

Review Article

# BIM-Based Construction Project Supported by an Integrated Project Delivery Contract Model for Building Energy Efficiency

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**Abstract** - Buildings are responsible for a significant share of the world's energy use and carbon emissions. Traditional project delivery methods do not help much in improving overall performance in this regard. This is where the introduction of Building Information Modelling (BIM) with Integrated Project Delivery (IPD) comes into its own, as they provide a far more collaborative and efficient way of tackling not only environmental concerns but also economic and social ones by streamlining the design process. This Article examines how the two approaches have shaped energy efficiency in buildings over the last 10 years, from 2014 to 2024. Using the PRISMA approach, 102 papers were extracted from reputable databases such as ASCE, Emerald, Scopus, and ScienceDirect. Attention was given to the influence of BIM and IPD on project management, precast construction methodologies, and building energy. These two systems are similar in that they can be used as multiple-feature systems. A SWOT analysis facilitated an overall assessment of how BIM-led projects under the IPD model can deliver better energy outcomes. From all of this, the study offers a conceptual model illustrating how BIM and IPD, combined, represent a formidable strategy for designing and realising more energy-efficient buildings.

**Keywords** - Project Delivery, Energy Efficiency, Building Projects, IPD, BIM, Construction.

## 1. Introduction

In recent years, energy efficiency has become an urgent issue, particularly considering growing awareness regarding environmental degradation and climate change. This urgency has led the construction industry to become heavily involved in the design of ever more efficient equipment and systems that consume less energy (Lin et al., 2025). In response, the building industry has developed a range of novel technologies, materials, and design strategies to enhance energy performance (Orikpete, Ikemba, & Ewim, 2023). Meanwhile, a quest for both luxury and utility in living spaces remains one of the main forces shaping modern building trends (Kwon & Kim, 2024). To achieve this, of course, designing for energy performance cannot be ignored in any way, shape, or form. Therefore, one of the most effective ways to implement these strategies and further improve building performance is through integrating IPD with BIM, which together can help

reduce energy use and greenhouse gas emissions across the entire life cycle of a building (Jones, 2014). The development of green building standards, such as Leadership in Energy and Environmental Design (LEED) certification, has been a key focus for the construction industry. These criteria aim to ensure that buildings are designed and built to improve energy efficiency while minimising the environmental impacts of construction (Gil-Ozoudeh et al., 2022). Another critical consideration in the connection between energy efficiency and the construction sector is the impact of government laws and incentives (Cheng et al., 2022). Generally, it has been shown that improving overall building performance using traditional project delivery systems is inefficient. According to Durdyev et al. (2019), conventional construction methods have included Design-Bid-Build (DBB) and design-build, both of which follow a relatively linear design process and have remained largely unchanged over the last few decades. As a



result, in a typical method, the owner is heavily involved early in the process by assisting in defining project needs. Still, the client subsequently gives leadership to the designers and builders, who bear responsibility and risk throughout the subsequent stages of the process. With the process moving down, collaboration is often minimised. As the design and construction process moves forward, the time frame for project changes and remodelling is slowly reduced (Du et al., 2019). Under the construction manager at risk arrangement, the construction manager must complete a project within a specified budget and time frame and must advise and make recommendations throughout the project delivery process. Still, they are not responsible for the project budget. Then, the client assumes responsibility for holding subcontracts and undertakes the cost and schedule risks as part of the construction management technique (Cavka, Staub-French, & Poirier, 2017). The efficiency of the construction sector, measured as output per input, has remained largely unchanged over multiple decades due to the lack of significant changes in the delivery model. Poor communication, a lack of standardisation, and non-collaborative contracts are only a few reasons for the industry's lack of productivity and low building energy efficiency (Suef & Dinariyana, 2024). The construction industry's productivity gap is well known. Many companies seek ways to close it by implementing newer technologies, altering procedures, and shared-risk contracts, among other things.

Therefore, it was recommended that IPD be used in a variety of construction projects. It establishes a new organisational and contractual framework for project delivery, enhancing collaborative and integrated practices (Kahvandi et al., 2019). BIM can serve as a platform for data gathering and integration, whereas IPD will establish a framework for collaboration with stakeholders who share the same goal (Wright, 2012). According to Ikudayisi et al. (2022), to effectively execute IPD, it is critical to understand the process's key characteristics and the relationships between stakeholders. Due to their capacity to assist in project management in a disciplined manner with the greatest results from a project across all parties, which include stakeholders, holders, construction companies, structural engineers, designers, and consultants, IPD and BIM combined show up as a quality enhancement for managing construction projects (Dalui et al., 2021).

### 1.1. Research Gap

Although BIM and IPD have each demonstrated significant potential to support sustainable design and energy-efficient construction, existing studies frequently address them independently. Many prior works investigate BIM-enabled energy simulation, clash detection, or sustainability assessment tools, while others examine IPD as a contractual framework that promotes collaboration and shared risk.

However, limited research has systematically examined how BIM and IPD can be jointly implemented as an integrated mechanism to improve building energy efficiency across different project phases. Furthermore, previous reviews tend to focus on isolated case studies or single aspects of building performance, lacking a comprehensive synthesis of empirical evidence across construction management, precast applications, and sustainability-oriented practices.

### 1.2. Problem Statement

The energy consumption of buildings remains a critical factor in meeting global carbon-reduction goals. The building environment in the developing world often results in inefficient energy use in construction projects due to fragmented project delivery procedures and late involvement of major stakeholders (Zarewa, 2019). In addition, the lack of agreement on digitalisation and policy support has never led the construction industry to deliver sustainable performance, as a result of poor contractual arrangements and the lack of integrated workflows (Bajpai & Misra, 2024).

However, the full potential of BIM to improve energy efficiency is unlikely to be realised unless it is embedded in delivery systems or processes that encourage shared responsibility and design coordination. There is also a gap in the clear relationship between IPD and BIM for better building energy efficiency.

### 1.3. Comparison between Existing Research and this Study

Table 1 below is divided into three columns to show how integrating BIM with IPD might improve operational efficiency. Here are some key elements of this paper. This study offers a broader perspective on the subject. The research applied PRISMA methods to conduct a systematic review. It suggests a mixed comparison on both academic and practical grounds, usable in real-world settings.

**Table 1. Comparative overview of existing literature and this study**

Aspect	Existing Studies	Novelty of This Study
Focus	Usually, examine BIM or IPD separately.	Integrates BIM and IPD together for building energy efficiency
Scope	Limited to single areas (e.g., BIM energy simulation or IPD contracting)	Covers three domains: project management, precast construction, and energy performance
Method	Case studies or conceptual discussions	Uses a PRISMA systematic review of 102 papers
Integration	Rarely explain how BIM and IPD interact	Identifies the synergy between BIM and IPD
Framework	Few studies propose combined models.	Develops a SWOT-based conceptual framework

## 2. Related Work

This section reviews the current literature on building energy efficiency, the usage of BIM, and the IPD method in construction projects. The goal of the Review is to provide the theoretical groundwork for integrating BIM and IPD to improve building energy performance. It also identifies gaps in the existing literature and emphasizes the importance of a BIM-IPD conceptual framework. A structured review methodology, using the PRISMA approach, is used to ensure transparency and consistency in the selection and analysis of relevant academic sources. Previous research indicates that building energy performance is frequently compromised by inefficient design decisions, insufficient coordination among project stakeholders, and inadequate use of simulation and analytical techniques.

According to Darko et al. (2020), sustainable building is increasingly reliant on comprehensive approaches that incorporate technical innovation, supportive regulatory frameworks, and collaborative project environments. In this regard, integrated delivery models such as IPD and digital technologies such as BIM are widely acknowledged as significant sustainability enablers. By enabling sophisticated, centralised digital models that facilitate collaboration, visualisation, and performance analysis, BIM has completely changed construction procedures.

From an energy-efficiency standpoint, BIM enables early-stage energy modelling, HVAC system optimisation, daylighting analysis, and material lifecycle assessment (Kassem et al., 2015). Multidimensional simulations that enable quantifiable sustainability outcomes and guide design decisions are made possible by programs like Revit, IES VE, and Design Builder (Lu et al., 2017). Additionally, BIM promotes multidisciplinary collaboration by facilitating real-time input from engineers, architects, and sustainability experts via a Common Data Environment (CDE). This cooperative approach minimises construction waste, expedites decision-making, and lessens design disagreements (Laovisutthichai, Lu, & Bao, 2022). However, without a project delivery strategy that promotes early collaboration and shared accountability among stakeholders, BIM alone is unlikely to deliver consistent, energy-efficient results, despite its technological advantages.

