CABA™

Intelligent Buildings: Design & Implementation

LANDMARK RESEARCH PROJECT

EXECUTIVE SUMMARY

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The Steering Committee contributed its time and industry expertise to the project during numerous Web conference meetings, offline sessions with the research team, and through interim and final review of the research processes, discussion guides, and this extensive report. The organizations and their representatives are:

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Project Background and Introduction

The Continental Automated Buildings Association (CABA) is a not-for-profit industry association dedicated to the advancement of connected home and intelligent building technologies. The Intelligent Buildings Council (IBC), a core working council of CABA, commissioned this landmark research project, titled "Intelligent Buildings: Design & Implementation", to obtain, on behalf of the Council members and the intelligent building industry stakeholders, a comprehensive understanding of the practices, challenges, process influencers and opportunities pertaining to intelligent building design and implementation. Traditional design and implementation processes are inadequate when catering to the needs of dynamic entities such as intelligent buildings. By undertaking this project, the IBC members sought to understand the importance and implications of adopting the right design practices and implementation methods that could bolster the adoption of the concept of intelligent buildings and the technologies and services associated with it.

The research examined the concept of intelligent buildings design and implementation processes from the perspective of building owners, occupants, vendors and service providers, industry associations, and think tanks. It referenced an existing body of literature in the public domain that pertains to this issue to corroborate findings obtained through discussions with industry participants and a comprehensive industry professionals' research survey. This executive summary offers a concise snapshot of the entire research project in a distilled manner, concentrating on the high-level and critical aspects of the findings. For easy reference, the key sections of the executive summary correlate to individual chapters in the body of the main report: Chapters 1-5.

The intelligent buildings industry is heterogeneous and fragmented by nature, and some segments of the industry are more open to adopting design practices and technology justification processes than others. Investment metrics, in relation to the efficiencies created by intelligent and integrated building design and implementation concepts, can significantly reduce ongoing operating costs and produce a timely return on investment for owners. Winning over project partners, service providers and key decision influencers, involved in technology procurement and fund allocations in the design, construction and operations processes, is often a complex proposition. The research confirms that in this highly complex and transitioning world of intelligent buildings, addressing core issues associated with pursuing the right design and implementation processes requires dismantling traditional silo based approaches, obtaining industry-wide consensus on change, and ultimately taking a strategic long term view of projects, beyond first costs.

CABA and Frost & Sullivan hope this report will drive attention to this key industry challenge and encourage effective dialogue among industry participants for creating awareness and exploring collective initiatives for driving optimal intelligent building design and implementation practices.

About the Report

CABA commissioned Frost & Sullivan to undertake this research project on behalf of the Intelligent Buildings Council (IBC), a working group of CABA. The project was funded by CABA and members of the IBC to understand the practices, challenges, process influencers and opportunities pertaining to intelligent building design and implementation (IBDI). The research commenced in May 2017, was conducted over a 20-week time period, and completed with a final webinar session in mid-2018.

The concept of intelligent buildings, and the value chain that caters to it, has expanded quite rapidly over the last decade. Encompassing players from a wide spectrum covering vendors, service providers, project execution partners and third-party professionals that help design, develop, fit-out, operate and continually service such an entity, this is a highly evolving landscape with a significant degree of fragmentation associated with its value delivery process. The challenge of keeping pace with technology has resulted in products and solutions often being incorporated in a sub-optimal manner, in additional to noticeable deviations in original design intent and ultimate outcome.

The outcomes of this collaborative research offer insights into the extent of these challenges, ways to alleviate inadequate practices, potential counter measures to be adopted and best practices identified that could help industry participants use design processes in a more favorable way. The findings will help vendors and service providers consider incorporation of design elements and implementation measures into their value proposition to create better buildings catering holistically to occupants' needs.

Role of the Steering Committee

The Steering Committee represents a cross-section of vendors, service providers, industry associations, utilities, and experts in the intelligent buildings marketplace. Representatives from each organization joined Frost & Sullivan and CABA on regular collaboration calls to guide the research scope and ensure that it met project objectives. Figure ES 1 shows the organizations that supported the project as Steering Committee members.

Figure ES 1: Project Steering Committee

About CABA

The Continental Automated Buildings Association (CABA) is an international not-for-profit industry association, founded in 1988, dedicated to the advancement of connected home and building technologies. The organization is supported by an international membership of over 365 organizations involved in the design, manufacture, installation and retailing of products relating to home automation and building automation. Public organizations, including utilities and government are also members. CABA's mandate includes providing its members with networking and market research opportunities. CABA also encourages the development of industry standards and protocols, and leads cross-industry initiatives.
Please visit http://www.caba.org for more information.

