), which led to focused improvements (Case Study 3).
- Comfort of occupants

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- By resolving underheated/overheated zones, thermal and airflow assessments increased satisfaction among tenants (Case Studies 2–3).

5.4 Conclusion in Indian context

- BIM increases energy efficiency lowers expenses for upkeep, and improves problem detection when used alongside BMS, CMMS, and BEMS. By detecting HVAC problems early and refining retrofitting techniques, it makes proactive maintenance possible. Sustainability is further improved by data analytics and digital twins. High expenses and complicated retrofitting are obstacles, though.
- Adoption of BIM is required in India because to the country's aging infrastructure and excessive energy consumption. BIM assists in optimizing energy use, addressing HVAC inefficiencies, and complying with energy laws. Maintenance and retrofitting are improved when BIM is used with CMMS and BEMS. Government incentives should be used to assist the development of affordable BIM solutions that are adapted to the regional resources, climate, and legislation. Programs for BIM-based energy optimization training are essential. AI-driven failure identification for real-time HVAC efficiency improvements should be the main focus of future research.

5.5 Final takeaway connecting semi structured interviews and case studies

5.5.1 ROI and preventive maintenance

- The ROI for large-scale projects (such the commercial complexes in Dubai) was 3–4 years, which is consistent with Case Study 3's breakeven point after HVAC upgrading. Large upfront expenses, on the other hand, presented difficulties for smaller Indian facilities, supporting the demand for scalable approaches like BIMx (freeware), which was brought up in interviews.
- The potential of BIM to anticipate HVAC issues was shown in every case study (e.g., refrigerant leakage in TR5 and valve problems in King Pavilion). This was supported by interviews, where experts reported that BIM-driven preventive alarms resulted in 25% fewer AC problems.

5.5.2 Increased efficiency in operations

- Validated interview responses from Case Studies 1 (UPC's TR5 Building) and 2 (King Pavilion) demonstrated how BIM can cut down on time spent on maintenance (35%) and energy expenses (15–20%). In a similar vein, experts from the UAE and India reported 25–30% fewer HVAC breakdowns as a result of predictive maintenance processes made possible by automated alarms and BIM visualization.

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- As in the third case study (San Francisco retrofitting), interviewees highlighted BIM's 3D collision identification for electrical systems, which prevented two weeks of rework by identifying inefficient wiring layouts.

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