### 2.1. BIM for Energy Efficiency

To support environmentally friendly building performance, BIM is becoming an increasingly important technology. BIM can efficiently assist energy modelling, daylight analysis, HVAC optimisation, and lifecycle energy evaluation, according to several studies (Lu et al., 2017; Maltese et al., 2017). BIM improves the trustworthiness of design results by enabling energy analysis at the early design stage, enabling designers to make better-informed decisions based on anticipated performance rather than general

assumptions. Furthermore, BIM provides robust interoperability with specialised analytical tools such as eQuest, Green Building Studio, EnergyPlus, and IES-VE. Building orientation, facade performance, insulation techniques, and thermal comfort factors are just a few of the design options that can be quickly tested thanks to these integrations.

Early energy modelling can result in significant reductions in CO<sub>2</sub> emissions and long-term operating energy consumption, according to research on BIM-based Life Cycle Assessment (LCA) (Darko et al., 2020). Nevertheless, despite these technical benefits, BIM alone cannot address broader collaboration issues such as fragmented communication and delayed decision-making.

This emphasizes how crucial it is to combine BIM with a cooperative project delivery strategy that guarantees simulation results will improve the energy efficiency of the building throughout the whole construction process.

### 2.2. Integrated Use of BIM and IPD

Although the benefits of both BIM and IPD are well established, their combined use is yet to be fully explored in the literature. According to earlier research, BIM can help IPD by facilitating shared data environments and enhancing communication and transparency among project participants (Poorang Piroozfar et al., 2019). Encouraging early stakeholder engagement and establishing structured collaboration procedures can improve BIM outputs. Despite this, very limited research has focused on.

### 2.3. Government Policies and Industry Trends Supporting BIM-IPD

BIM is increasingly recognised as an important tool for regulatory coordination and sustainable development, especially for public sector projects (Paik, Leviakangas, & Choi, 2022). Some megaprojects have employed IPD processes. These developments reflect growing interest in the potential benefits of BIM use in IPD, including better cost control, greater innovation, and improved overall project integration. It is a practical way to enhance project quality and environmental performance by combining with collaborative governance. Nevertheless, the current legislative conditions for the implementation of BIM and IPD are not well developed.

### 2.4. Summary of Literature Review

In summary, although BIM and IPD each make their own contributions to construction work, the combined impact on improving energy efficiency has not been explored. The fragmented nature of existing research underscores the need for integrated analysis. By applying a PRISMA-guided methodology and reviewing 102 publications, this section establishes the foundation for the study's contribution. It clarifies the broader academic and industry context in which BIM-IPD integration operates.

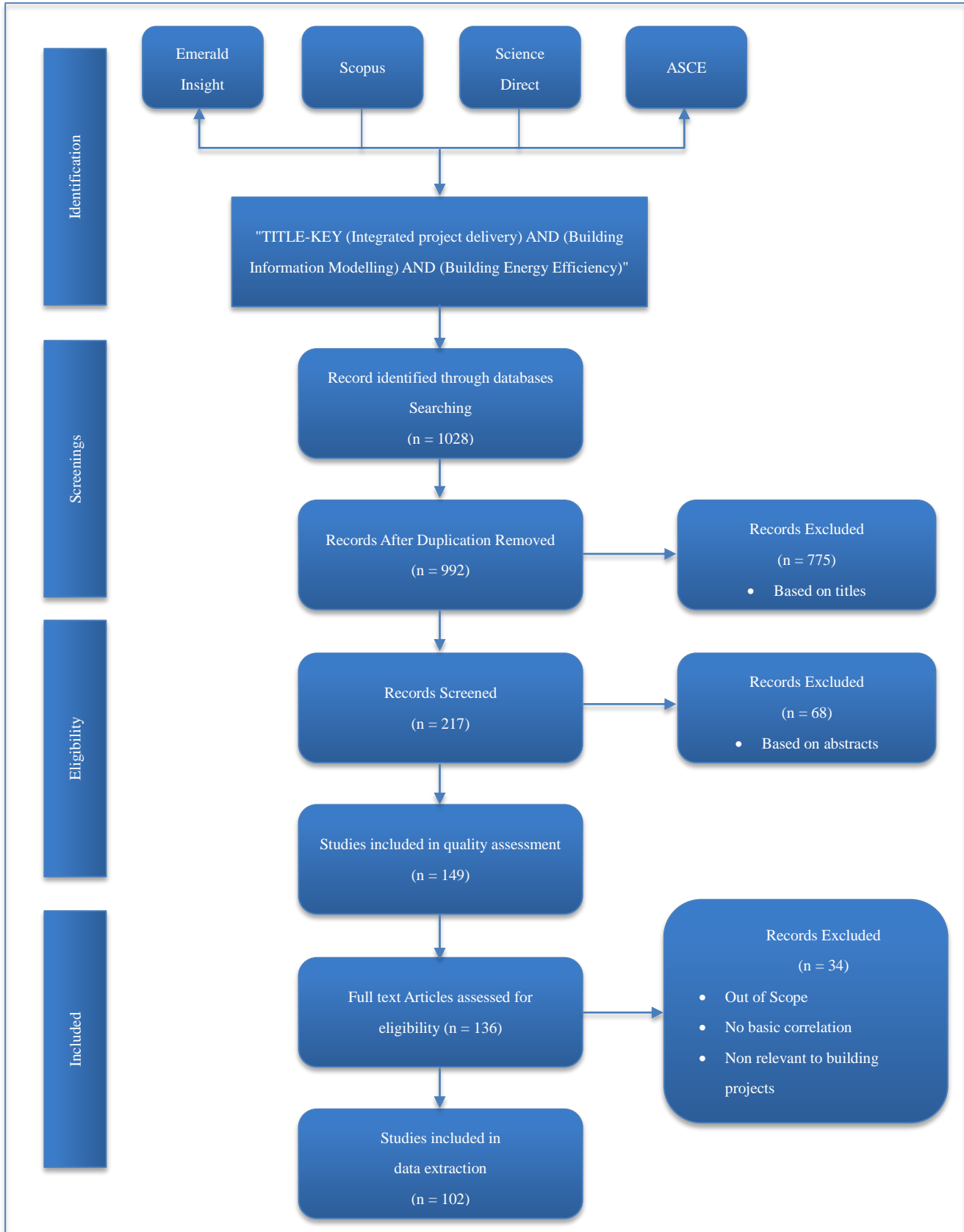


Fig. 1 PRISMA Statement

### 3. Research Methodology

Many researchers have acknowledged the PRISMA statement (Rethlefsen et al., 2021). PRISMA was chosen for this review paper because systematic reviews are assessments of specifically defined topics that use structured and systematic methods to categorise, decide, and objectively investigate relevant research, as well as to collect and analyse the data used in the assessment (Rethlefsen et al., 2021). As part of a systematic approach, a SWOT analysis was conducted to analyse both environments. PRISMA was used to identify the selection criteria.

#### 3.1. Research Strategy

Four large databases were used to gather relevant literature: ScienceDirect, Emerald Insight, Scopus, and ASCE. Key terms like Integrated Project Delivery, Building Information Modelling, and Building Energy Efficiency were the focus of the search. To ensure the Review reflected more recent developments, a structured search strategy was used to select the studies most pertinent to the research aims. The inclusion criteria were limited to publications from 2014 to 2024. Figure 1 shows the overall PRISMA flow, while Figure 2 shows the trend in publications on BIM and IPD from 1973 to 2024.

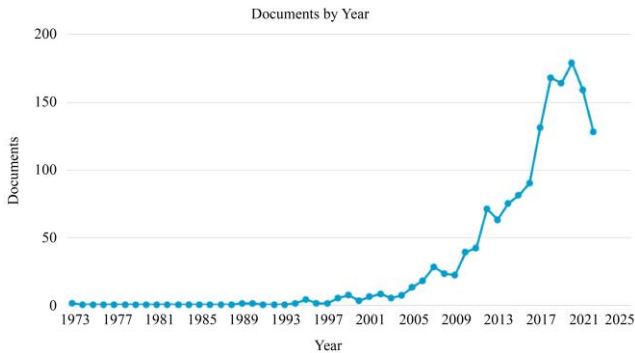


Fig. 2 Number of publications from 1973 to 2024

#### 3.1.1. Selection Criteria

This Review addresses the use of BIM in the IPD context of the construction industry, specifically focusing on energy efficiency at various stages of the project cycle. The PRISMA guidelines were applied to the review process to ensure a systematic and transparent approach to study selection. A preliminary search yielded 1,028 records, filtered by publication domain, document type, time coverage, and language.

#### 3.1.2. Quality Assessment

The retrieved papers were compiled after removing duplicates; 992 articles were recorded after 36 articles were identified as duplicates and removed from the list. Following that, the file is inspected by deleting papers with inappropriate titles, leaving 217 documents for further screening after excluding 775 articles. The abstracts are then reviewed, and 68 are excluded to ensure that only articles that fulfill the purpose of this study are included. Following an evaluation, 149 articles were identified for quality assessment. Only 136 papers were selected after screening titles and abstracts and removing duplicates. Following the eligibility studies, 102 studies were identified that met the inclusion criteria.