About Frost & Sullivan

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Frost & Sullivan led the research project for CABA, with integral support from Frost & Sullivan's Customer Research Group. The core consulting team and report contributors are:

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Overview and Focus Areas

Intelligent buildings (IB) are prime examples of innovative applications of technology meant to enrich occupant experience, enhance operational efficiency and provide long term value justification to owners and investors. The true value of an IB is realized through successful concept planning, design and technology implementation, effective operation and management (O&M), and cost savings via predictive maintenance and optimization, all of which are typically realized when pursuing a fully integrated design and implementation approach. This, in turn, is reliant on the building industry's motivation to adopt open standards and integrated systems, selected on the basis of their ability to scale over time, and seamlessly incorporate technology advancements that will allow the IB to offer ongoing benefits and advantages to its owners, occupants and operators. In reality, however, IBs exhibit a myriad of flaws in terms of their planning and implementation process, in turn delivering subpar performance and limited technology advancements.

The key focus areas of the project included the following:

- Evaluating the benefits of adopting proper design and implementation practices
- Understanding various design processes currently in use and the ways to improve their adoption
- Addressing issues and challenges propagated by value chain participants and determining ways to mitigate them
- Determining opportunities for collaborations and partnerships to address common challenges

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Key Objectives

The key objectives of the research encompassed the following:

- **Evaluate the need and adoption influencers** for parametrically justified intelligent building design concepts
- **Understand the state of the market** and hindrance factors that lead to value engineering of core design elements based on cost, lack of knowledge or proven efficiency factors
- **Assess the positive and negative stakeholder influence** in the design and implementation process of intelligent building technologies, and ways to mitigate technical adoption barriers
- **Evaluate measures** that will allow design tools and methods to be incorporated early on in the process

Methodology

Frost & Sullivan used a combination of primary and secondary research methodologies to compile information for this project. This included both qualitative research and quantitative tools for analysis and projection of key issues.

Primary Research Process

Primary research formed the basis of this project, with two major components: an industry-focused research module and a survey module targeted at the intelligent buildings industry value chain participants. The description of each is provided below in Figure ES 2.

Figure ES 2: Primary Research Methodology Description

Item	Component	Description	Target Group Profile	Sample Size	Research Technique
A	**Intelligent buildings**	Selection of technologically advanced buildings and smart campus projects	Builder owner, developer, facility operator	n=8-10	Analyst Interviews
B	**Intelligent building technology vendors and service providers**	Vendors and product suppliers of IB technology, connectivity and IoT solution vendors and third-party service providers	Vice Presidents, Directors, Product/Sales Manager, R&D Specialists, Alliance Partners	n=120-130	Analyst Interviews
C	Industry Influencers	Codes and Standard Development Organizations, Industry Associations, Academic Influencers, Regulators	Technical committee personnel, academia, regulators	n=22-30	Analyst Interviews
Total sample target Interviews accomplished (Average across groups A, B, and C)				**n=150-170 73%**	

Item	Component	Description	Target Group Profile	Sample Size	Research Technique
D	Industry professionals survey	Building owners, occupiers, internal decision makers of large portfolio real estate clients, operators, contractors, EPCs, design build firms, architects, specifiers, ESCO, system integrators	Developers, building operators, consulting engineers, general contractor, master service integrator, technology contractor, project designer, ESCO, specifiers, commissioning agents	Target: n=600-650 Actual: n=655 US: 85% Canada: 15%	Survey by invitation to online panel

Frost & Sullivan adopted extensively structured and high-profile discussion techniques with target participants for the industry-focused primary research, involving single or multiple senior level personnel and Frost & Sullivan's team of analysts and consultants to engage in insightful deliberations on the subject. This resulted in maximum value output in terms of information exchange and excellent validation of findings from the industry professionals' research survey. Similarly findings of the survey were triangulated with insights from the industry-focused primary research process.

Research Instruments: Questionnaire/Discussion Guide

The discussion guides for both modules of the primary research process were developed by Frost & Sullivan in consultation with the steering committee. Draft discussion guides were reviewed at the early stages of the project and feedback was mutually exchanged between the project team and the steering committee. Thereafter, the discussion guides were run through a soft launch process for market testing. Subsequently, the two research modules were launched. The sample for both research modules were generated using Frost & Sullivan's vast repository of contact sources and databases. The industry-focused primary research accomplished an average 73 percent fulfillment of the target sample. The data obtained from these discussions were analyzed and distilled into the commentary of the report. The online industry professionals' survey was launched and remained active for a period of seven weeks in the field. A total of 655 responses were collected against an original target of 600-650. The data from these responses were then analyzed using various qualitative and quantitative tools for interpretation in the report.

Secondary Research

Secondary research comprised the balance of the research effort and included published sources such as those from government bodies, think tanks, industry associations, Internet sources, the CABA Research Library, and Frost & Sullivan's repository of research publications and decision support databases. This information was used to enrich and externalize the primary data. A listing of all works cited is in the appendix. References are cited on the first instance of occurrence. Dates associated with reference materials are provided where available.