#### 3.1.3. Interpretation and Analysis

The summary includes a visual breakdown of publications by year, illustrated in Figure 3. Additionally, the keyword analysis conducted using VOSviewer software is presented in section 3.1.5. The articles were then thoroughly interpreted in a tabular format, including the identified construction project subsections and the relevant IPD with BIM-applied techniques. The included papers were then analysed, and a conceptual framework was proposed to explain how IPD with BIM has affected the construction sector and to recommend necessary future developments. Figure 3 shows the total of 102 selected papers from the qualitative analysis and PRISMA statement.

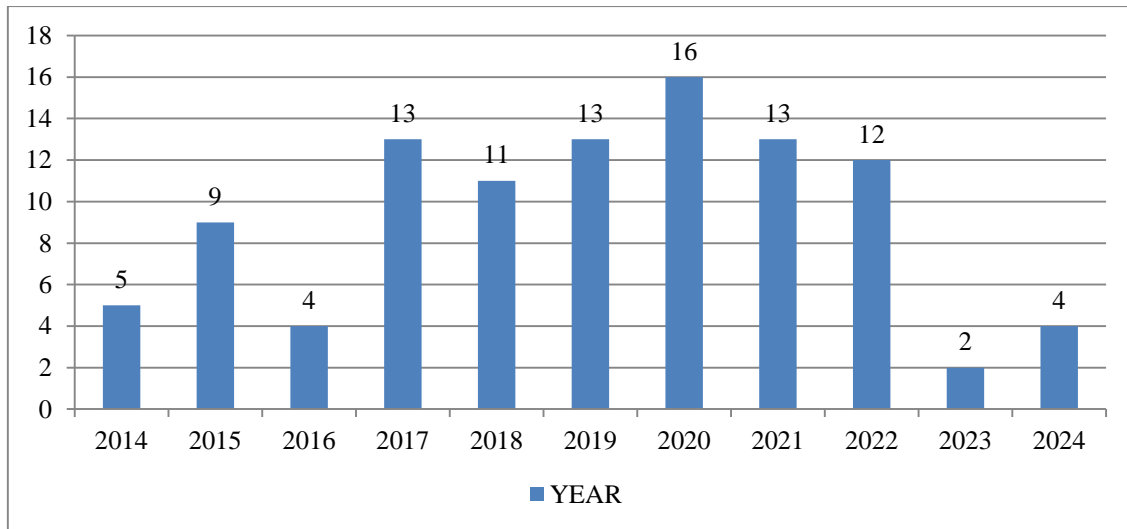


Fig. 3 Summary of total selected papers

3.1.4. Summary of Extracted Articles

Four databases (Scopus, Science Direct, Emerald, and ASCE) were used, as shown in Figure 4.

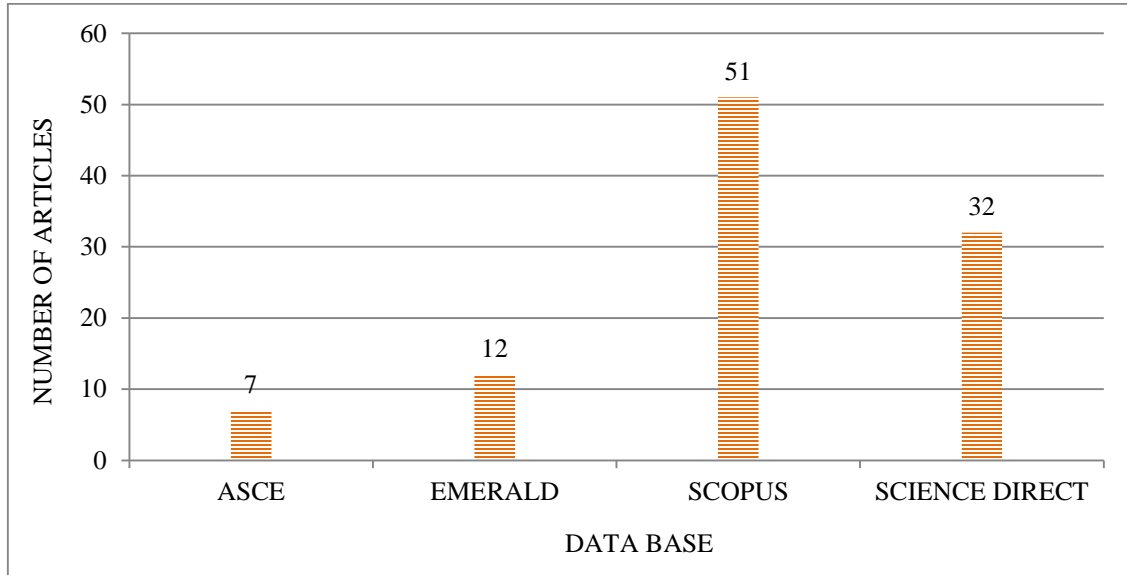


Fig. 4 Number of articles

3.1.5. Keywords Co-Occurrence Analysis

Keywords analysis clarifies research trends and relationships. Co-occurrence analysis, conducted via VOSviewer's "full counting" method, identified 35 keywords

with at least two occurrences, forming 8 fuzzy clusters. The keyword network visualisation (Figure 5) illustrates these relationships.

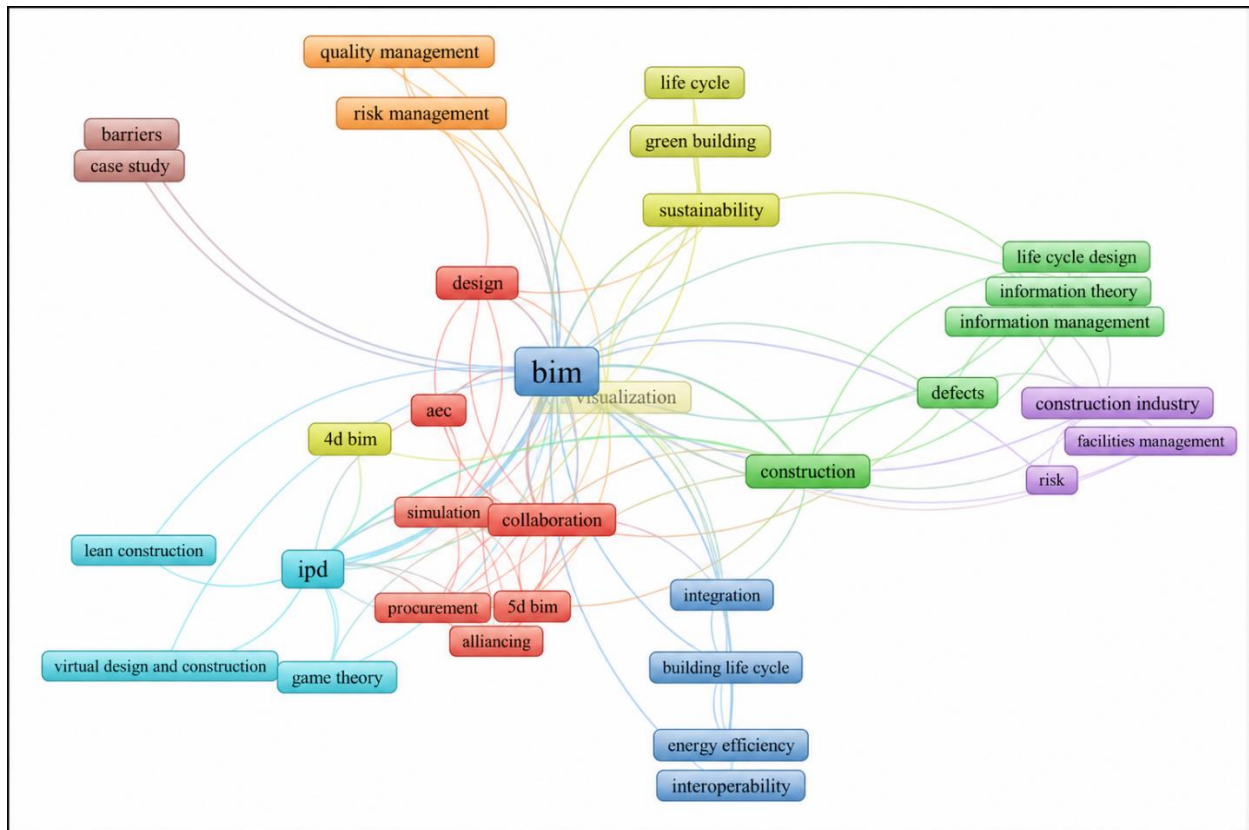


Fig. 5 Network visualisation of keywords co-occurrence

### 3.1.6. Focused Area Analysis of Journals on Keywords, Cluster, and Occurrences.

Table 2 below presents the focused area on IPD with BIM, classified by keywords, clusters, and occurrences throughout the paper via VOSviewer.

**Table 2. IPD-BIM focus areas, keywords, clusters, occurrences**

No.	Keywords	Cluster	Occurrences
1	5D BIM	1	4
2	AEC	1	2
3	Alliancing	1	3
4	Collaboration	1	8
5	Design	1	3
6	Procurement	1	2
7	Simulation	1	2
8	Architectural Design	2	2
9	Construction	2	9
10	Defects	2	2
11	Information Management	2	4
12	Information Theory	2	2
13	Life Cycle	2	4
14	BIM	3	62
15	Building Life Cycle	3	2
16	Energy Efficiency	3	9
17	Integration	3	3
18	Interoperability	3	2
19	4d BIM	4	2
20	Green Building	4	4
21	IFC	4	2
22	Prefabrication	4	15
23	Sustainability	4	5
24	Construction Industry	5	7
25	Facilities Management	5	3
26	Information Modelling	5	2
27	Risk	5	2
28	Game Theory	6	2
29	IPD	6	25
30	Lean Construction	6	3
31	Virtual Design	6	2
32	Risk Management	7	2
33	Quality Management	7	2
34	Barriers	8	2
35	Case Study	8	2

### 3.1.7. Assessment of Construction Project Management with IPD-BIM

Traditional delivery techniques in the construction business are inefficient. Despite their long history of use, many professionals are unhappy with the results. Due to their failure to keep up with present trends, the distribution methods now in use are considered inadequate, contributing to dissatisfaction. In this regard, the appropriate delivery strategy is increasingly seen as essential to a project's overall success. IPD introduces itself as a revolutionary construction strategy that accelerates project implementation through a holistic approach to improving and enhancing existing delivery techniques. Salim and Mahjoob (2020) stated that the advantages of using IPD are fully in line with the advantages of the BIM method, which include using virtual reality software and a common model to organise group discussion, achieving higher design quality with less waste, cutting down on project timelines and costs, detecting interference and collisions, and improving contract documentation. BIM technology was seen as a catalyst for the IPD process and as an improvement to the quality of building projects. Besides, as noted by Viana et al. (2020), when properly applied across five key areas: agreement, method, data, group, and connection, the IPD technique may offer several advantages for a project, including time management, cost control, improved quality, and mitigation of unforeseen challenges. Contrarily, the stated IPD necessitates stakeholders' cooperation, where cultural differences among team members may ultimately have an impact on project relationships generally, information flow, and ultimately the project's result. Furthermore, the "cost overrun with BIM" was directly impacted by "technical difficulties," "poor information sharing and cooperation," and "responsibility for data entry," whereas all other risks had an indirect impact on cost through these three risk categories (Durdyev et al., 2019; Zhao, Wu, & Wang, 2018).

Therefore, proposed that a BIM Execution Plan (BEP) is critical to encourage culturally inclusive team development and to understand the specific contractual terms for BIM construction projects, with thorough end-product lists, among the consulting workforce working on IPD projects. Othman and Youssef (2021) mentioned that Architecture Design Firms (ADFs) have a structure to carry out the IPD approach during the design process that includes five functions: recognising the implementation problem, forming implementation objectives, constructing a project plan, carrying out a project plan, and tracking the project plan. Erazo, Guzman, and Espinoza (2020) stated that due to the ease of interaction between all stakeholders made possible by applying BIM combined with the IPD framework, reaction time was reduced by 67% compared to a conventional construction project. According to Ren and Zhang (2021), an integrated information process BIM is vital for effective scheduling and control in the Architectural, Engineering, and Construction (AEC) industry. BIM has significant potential to be linked with various other digital technologies, project delivery approaches, and cutting-

edge building procedures across the whole CEM process as a data repository for ACE facilities (R. Jin et al., 2019). To provide support to BIM connectivity between structural analysis and architectural design, a six-step methodology was implemented. Jin, Hwang, and Kim (2020) suggested that the AEC curriculum's IPD and BIM collaboration education is taught using the "Constructivism Collaboration Process". When BIM is used for resource management through collaboration, procurement management through quantity take-off, and time management through 4D modelling, it contributes to improving and implementing Knowledge Areas (KAs) in the AEC sector. Du et al. (2019) conducted a numerical simulation in MATLAB 2016a showing that the interaction behaviour of the two game participants would shift towards an asset allocation strategy when the incentive was larger than the total speculative profit and ownership cost. According to Meng et al. (2020), "the digitisation process of the interior and exterior features of the building" is how BIM is defined and serves as a "Community-wide information repository for decision-making throughout the project's lifespan". BIM enables digital management and can significantly enhance timelines and performance, control building costs, minimise risk, and so on. Andriamamonjy, Saelens, and Klein (2018) developed a BIM-to-BEPS (BII) workflow that spans the entire project life cycle and specifies that, at this stage, Modelica library components must be compatible with the BII. This workflow also includes an official requirement process for exchanging data, with the necessary tools (guidelines and MVD) to ensure the required data is included in the BIM and exported to IFC.

Meng et al. (2020) proposed an industry development framework for implementing BIM and summarised that the scheduling and handover process has recently changed from a traditional method to IPD in a collaborative environment with

BIM. Manca et al. (2020) presented a Life Cycle Assessment (LCA) methodology that, when executed with environmental impact data from the BEDEC database using IPD, reduced energy use by 40% compared to the comparable baseline model. Abanda et al. (2018) noted that BIM-era construction project management success in the twenty-first century should incorporate intelligent technologies to assist teams in making informed decisions. In the AEC sector, a cutting-edge modelling technique known as 4D BIM is emerging that links 3D BIM components with timing and scheduling data. AEC professionals may analyse options and make decisions in the early design stage thanks to BIM's Virtual Design and Construction (VDC), which provides representations of the building design over time. Users of the DSC-BV-TI system can quickly see the results of project design thanks to immersive VR technology. Professionals can use it to assess the results of engineering, alternative design, and material selection, as well as to coordinate and improve design plans in the early stages of projects (Hao, Zhang, & Zhao, 2021). According to Tudora et al. (2024), several people can coexist virtually and remotely handle on-site work by simulating with VR software. In contrast, Umar et al. (2015) stated a strategy to optimize the 4D model for IPD in businesses' demand to optimize qualifications of the IPD process in construction projects. Engineers and supervisors can use snapshots of 4D models to assess daily progress and discuss simple goals with the team. The management of the construction schedule, alignment of the timeline with the site schedule, forecasting and preventing interruptions between teams and tasks, and validation of the validity and appropriate sequence of activities are all tasks that project teams can manage using 4D models. Elghaish, Abrishami and Hosseini (2020) found that using the suggested automated multi-objective optimisation of 4D BIM results in a 22.86% cost savings, and the degree of contribution to the management IPD project at the trade package level is 33.33%.

**Table 3. Assessment of construction project management with IPD-BIM**

<b>Author</b>	<b>Area</b>	<b>Finding</b>
(Jones, 2014)	CPM; Design and Construction Considerations	Criteria and constraints imposed by the project requirements of a client.
(Kraatz, Sanchez, & Hampson, 2014)	CPM; virtual design and construction (VDC)	Revealed gaps between current and best practice
(Liu et al., 2014)	CPM; framework	Retrofit project goals for energy efficiency in buildings
(Solnosky, Parfitt, & Holland, 2014)	CPM; education; AEC	Significant advantages over the commonly used cookie-cutter
(Zanni, Soetanto, & Ruikar, 2014)	CPM	Help the design team manage key project processes.