Any reference to "Frost & Sullivan's research findings, industry interactions, and discussions" in this report is made in the context of primary research findings obtained from this project "Intelligent Buildings: Design & Implementation," unless otherwise stated. However, the analysis and interpretation of data in this report are those of Frost & Sullivan's consulting team.

Definitions and Industry Professionals' Survey Qualification Criteria

For the purpose of this research Frost & Sullivan adopted the following definition, in consensus with the project steering committee: "An intelligent building is characterized by the presence of two of more integrated and interoperable systems that aids in intelligent decision making regarding its operational state at present and in the future." Defining a rapidly evolving concept as IB with such a broad stroke provided the study participants a degree of flexibility in envisioning and discussing it. Based on the

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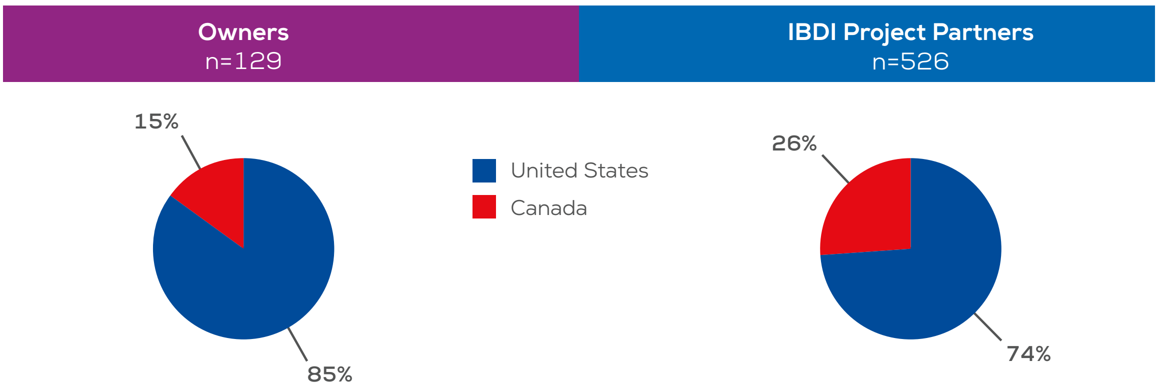
level of integration achieved, a building can move up or down the intelligence spectrum, with the corresponding benefits and key value drivers ranging considerably.

Participants in the industry professionals' survey were offered the same definition of an intelligent building; however, for easy understanding and screening purposes, a battery of screening questions was asked as part of the qualification criteria before allowing them to proceed with the survey. The respondent screening and qualification process entailed the following qualifiers:

- Country of organization
- Size of the firm
- Type of organization and the activities it is involved in
- Whether or not the participant played a role in designing, planning, or implementing the IB technologies
- The responsibility and accountability profile in the decision-making process
- Other qualifiers specific to the organization profile of the respondent

Accordingly, a respondent who did not fall within the requisite criteria was disqualified from the sample. Once the respondents were qualified to proceed further with the survey, they were taken through a series of questions. Several criteria within the set questions were looked at to classify respondents in relevant categories to aid resourceful analysis. The sample was broadly classified into building owners/ occupants and project partners. Further sub-divisions were obtained within each broad category. The results of the respondent profiling process are illustrated below. Chart ES 1 shows the country classification of the broad category of respondents.

Chart ES 1: Country Classification within the Category of Respondents



Q: Country of organization

Respondents were geographically categorized for United States (US) and Canada. The US respondents comprised 85 percent of the sample, while the remaining 15 percent were from Canada. Of the total sample, 19 percent of owner-operated companies and 17 percent of project partner companies had revenue greater than USD $30 million.

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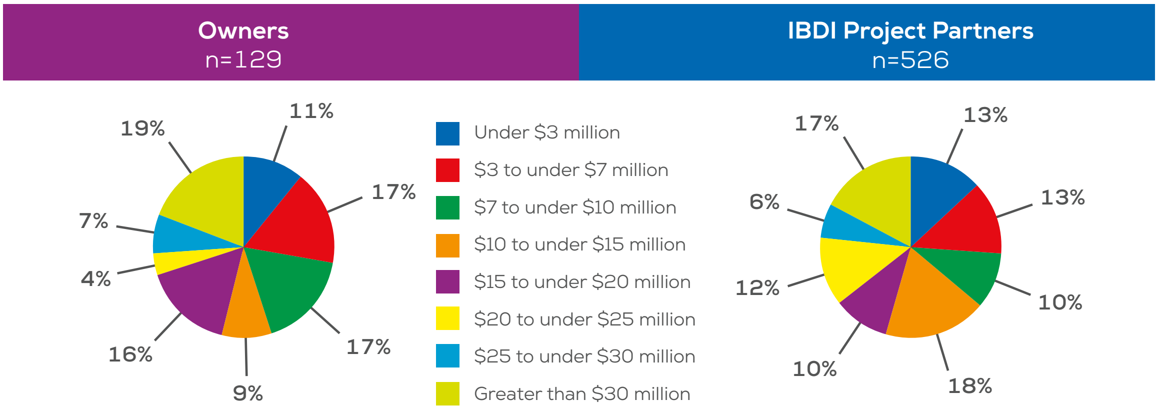
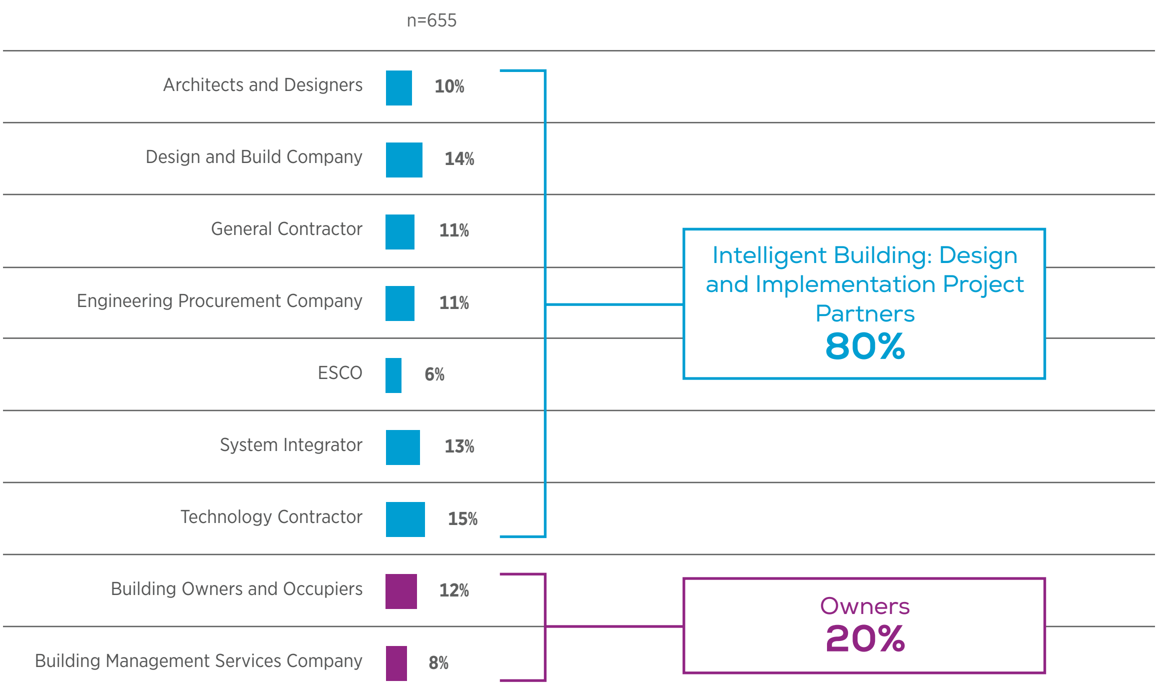
Chart ES 2: Annual Revenues of the Organization



Q: What was your company's total revenue for the last full fiscal year?