(Akob, Abang Hipni, & Abd Razak, 2019)	CPM; sustainable	Sustainable design embedded IPD framework
(Halttula, Haapasalo, & Herva, 2015)	CPM	RPDA and BIM characteristics that provide additional benefits
(Cao et al., 2015)	CPM	BIM's potential could be better utilized within the industry.
(Harrison & Thurnell, 2015)	CPM; virtual design and construction (VDC)	5D BIM enabled efficient, detailed elemental cost plans.
(Kassem et al., 2015)	CPM; life cycle	Access FM data to improve efficiency
(Saad, Baba, & Amoudi, 2015)	CPM; life cycle; VDC	Expectations for the project's successful completion have increased considerably.
(Umar et al., 2015)	VDC; life cycle	Improve efficiency for the AEC sector and all parties
(Aladag, Demirdögen, & Isik, 2016)	project management	The project would save money and time by improving workflow efficiency.
(Cavka, Staub-French, & Poirier, 2017)	CPM; life cycle	Information exchange between the design and operational phases.
(Gerrish, Ruikar, Cook, Johnson, et al., 2017)	CPM; life cycle	Energy performance of a building in relation to its architectural objectives.
(Gerrish, Ruikar, Cook, Johnson, & Phillip, 2017)	CPM	Management of data in each stage must be considered for novel purposes
(Grzyl, Miszewska-Urbańska, & Apollo, 2017)	CPM; AEC	The entire programming and design process allows the stakeholders to integrate the work of many individuals.
(Lam, Mahdjoubi, & Mason, 2017)	CPM; SME	Phase of involvement, project cost, funding source, and procurement method
(Mei et al., 2017)	CPM	Significant influence on the effectiveness of supervision, rewards, and punishment
(Abanda et al., 2018)	CPM	Emerging technologies used on-site to manage construction activities
(Andriamamonjy, Saelens, & Klein, 2018)	CPM; life cycle	Inifc4 file into a Modelica-based BEPS model
(Arayici et al., 2018)	CPM; AEC	Business processes across organizations reflect an integrated supply chain for energy efficiency.
(Govender et al., 2018)	CPM	Lack of transparency of risk and rewards between all stakeholders.
(Nývlt, 2018)	CPM	information and CSF management
(Zaker & Coloma, 2018)	CPM; VDC	VR must concentrate on realising its capabilities and the opportunities it provides.
(Zhao, Wu, & Wang, 2018)	CPM; AEC	There were 15 statistically significant hypothetical risk paths.
(Ahmad, Azhar, & Chowdhury, 2019)	project management	Making ICT financial decisions to enhance IPD performance characteristics

(Hamzah et al., 2016)	project management; risk and responsibility	IPD characteristics align with the industry's current contractual landscape.
(Boon et al., 2019)	CPM	Analyses of the current condition of the BIM and new contractual structures for combining design and construction
(Du et al., 2019)	AEC	IPD with BIM implementation assists in improving sustainable
(Durdyev et al., 2019).	project management	By offering novel insights into the nature of important barriers,
(Elghaish et al., 2019)	project management	Participants can track their expenses on PCs and mobile devices using the EVM-Web grid.
(Whang, Park, & Kim, 2019)	project management; critical success factors	Using factor analysis, 29 candidate variables were chosen and categorised into 7 CSFs.
(Karasu, Aaltonen, & Haapasalo, 2023)	project management	conceive up fresh methods and a plan for BIM contractual document frameworks.
(Jin, Hwang, & Kim, 2020)	life cycle	Determining important input characteristics and the BPA workflow
(Ruoyu Jin et al., 2019)	AEC	Digital technology, project delivery strategies, and cutting-edge construction practices are integrated throughout the CEM process.
(Nguyen, Tommelein, & Martin, 2018)	project management	Provide information on how projects that utilised ILB
(Kahvandi et al., 2019)	project management	Constitutional macro issues are seen as implementation difficulties for IPD.
(P. Piroozfar et al., 2019)	project management	IPD helps remove obstacles to collaboration, enhances early involvement, and raises trust among key stakeholders.
(Elghaish et al., 2019)	project management; 4D BIM automation	Activity-based costing in 4D BIM is important.
(Elghaish, Abrishami, et al., 2020; Elghaish, Hosseini, et al., 2020)	project management; cost structure	Make sure the parties involved in IPD projects are fairly distributed in terms of risk and profit.
(Elghaish & Abrishami, 2020)	project management; cost management	BIM-enabled web-based management systems are successful in IPD.
(Erazo, Guzman, & Espinoza, 2020)	project management; integration	Boost productivity during the building project and guarantee the client receives benefits.
(Jin, Hwang, & Kim, 2020)	project management; education	BIM/IPD education can be beneficial.
(Maliha, Tayeh, & Aisheh, 2020)	AEC	Kas to the AEC rise if BIM is implemented more frequently.
(Meng et al., 2020)	life cycle	Future industry development framework
(Salim & Mahjoob, 2020)	project management	BIM technology that complements the advantages of an IPD system

(Salim & Raof Mahjoob, 2020)	project management	BIM can be applied alongside the IPD approach.
(Sun, Xu, & Jiang, 2020)	project management; risk factors	Project participants' inconsistent views on BIM, modifications to the delivery method, and issues with software functionality
(Theißen et al., 2020)	life cycle	BIM tool-LCA framework.
(Viana et al., 2020)	project management	IPD implementation focuses on process and communication
(Wang et al., 2020)	project management; WBS	Social network analysis examines changes in stakeholders
(Dalui et al., 2021)	Collaborative approach; emerging technologies	Sustainable benefits from the infrastructure projects
(Evans et al., 2021)	AEC	Transformational Lean IPD&GID programs and FOW worldwide efforts
(Hao, Zhang, & Zhao, 2021)	VDC	VR-based solution
(Othman & Youssef, 2021)	project management	The least significant obstacle was a lack of training and enthusiasm for adopting IPD.
(Othman et al., 2021)	project management	Intense workshops promoting BIM should demonstrate the BIM implementation process.
(Ren & Zhang, 2021)	AEC	An approach for representing and validating material information using invariant signatures is more efficient.
(Sanhudo et al., 2021)	project management; EIR	Framework to connect prior knowledge with the new realities of BIM and moderate current practices.
(Su et al., 2021)	project management	Strategies for risk sharing in IPD projects

### 3.1.8. Assessment of Precast with IPD-BIM

Precast construction is credited with greatly reducing construction time, increasing productivity, and achieving more cost savings through the efficient administration of various tasks, including the flow of goods, services, and materials. According to Abedi et al. (2016), precast construction projects involve several activities, numerous parties, extensive work, and various processes, necessitating the delivery of timely, relevant information to facilitate cooperation and integration and enable efficient communication. Prefabrication and design-build were thought to benefit the most from BIM. According to Ma et al. (2018), prefabricated construction was among the modern construction approaches with which BIM was thought to have the strongest relationships. Customers in the precast construction sector are looking for projects that are more affordable, quicker to build, higher quality, and give current information. The main problems with the precast supply chain include poor integration, poor planning and scheduling, manufacturing timing issues, poor coordination, poor inter-party communication, inaccurate deliveries, and inadequate control and supervision. BIM with context-aware cloud computing was eventually provided as a prototype and system

architecture to support suitable delivery, effective monitoring, coordination, and cooperation, with enhanced communication (Abedi et al., 2016). To boost systematic innovation in the precast sector, Darko et al. (2020) recommended modular integrated construction (MiC) employing BIM and BIM-related digital technologies (f BIM-based MiCRM). Hamzah et al. (2016) reported that a CMMS professional uses BIM to collect, analyse, and interpret information on renovation projects. to enable IBS diagnosis and build support for positive supply. With an emphasis on the coordination of site installation and logistics operations that deliver and assemble prefabricated concrete structures that adhere to the "reduce variability" and "pull production" principles. Bataglin et al. (2020) proposed scheduling and managing the supply and erection of ETO precast building systems. Ansah et al. (2021) developed a BIM-based LCA method for prefabricated buildings that incorporates multiple evaluation levels, with distinct system boundaries and functional units, to assess the energy and environmental impacts of prefabricated structures throughout their lifetimes. At the same time, Cheng et al. (2022) noted that pre-casting can minimise formwork waste by 60%–70%, primarily from slabs and walls. If prefabrication is encouraged and used more, it can reach as high as 90%.

**Table 4. Assessment of precast with IPD-BIM**

<b>Author</b>	<b>Area</b>	<b>Finding</b>
(Abedi et al., 2016).	precast construction	Development of system architecture and the prototype of CACCBIM
(Kassem et al., 2015)	precast construction	Employing a BIM-based CMMS Expert can enhance IBS performance.
(Ma et al., 2018)	precast construction	Provide insights and the big picture of China's construction industry
(Bataglin et al., 2020).	precast construction; project management	“Pull production” and “reduce variability” principles
(Darko et al., 2020)	precast construction; project management	BIM-based micrm software development
(Manca et al., 2020)	precast construction; project management	Overall energy consumption of the proposal is reduced by 40%
(Ansah et al., 2021)	precast construction; LCA	Automated BIM-based LCA
(Hjelseth, 2017)	precast construction	Automation of the BIM design process and upcoming work
(Zhang et al., 2021)	precast construction; project management	Interactive correlations among barriers
(Gerrish, Ruikar, Cook, Johnson, & Phillip, 2017)	precast construction	The primary contributing aspect is BIM PBS policies and guidelines.
(Cheng et al., 2022)	precast construction; LCA; life cycle	Formwork waste can be reduced by 59.68% to 71.83%.

### 3.1.9. Assessment of Building Energy Efficiency

BIM has the potential to significantly enhance productivity, reduce construction waste, and promote sustainable development (Atabay, Pelin Gurgun, & Koc, 2020). It is possible to leverage a variety of software platforms within an IPD process to improve project delivery outcomes by using them within the Open BIM-facilitated single data environment and swiftly prioritising interoperability detection to obtain a comprehensive assessment of the environment. A BIM-based sustainability program saves a lot of time and money; a poorly constructed model primarily caused discrepancies between software and manual results. The experience demonstrated that 3D simulation transfer techniques can be used to accelerate the environmental evaluation of digitally created buildings using BIM, enabling concurrent, quick, and effective LEED reviews (Alwan, Greenwood, & Gledson, 2015). BIM is specifically applied to supply data for energy-efficiency measurement and evaluation. According to Maltese et al. (2017), green BIM enables

integrated Net Zero Energy building design, build, and maintenance. Moreover, innovative design organisations are implemented. BIM may provide information to help compute several points to set desired sustainability levels for rating systems. Maltese et al. (2017) also provided a framework and initial examples to help grasp the possibilities of an interoperable approach to grading buildings' Sustainability in accordance with major international protocols (LEED, BREEAM, and CESBA). According to Oduyemi, Okoroh, and Fajana (2017), experts assessed integrated project delivery as the most well-established advantage of BIM for building energy efficiency.

A lack of interoperability was identified as the biggest technological challenge. To encourage the integration of Sustainability into design choices and the evaluation of Sustainability during the infrastructure project's initial phase. Liu et al. (2018) demonstrated that using BIM for different performance studies, systems for rating sustainable

infrastructure are suitable for evaluating an infrastructure's environmental and social performance. A framework was suggested to improve designs and guarantee that sustainable goals are achieved and verifiable. Building Materials Reuse (BMR) workflow was mapped in Business Process Modelling and Notation language (BPMN) for inventive architectural design process reorganization that permits resource reuse in a new building (Ali & Badinelli, 2016). It was highlighted that the BMR process, when paired with BIM execution planning, might significantly lead to a circular, sustainable building design.

To conceptualize how BIM and green buildings interact, Lu et al. (2017) proposed the "Green BIM Triangle" taxonomy. It was revealed that green BIM applications could have a few advantages for Green Building Assessments (GBA), which involve managing application materials, determining GBA scores, and boosting the efficiency of the GBA procedure. To make the construction timeline more data-driven, El-Diraby, Krijnen, and Papagelis (2017) created and developed an online system called Green2.0. It makes use of developments in BIM, tools for simulating energy efficiency, and methods for analysing social networks online.

Linking BIM with energy analysis tools allows users to select product variants, evaluate their energy consumption, and collaborate on design ideas. This integration provides valuable data that helps researchers and professionals develop more effective and sustainable construction design concepts. The advancement of sustainable development's state of the art in the design of green buildings. According to Ohueri, Enegbuma, and Kenley (2018), the energy usage of green buildings will be significantly reduced by merging strategic plans such as build, enforce, and assess plans, the use of an innovation strategy, and owners' behaviour techniques (education, rewards, user advice on renewable energy, etc.). Bu et al. (2015) broaden the scope of the BIM-facilitated Green Retrofit Design (GRD) design framework for retrofitting existing structures, which is important for theoretical research, instruction, communication, and practical GRD development work. According to Atabay, Pelin Gurgun, and Koc (2020), BIM technologies may effectively be utilised to support the Sustainability of the construction sector as a platform for creative and comprehensive systems. Therefore, incorporating the BIM method and energy efficiency of building fundamentals is for the benefit of the construction industry.

**Table 5. Assessment of building energy efficiency with IPD-BIM**

Author	Area	Factors
(Alwan, Greenwood, & Gledson, 2015)	Museum (sustainable infrastructure)	Green building, Environmental assessment
(Bu et al., 2015)	Retrofitting process	Greenhouse emissions, Renovation
(Luo & Wu, 2015)	Building performance	Energy performance
(Ali & Badinelli, 2016)	Building materials	Greenhouse emissions
(El-Diraby, Krijnen, & Papagelis, 2017)	Building design: elements	Greenhouse emissions, Sustainability, IFC
(Lu et al., 2017)	Building performance	LEED, Greenhouse emissions, Sustainability
(Maltese et al., 2017)	Building performance	Greenhouse emissions, Energy performance
(Oduyemi, Okoroh, & Fajana, 2017)	Building design	Environmental assessment
(Liu et al., 2018)	Infrastructure's environmental performance	Greenhouse emissions
(Ohueri, Enegbuma, & Kenley, 2018)	Office buildings	LEED, Greenhouse emissions, Sustainability
(Du et al., 2019)	Moral hazard behaviour	None
(Gao, Koch, & Wu, 2019)	Building design	Renewable energy
(Atabay, Pelin Gurgun, & Koc, 2020)	School building	LEED
(Haruna, Shafiq, & Montasir, 2021)	Sustainable construction	Sustainability

**3.2. SWOT Factors for BIM-based Construction Project Supported by IPD**

Table 6 below shows the summary of SWOT factors for BIM-based projects supported by the IPD contract model for building energy efficiency.

**Table 6. Summary of SWOT factors**

SWOT factors	Description	Authors
Strength (S)	Minimising construction errors.	(Mei et al., 2017)
	Increasing sustainable building design.	(Jones, 2014)
	Project benefits and risks are shared among stakeholders.	(Halttula, Haapasalo, & Herva, 2015)
	Collaborative improvement	(Fakhimi, Sardroud, & Azhar, 2016)
Weakness (W)	High procurement and implementation cost.	Kiani et al. (2023)
	Incompatibility issue.	(Fakhimi, Sardroud, & Azhar, 2016)
	Barriers in implementation and the contract model.	(Kahvandi et al., 2019)
	Traditional mindset among stakeholders.	(Hamzah et al., 2016)
Opportunity (O)	Decrease environmental impact.	(Wright, 2012) (Halttula, Haapasalo, & Herva, 2015)
	Improvement in the contractual matter.	<b>(Fakhimi, Sardroud, &amp; Azhar, 2016)</b>
	Globalization through the involvement of multinational stakeholders.	(Mei et al., 2017)
	Greater Innovation.	(Mei et al., 2017)

Threat (T)	Lack of qualified expertise.	<b>(Fakhimi, Sardroud, &amp; Azhar, 2016)</b>
	Lack of legal support from the authority.	(Kiani et al., 2015)
	Lack of proper courses and educational material.	(Kiani et al., 2015)
	Lack of insurance cover for the projects adopting IPD with BIM.	(Kahvandi et al., 2019)

**3.2.1. SWOT of IPD in Supporting BIM-based Projects for Building Energy Efficiency**

*Strength (S)*

- **Minimising construction errors:** The overall performance of the project will be enhanced with a lower rate of errors. When IPD is used to support a BIM-based project, errors can be greatly decreased and avoided (Mei et al., 2017).
- **Increasing the sustainable building design:** BIM is a tool that is effective for sustainable design and performs building energy analysis, which can be greatly improved by IPD, which facilitates the integrated design of a method that could help create a safer, greener, and more sustainable environment (Jones, 2014).
- **Project profits and risks are shared among stakeholders:** With the help of BIM 3D collaboration, all project stakeholders have a fair probability to predict how designs will impact their portion of the project, and modelling of the entire construction project to make sure the choices taken are suitable for the common and singular goals (Halttula, Haapasalo, & Herva, 2015).
- **Collaborative improvement:** Integration and early involvement are key elements of IPD, while BIM is a complex storage of data and a collaboration platform. IPD-supporting BIM-based projects also provided clearer communication among stakeholders, enhancing collaboration (Fakhimi, Sardroud, & Azhar, 2016).

#### *Weakness (W)*

- High procurement and implementation costs: Kiani et al. (2015) stated that due to a major lack of funding for BIM implementation, the project stakeholders believe that it is costly. Unless a large return on investment can be demonstrated, the client will not participate in the contract.
- Incompatibility issue: Fakhimi, Sardroud, and Azhar (2016) mentioned that only certain software programs can run the BIM model, and it is not compatible with other programs. BIM's lack of interoperability will destroy both BIM and IPD's capacity to integrate and collaborate.
- Barriers in implementation and contract model: Absence of standard collaborative contract documents and practical implementation leads to difficulties in understanding the contract model (Kahvandi et al., 2019).
- Traditional mindset among stakeholders: Most of the project stakeholders are unwilling to make a culture change to adopt the new project delivery model, where IPD supporting BIM-based projects needs significant changes and culture changes among project stakeholders. (Patching et al., 2024).