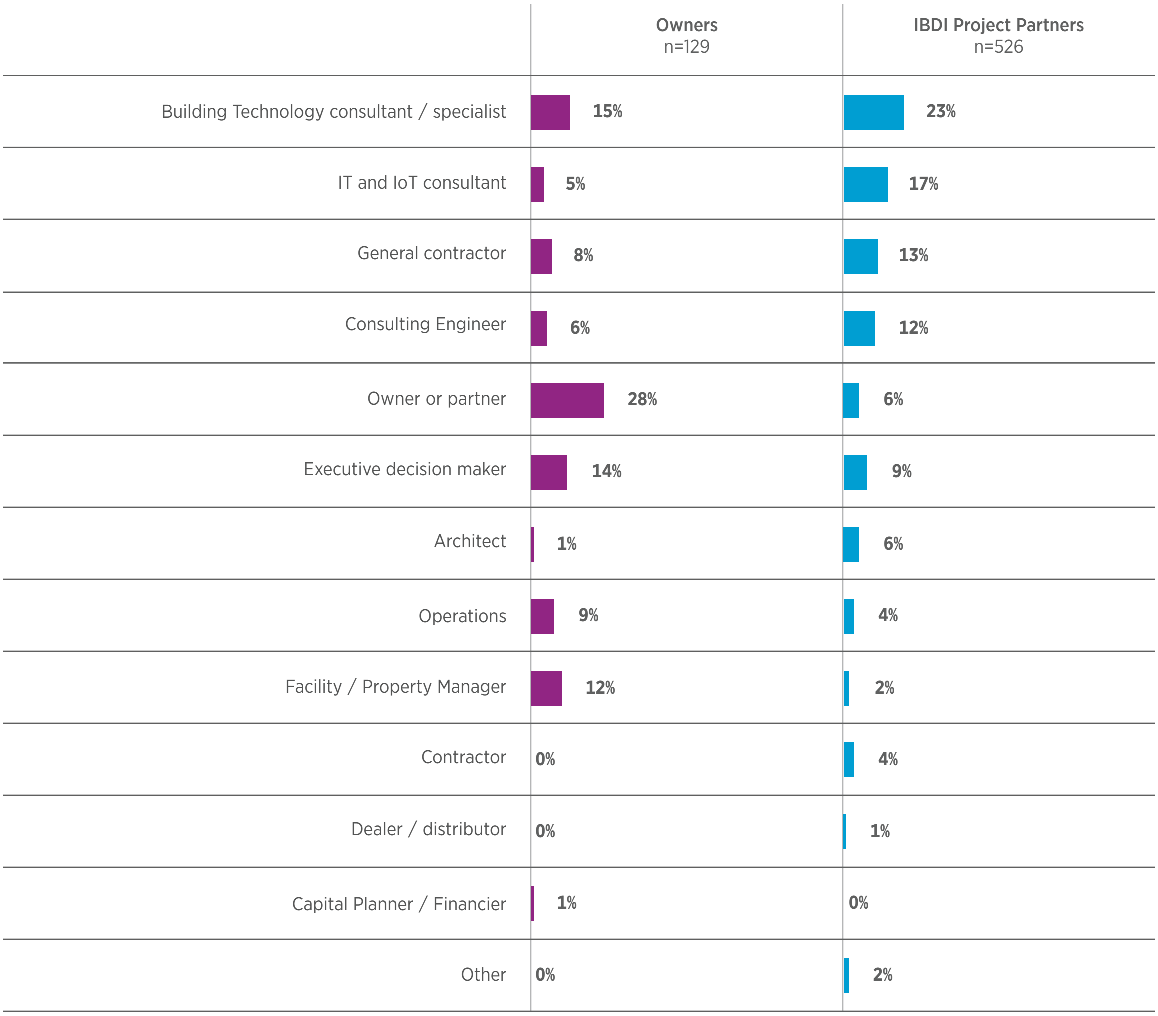
A significant 20 percent of respondents were building owners and 80 percent were project partners. The respondents were further categorized based on their job profile within the organization, thus allowing the research team to glean distinct feedback from key decision makers involved in such processes and their specific perceptions regarding various aspects of the design and implementation process.

Chart ES 3: Organizational classification of respondents



Q: What type of organization do you represent?

Chart ES 4: Profile of Respondents



Q: Which of the following best describes your job title?

Layout of the Report

The report is structured into five chapters with an executive summary outlining the overall objectives, research areas and findings, Chapters 1-5 and an appendix. Figure ES 3 provides a brief layout of the report to help navigate its contents.

Figure ES 3: Intelligent Buildings: Design and Implementation: Layout of the Report

Sections	Title	Content
Preface	Executive Summary	Background and introduction; objectives, methodology and definition, overview of top findings
Chapter 1	Intelligent Buildings: Design & Implementation – An Overview	Overview of intelligent buildings industry, definitions, IBDI methods, participants' roles and responsibilities, issues and challenges, areas to be addressed

Sections	Title	Content
Chapter 2	Industry Perception Analysis	Introduction and methodology, sample classification; IBDI adoption potential analysis; benefits and outcomes; expectations from vendors and project partners; key takeaways
Chapter 3	Addressing Key IBDI Adoption Challenges	Issues and challenges in IBDI adoption; consensus development on core issues; process optimization needs
Chapter 4	Evaluation of Process Optimization Requirements	IBDI process optimization: key elements; best practices; value chain interdependency evaluation
Chapter 5	Conclusions and Recommendations	Conclusions of the research and key recommendations
Addendum	Appendix	Glossary of terms; references

Summary of Key Findings

The key findings of this research as discussed through Chapters 1-5 are outlined subsequently. Discussion under each heading represents a synopsis of the chapter corresponding to it in the report. For example, ES-CH 1 corresponds to executive summary of Chapter 1.