#### *Opportunity (O)*

- Globalisation through the involvement of multinational project stakeholders: According to Mei et al. (2017), the partnership of IPD supporting BIM-based projects can increase international market opportunities due to the possibility of a mutual partnership to increase project effectiveness.
- Decrease environmental impact: Increased deployment of IPD supporting BIM-based projects will be able to meet the need for reducing construction sector environmental impacts (Wei, Shi, & Xia, 2021). Aside from that, IPD and BIM will significantly improve the Sustainability of the construction process by reducing on-site waste (Halttula, Haapasalo, & Herva, 2015).
- Greater Innovation: Collaboration between several teams up front, along with the potential for the project to use any team's essential strengths as unexpected obstacles emerge, generally results in more creative, efficient ways of achieving the goal (Karasu, Aaltonen, & Haapasalo,

2023).

- Improvement on the contractual matter: The lowest bidder is the only thing that matters in conventional contracting models. This bidding procedure has hindered the integration of project stakeholders. As a result, a better cooperation contract model is required, particularly for IPD-supported BIM-based projects (Whang, Park, & Kim, 2019).

#### *Threat (T)*

- Lack of proper course and education material: There are hardly any educational tools available for implementing IPD and BIM, and the condition of limited BIM products in the market influences them (Kiani et al., 2015).
- Lack of qualified expertise: As mentioned by Fakhimi, Sardroud, and Azhar (2016), the absence of a qualified implementation team/users/operators is the main barrier and challenge in implementing IPD-supporting BIM-based projects.
- Lack of legal support from the authority: Lack of authority support to install the technology, software incompatibility, and unwillingness to change from the traditional delivery method are major threats to implementing IPD-supporting BIM-based projects (Kiani et al., 2015).
- Lack of insurance cover for the projects adopting IPD with BIM: Employers' insurance coverage in special cases is also crucial because, if insurance firms do not support IPD, it will be hard to share profit and loss, as present insurance does not completely allow delegating responsibility (Kahvandi et al., 2019).

## **4. Discussion**

The findings of this Review indicate that BIM and IPD, when applied together, form a complementary system that addresses many of the structural limitations of traditional project delivery methods. Although BIM provides the technical basis for analysing energy performance, identifying design conflicts, and supporting multidimensional coordination, IPD takes these functions a step further by promoting early stakeholder integration and collaborative decision-making. This integration is particularly important in the early stages of design, as having precise digital information and robust contractual arrangements enables

project stakeholders to consider energy-efficient solutions and evaluate design options with confidence. The BIM and IPD are integrated to complement each other, with information consistently shared between them rather than viewed as a process. This is opposed to conventional delivery systems (DBB or DB), where late design changes and disjointed reporting can hinder the delivery of energy efficiency.

The Review also notes that although BIM and IPD have tended to relate to positive outcomes in scheduling, cost control, and project coordination, the integrated influence of the two methods on energy efficiency is less frequently recognized, especially across different construction types. Based on a review of 102 studies, five common mechanisms were identified: improved design coordination through the adoption of new technologies; shared risk and accountability mechanisms to facilitate substation/outsourcing; and better lifecycle-based planning. When used in combination, the factors tend to result in reduced energy use and better sustainability performance. The overall implications of the results obtained in this study are that BIM is effective when considered alongside IPD, and thus, combining the two can improve project performance more than either could achieve independently.

#### **4.1. Implications for Key Stakeholders**

The convergence of BIM and IPD has serious implications for construction industry participants. For designers and consultants, access to early digital performance data enables the consideration of design options with greater detail. This comprised mechanical system optimisation, integration of passive design strategies, and research into facade solutions, helping to achieve enhanced end-project results from inception. Also, more construction-friendly information and less rework are beneficial to contractors, especially for complex materials such as precast elements, where accurate modelling and collaborative planning reduce fabrication errors. Clients and stakeholders are direct beneficiaries of a near-match between project performance and energy use targets. Shared governance tools within an IPD context can be used to establish sustainability objectives early, with benchmarks that guide a project throughout the design and construction phases. Better utilization of integrated digital workflows and BIM-enabled submissions may also help regulators with compliance checking and a clearer understanding of decisions on energy performance. By strategically shifting stakeholder engagement on projects from task coordination to collaborative ownership of performance outcomes, BIM with IPD has the potential to revolutionise project accountability and improve sustainable outcomes.

#### **4.2. Case studies Practical Insights from Existing Research**

Several case studies demonstrated the practical benefits of using BIM under IPD in real-world practice. Initiatives that adopted BIM- and IPD-enabled practices achieved greater schedule predictability, faster decision-making, and

significantly fewer design conflicts. BIM-enabled IPD projects reported improved schedule predictability, faster decision-making, and fewer design conflicts. In several projects, project teams identified cost-effective energy-saving services early in the conceptual stage through a combination of digital simulation and collaborative contractual arrangements.

This led to better operational performance and a longer product lifecycle. Further advantages of this holistic concept were demonstrated in precast construction projects. Fabricators and builders also achieved greater production scheduling accuracy by implementing BIM for shop drawings and digital fabrication models. When precast operations were incorporated into an IPD environment, design changes became more visible to the project partners, and the team had greater insight into planning changes, reducing potential material waste as well. Findings from the case studies confirm that the workability benefits of integrating BIM and IPD are greater in practice than in theory, as prior research has discussed.

#### **4.3. Expanded SWOT Analysis and Broader Sector Implications**

The SWOT analysis indicates several important strengths in adopting BIM–IPD integration to promote energy-efficient buildings. Principal benefits include streamlining planning activities, improving data integrity, and more efficient communication within the project team. The results also suggest emerging opportunities arising from stronger regulations related to green buildings and the digital transformation within the construction industry. However, the Review also identifies several challenges, including contract complexity, interoperability, and varying levels of expertise across the sector. These are indicative of wider structural constraints that policy interventions and capacity-building must continue to address. These attributes indicate that adopting BIM with IPD could drive broader transformation within the construction industry, particularly for those seeking to enhance environmental performance and operational effectiveness.

#### **4.4. Techniques of Implementation of IPD with BIM**

##### **4.4.1. Improvement of Skill Acquisition in the AEC Industry**

The insufficient IPD and BIM knowledge among the current generation of professionals concerns the AEC industry as a whole (Kahvandi et al., 2019). Following significant industry changes, academia is under additional pressure to develop suitable routes for the AEC workforce of the future. Jin, Hwang, and Kim (2020) stated that IPD provides the path, whereas BIM improves the construction building life cycle and supports IPD goals.

##### **4.4.2. Industrial Transformation**

The establishment of government-directing organizations to encourage industry conversion and deployment of model

projects to advance IPD and BIM (Kraatz, Sanchez, & Hampson, 2014; Reed et al., 2017).

#### 4.4.3. Adoption of IPD and BIM in CPM

Applying IPD and BIM seeks to overcome barriers to implementation in construction projects, as IPD can deliver several benefits, including cost control, time management, improved efficiency, and control over unexpected circumstances. BIM is a real-time method for multi-functional data design, storage, and operation on a collaborative platform (Fakhimi, Sardroud, & Azhar, 2016; Lam, Mahdjoubi, & Mason, 2017; Lee, Kim, & Yonghan, 2018).

#### 4.4.4. Shared Risk and Profits Based on Project Outcome

IPD contracts link rewards to the achievement of construction project goals. Despite variations in the formulation, the profits of stakeholders may be entirely or partially at risk and may even increase if the accomplishment is achieved or exceeded.

Personal profit results from the project's overall achievement rather than from the quantity of work completed or a person's productivity (Elghaish et al., 2019).

#### 4.4.5. Early Involvement of Key Participants

Accepted by the owner, designer, and builders. Mechanical, electrical, and plumbing designers and contractors are typically among the essential players since their expertise significantly influences design and because these parties are crucial to the project's success (Jones, 2014).

#### 4.4.6. Supply Chain Integration

The interaction between the supply chain and the project is crucial to the success of IPD, as supply chain integration affects waste, direct work, and coordination work. Supply chain integration is widely used to describe the involvement of crucial upstream and downstream partners in the industry. Through cooperative working techniques, strategies, and behaviours that encourage an atmosphere where project participants can openly discuss knowledge (Pu et al., 2023).

#### 4.4.7. Collaborative Innovation and Decision Making

Olaseni (2022) mentioned that integrating is a technical expertise activity, whereas cooperation is a data-centric activity. The AEC sector must put new building methods into practise and experience their synergistic cooperation before merging them, as interaction is the first stage in integration. (Ma et al., 2018) proposed a platform for BIM-based collaboration between different BIM servers and the large, "high resource-using" room, as an overlooked cause of BIM applications failing in IPD projects. Du et al. (2019) demonstrated a substantial negative correlation between the usage of incentive payments and penalties and hazard behaviour. The essential players participate in the collaborative invention and decision-making phase, which results in sustainability design methodologies (Kralisch et al.,

2018).

#### 4.4.8. Cost Management

Cost estimation and control are major concerns in complex projects. BIM has been shown to reduce variation orders, a primary cause of cost overruns. Elghaish et al. (2019) recommended that BIM be integrated with earned value management (EVM), activity-based costing (ABC), and blockchain to enhance transparency, trust, and financial control.

#### 4.4.9. Scheduling and Management

Ma et al. (2017) highlighted that the capacity of BIM has been proven effective in minimising change orders, although the implementation of IPD, to detect variation orders in a preliminary phase of construction projects, and noted that variation orders are a significant cause of cost overruns. Further investigation has proposed integrating BIM with cost management formulae, such as Earned Value Management (EVM), Activity-Based Costing (ABC), and blockchain solutions to improve the accuracy of cost estimation and accelerate the financial processes of IPD projects (Elghaish et al., 2019)

#### 4.4.10. Building Energy Efficiency

To significantly improve productivity, reduce construction waste, and promote energy efficiency. (Atabay, Pelin Gurgun, & Koc, 2020). (Oduyemi, Okoroh, & Fajana, 2017) reported that experts identified integrated project delivery as the most well-established advantage of BIM for building efficiency.

### 4.5. Conceptual Framework

Figure 6 below shows the research presented a preliminary IPD framework for the development of energy efficiency, integrated with the SWOT analysis, and illustrated based on initial findings.

The IPD and BIM adoption, project delivery contracts, cost control, financial management, and building energy efficiency and technology were the study subjects that received the greatest attention from academics. Early engagement of key players is essential, but at the same time, it is also a weakness of the progress as incompatibility issues; barriers in implementation and contract model; traditional mindset among stakeholders are highly shown in this phase, where the themes of early integration and supply chain integration were in connection to the long-standing problem of construction project fragmentation, a prerequisite of IPD. All sides must keep the lines of communication open throughout the whole process. The general IPD framework also necessitates initial goal formulation as a result, the project's primary agendas for esteem and confidence, distribution of benefits and rewards, management of risks, organisation, and leadership must all be worked out before it can move forward to show a strength such as its able to minimise construction errors; increase the sustainable

building design; improvement collaborative and share project benefits and risks among stakeholders. In construction, it shows up as a threat to this progress, as there is a lack of qualified personnel expertise, a lack of legal support from the authority, a lack of proper course materials and educational materials, and a lack of insurance cover for the projects.

Besides, there are not many papers on scheduling for building projects, and the KPIs for schedule and budget cannot be separated; hence, the topic was also covered within the cluster of cost management and finance. The main players participating in the collaborative creativity and decision-making process, using the right technology, show the opportunity to reduce environmental impact, improve

contractual matters, and foster greater innovation in building projects, resulting in building energy-efficiency design methodologies previously emphasised in this study. After the design phase, the planning and management of the construction project should be intensified to validate the targets and objectives. If the team's objectives are not met, the IPD team will collectively revise the design (as shown by the dashed arrow in Figure 6) before the building energy efficiency design is reviewed. The team will deliver a project that all key players originally desired if everything goes according to plan and the goals are met. Overall, we may conclude that the IPD's emphasis on BIM provides several coherence benefits over alternative project delivery methods.

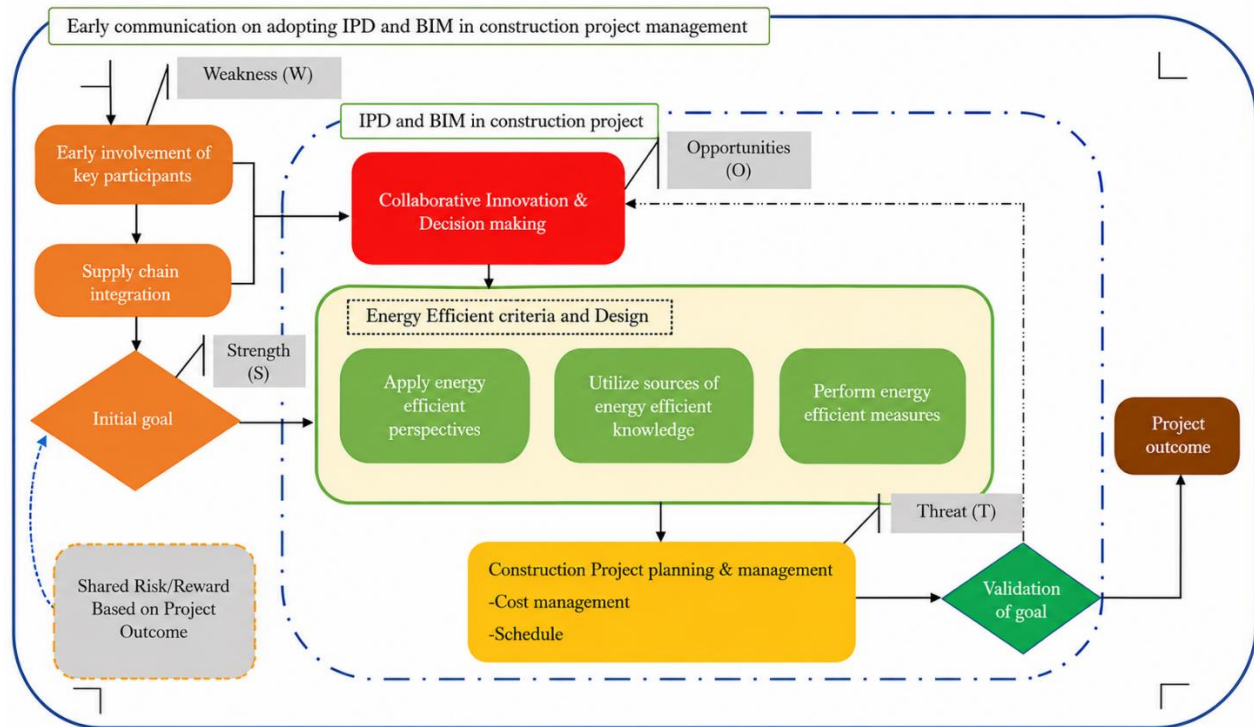


Fig. 6 Conceptual framework

## 5. Conclusion

To improve building energy efficiency, this Review provides a comprehensive assessment of studies on integrating BIM and IPD. The 102 papers in the fields of construction management, precast construction, and building energy performance were examined using a PRISMA-guided methodology. The findings show that while IPD and BIM have both been extensively studied, research on their combined use remains rare and scattered. Most of the literature currently available focuses either on the contractual and organizational aspects of IPD or on the technical capabilities of BIM, with little emphasis on how these approaches can collaborate to reduce inefficiencies, improve teamwork, and facilitate energy-focused decision-making in the early stages of design. This is followed by an overview of a few applied scenarios in which BIM and IPD interact for sustainable

building. BIM is a rich data environment that supports interdisciplinary design collaboration, performance analysis, and simulation. IPD reinforces this base by fostering the early involvement of stakeholders, risk-reward sharing, and transparent decision-making. By integrating these two methods, project teams can more effectively evaluate energy strategies, reduce rework, and increase constructability while ensuring that design decisions are increasingly aligned with sustainability goals. Case study findings also show that the combination of BIM and IPD in both cast-in-place and precast processes can support better performance throughout the lifecycle and has the potential to minimise material waste, favorably influencing final project outcomes.

The research contributes to the literature in three main ways. Firstly, it attempts to fill a significant gap in the

literature by providing an inclusive overview of BIM and IPD integration, whereas this issue has not been well established in the context of energy efficiency improvement. Secondly, an enhanced SWOT analysis framework is introduced to assess the internal and external factors affecting the adoption of BIM-IPD integration. Such a model offers significant implications for practitioners and policymakers in their reconnaissance of issues faced or strategic opportunities within the policy area. Third, the paper suggests several policy considerations and future research needs, such as further development of digital skills, empirical research on implementation in practice, and legislation to enable greater uptake of integrated project delivery methods. This Review contributes to a better understanding of BIM and IPD integration, though it has some limitations. The search was restricted to specific databases and English publications, so relevant studies in other languages or sources might have been missed. Furthermore, a large proportion of the literature reviewed remains conceptual or case-study-based, leaving considerable scope for further empirical research and long-term performance evaluation. The terminology used and the

definitions applied in BIM and IPD studies may also affect the extent of results across comparative evaluations. The research will focus on comparative field studies, integration with emerging technologies such as digital twins and real-time energy monitoring systems, and the development of supportive policy and regulatory mechanisms to enhance collaborative delivery in sustainable construction. In conclusion, BIM and IPD integration offer clear potential to enhance outcomes in energy-efficient construction. The integrated BIM-IPD process enables sustainable building performance throughout a project's life, supports intelligent decision-making, and drives collaboration that is crucial as the construction industry evolves through digital transformation. This overview is for the development of a more sustainable and synergistic built environment, as a basis for future study and project applications in practice.

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