ES-CHAPTER 1 INTELLIGENT BUILDINGS: DESIGN & IMPLEMENTATION–AN OVERVIEW

Overview of the Intelligent Buildings Industry

The term 'intelligent building' (IB) has had a variety of definitions and terminologies since the early 1980s. The definitions cover differing levels of importance given to various aspects and measuring parameters that contribute to building intelligence. Commonly, IBs are characterized by the presence of devices, controls, and systems that interconnect and communicate with one another to enable an environment that is responsive and adaptive to occupants' needs and comforts. The degree of "intelligence" varies by the sophistication underlying the software-aided applications and communication network that helps these devices and systems function in an interoperable manner and share operational data. This ultimately forms the backbone of this evolving concept. The evolution and transition in buildings has led industry experts to dwell upon various terminologies such as green, automated, intelligent, smart, and high performance to define these buildings.

Defining an Intelligent Building

For the purpose of this research Frost & Sullivan adopted the following definition, in consensus with the project steering committee: "An intelligent building is characterized by the presence of two of more integrated and interoperable systems that aids in intelligent decision making regarding its operational state at present and in the future." Defining a rapidly evolving concept as IB with such a broad stroke provided the study participants a degree of flexibility in envisioning and discussing it. Based on the level of integration achieved a building can move up or down the intelligence spectrum, with the corresponding benefits and key value drivers ranging considerably.

Figure ES 4 depicts a building's characteristics associated with its corresponding level of system integration and intelligence, as progressively tracked by Frost & Sullivan over the last decade.

Figure ES 4: IB Characteristics and the Level of System Integration

Building Profile	Design and Spec Approach	System Integration Specialist	Integration Determinants	Limiting Factors
Non-integrated	• Segregated approach divided across different participant groups • Performance specs with minimal design documentation	• Overtly dependent on contractors	• Availability • Low cost • Relationships • Lack of open standards • Difficult to accomplish system integration	• Least conducive to occupant needs • Long-term maintenance contracts of manufacturers • Engineering-by-design not adopted as a norm • Costly upgrade contracts
Partially integrated	• Combination of segregated and integrated approach • Some design documentation, but generally standalone system/hardware intensive • Meets the minimal criteria of achieving an IB status	• Dependency on contractors and system integrators	• Advocacy of open standards to some degree • Cost still overrides decisions • Benefits of integration not fully exploited	• Hardware intensive with multiple communication interfaces/gateways making the switch to full integration cumbersome • Proprietary strongholds persist • Partially responsive to occupant needs, though features significant gaps
Fully integrated	• Technology contracting or integrated consulting approach with a sole source contractor assigned • Design documentation is a mandatory norm • Sub-system integration at the control network level	• Collaborative approach and accountability shared by multiple stakeholders with the building owner at the center of decision making	• *Features an integrated design and execution process* • *Specs dictated by compatibility and interoperability* • *Demonstrates lowest life-cycle cost*	• Variances in cost estimation • Perception issues with regards to cost and time consumed • Lack of skilled professionals • Lack of project partner coordination

The IBDI Methods and Practices

This research found that there are no clear cut methods or implementation processes that specifically exist for IB projects. However, various permutations of widely used and traditional design and procurement methods, such as bid-and-spec and construction management, currently serve as the "go-to methods" for IB projects.

Given the undefined and informal nature of this space, it was imperative to start by isolating such processes embedded within these traditional methods that can conform to IB project planning and delivery requisites and adopting a separate nomenclature that can help appropriately position them as "IBDI methods". Accordingly the following methods were identified, as depicted in Figure ES 5.

Figure ES 5: IBDI Methods Prevalent in the Industry

IBDI Methods	Description	Key Highlights
Design-bid-build	• The design-bid-build method, when used for IBDI, works on similar principles, as when used in a non-IB context. • It starts with the building owner's selection of a design build or a consulting engineering firm. • IB design and procurements tasks, specific to each technology or process, are initiated sequentially with limited overlaps. Typically the building owner or occupant contracts with separate parties for the design and for the implementation of the project.	• Clear vision of technology requirements to be fulfilled • Demarcation of roles and responsibilities by design, procurement and implementation
Design-build and implementation	• In this method the building owner or operator contracts with a single party who takes charge of the design, procurement, integration and implementation of the IB technologies and processes that are contracted to this party. • This method can potentially reduce the project delivery time by overlapping the design and implementation phases of the project.	• Single point of contact enhances overall accountability • Simultaneously execution ensures better coordination of technology integration needs and processes
Performance-linked implementation	• This is essentially a variation of the "design-build and implementation" method in which a performance guarantee is linked to the technology or process implementation that is contracted from such service providers. • For example, guaranteed energy saving, compared to a baseline performance, is expected to be delivered under such contracts from the contracted party. • This has often been an instrumental way of adopting IB solutions, entailing zero, or negligible upfront investment in certain cases.	• Assured guarantee stipulations increases the onus and accountability of the service providers contracted • Considered the most effective way to fast track technology implementation in IBs in recent years
Collaborative implementation	• This method essentially combines best-of-breed processes and practices that are already inherent to the preceding three methods, in addition to provisioning the ability to incorporate specialists, new industry entrants, and outside industry entrants as needed. • The purpose of such collaboration is to facilitate a robust delivery and implementation process that is closely aligned with the owner's or occupant's vision and future expectations from the building.	• Proper coordination and collaboration ensures better technology and process integration • Ensures low life-cycle costs • Offer scalability of initial investment

In practice, it is quite common for some of these methods to be used in conjunction. Additionally, sub-classifications of these methods have tended to proliferate in response to market demand. The research revealed the following key imperfections that characterize the current value delivery process associated with majority of IBDI projects as discussed below.

Extreme Fragmentation Creates Polarization of Goals

OEMs, product vendors, and technology vendors work, either directly with the building owner, or through any of their supply chain partners. These partners generally include their own line of agent representatives, distributors, and system integrators. Unless working directly with building owners, often times these partners either interface with a contractor, architect, or a project management agency that takes on the responsibility of fulfilling the project execution and installation. As a result, a single project can have up to three different layers of supplier representatives and assigned integrators who liaise with the contractor, often creating conflict of interest, and jeopardizing their own prospects.

Multiple Decision Makers Lead to Fulfillment Nightmare

While the contractor typically assumes all technology procurement responsibility, actual decisions on what to procure are often incumbent upon what the project fulfillment partners, such as consulting engineers (CEs) or energy service companies (ESCOs), decide in conjunction with the building owner. There is a further fragmentation of the value chain at the general contractor level where electrical, mechanical, and other sub-categories start interfacing with the general contractor.

Static Model with Limited Dynamic Intervention

Linear and orchestrated as it may appear, the reality of conducting business within this value chain presents some critical challenges for all parties involved. Managing costs, expectations, project objectives, and ensuring that all parties understand and deliver to those objectives poses a major hurdle in each step of the process. However, a significant constraint arises in that the structure of the value chain has remained fairly static, despite the fact that technology and operational requirements of buildings have undergone considerable changes. Clearly the processes have not kept pace with these changes, thus resulting in situations where transactional practices have taken over what should have been a seamless delivery process.

Lack of Design Flexibility Eliminates Technology Integration Prospects

Each group in the value chain has a role to play in ensuring timely and quality design implementation, construction and installation in any project. However, due to the staggered nature of contracts awarded, it is not possible to involve all groups during the initial design phase. It is imperative that the architect be flexible enough to make the requisite changes as they often emerge down the road with key IB technologies. For example, integrating lighting systems that might require supplemental natural lighting for energy-saving methods may call for changes in the architectural design and clearance from the architectural design partner. These changes are often never factored in, nor budgeted for in advance, leading to futile negotiations and delays during the implementation phase.

ES-CHAPTER 2 INDUSTRY PERCEPTION ANALYSIS

The research survey conducted among industry professionals provided important insights into the overall adoption, issues and challenges associated with IBDI processes and methods from the perspective of value chain participants. The imperfections in design process integration, technology deployment using such processes, and the expectations of owners and occupants from project partners was obtained from this research. The top findings and strategic messages that can be drawn from the survey are highlighted below.

Growth Potential

Significant growth potential exists for the adoption of an IB design and implementation practice or method. The research indicates this trend could witness an average of 46 percent penetration within the next three years, pointing to a dynamic and fast-evolving market. Due to the application of different technologies in an IB, it is essential to have proper integration and interoperability for a successful outcome. The inclusion of lighting, security, fire alarms and HVAC systems in the design and planning phase of an IB is expected to witness five to 12 percent penetration in the next two years. Therefore, it can be concluded that the future demand for IB technology will feature the inclusion of smart lighting systems, robust security systems, and energy management equipment. Accordingly, in the immediate term, safety and security; energy efficiency; reduction in operational expenses; and better ROI management will continue to be key drivers for the adoption of IB technologies. The ability to quantify energy savings, create ways to reduce operational expenses, increase comfort and convenience, and, most importantly, maximize space utilization by offering compact interoperable systems will be instrumental in maintaining market demand for IB solutions.

Practices and Outcomes

A complete analysis of an IB project and having positive execution practices in place are the most important criteria for successfully designing and implementing an IB. Building owners and project partners should have a unified view of all the smart technologies included in the project. They should participate in every aspect of design and work as a team towards the constructive implementation of an IB. The favorable cost-benefit ratio associated with adequate planning are motivating factors for the adoption of proper design and implementation practices. Having a universal view of the design and implementation plan and active collaboration between project partners, such as design companies, architects, technology consultants, and system integrators (SIs) from the onset of the project will lead to the desired outcome. The benefits of adopting IB best practices, including financial management and through energy efficiency management, building operation optimization, and comfort and convenience, will lead to overall tenant satisfaction.

Distinctively disjointed value chain partners lead to poor IB execution. Haphazard inclusion of design partners and a lack of teamwork are the primary attributors to poor implementation processes in an IB project. Poor design, over reliance on outsourced partners such as contractors, a lack of communication between key stakeholders, and non-cooperation between workers and project partners are some of the top negative practices resulting in an undesired and delayed outcomes.

Adherence to Best Practices

Currently, only 30 percent of respondents follow best practices; however most respondents have a strong desire to implement key best practices. The incorporation of good building design ensures value propositions such as proper space utilization, energy management, and smooth operation of systems installed in an IB project. The trend of collaboration between design consultants and relevant parties helps minimize design changes and reduces project deadlocks. Clearly conveying the design process to various participants helps develop a roadmap for proper integration of the various technologies involved in an IB. This practice was significantly perceived as the most valuable process not only by project partners, but also by building owners. Other valuable practices include having an experienced internal team that can clearly understand project needs, managing project costs through the timely incorporation of technology solutions and respective vendors, and having good communication and teamwork. On the other hand, respondents who rely on the contractor to help implement the design are perceived to be using fewer best practices because this tends to cause significant delays and cost overruns.

Role of Value Chain Participants

The architect, design build contractor, and technology consultant are the top partners in determining the standards and specifications of an IB project. However, the influence level of these partners changes with the type of construction. These partners have the highest level of influence in new construction and renovation projects. Nevertheless, due to significant involvement of building owners and occupants in retrofit projects, they have less power in determining the standards. The role of project partners is not just to deploy and specify what goes into a building, but to also educate the value chain participants (such as consumers and building owner) about the benefits associated with proper design and implementation. Technology consultants must be able to demonstrate the value of implementing smart technologies from the very beginning. Project partners and building owners were involved in major initiatives to educate end-users, such as in producing informative videos and courses on how to correctly use and install the new technology and understand the benefits associated with proper implementation.

Overall, this research confirms that the practices currently followed during the design and implementation of an IB are not well-integrated by all value chain partners. Only 30 percent of respondents adopted a structured and systematic method of utilizing best practices in their IB processes. Because of this, most organizations have fundamental issues and challenges that need to be addressed in order to mitigate project completion delays and meet customer expectations.

ES-CHAPTER 3 ADDRESSING KEY IBDI ADOPTION CHALLENGES

The core issues that challenge incorporating IBDI processes revolve around broad themes of communication, capital expenditure (CAPEX) versus operational expenditure (OPEX), conflict resolution, improper expectation setting, and the inadequate training of resources. These affect both adoption rate and project execution processes for IBs. The resulting impacts include significant cost overruns and project delays. In certain cases, drastic deviations from the original vision and objectives are responsible for recurring maintenance challenges of these buildings and ongoing downtimes. Addressing these concerns involves navigating a myriad of critical issues and challenges for all stakeholders involved.

In this regard, some key issues and challenges for the industry stakeholders are shown in Figure ES 6.

Figure ES 6: IBDI Domain Issues and Challenges

Issues[1]	Challenge and Impact	Propagated By
Value Engineering of Components	• Driving project decisions on cost • Declining vendor interest for innovation	• Contractors, SIs, EPCs, Owners
Absolute Control of Contractors	• Lack of product incorporating knowledge • Driven by cost and schedule to complete and move on • Hindrance to the installation of other requisite systems as the project progresses	• General and mechanical contractions; sub trades
Inadequacy of Tools and Standards	• Lack of specific IB design tools • Generic elements and broad framework of design specification Master Formats • Inadequately defined specifications for rating quality and functionality of IB technologies	• Design Tool Developers; Specification Standard Developers; Professional Bodies
System Interoperability and Integration Issues	• Static design and inability to incorporate future innovative solutions • Limited control over processes and outcomes • Cost implications	• Vendors and SIs
Exclusion of Owners and Occupants	• Faulty structure of task allocation and communication flow • Lack of feedback loop • Vision and strategy mismatch with final outcome	• Design build firms; CEs; Vendors

Issues[1]	Challenge and Impact	Propagated By
Training and Certifications	• No institutionalized options • Training costs can be a deterrent • Consensus on qualifications to certify • Keeping pace with technology advancements • Maintaining a qualified resource pool	• Academic Institutions; Professional Certification Bodies; Vendors
Credits and Incentives	• Takes years to develop • Compliance cannot be enforced • Biased towards passive components • Lack of comprehensive treatment of IB technologies and practices	• Associations and Accreditation Agencies; Utilities

In addition to these challenges, the continued advancement in IB technology is increasingly creating a new generation of technology and services enabling participants. These participants will link users, suppliers, and intermediary channels in innovative ways and open up new communication flows. As a result IBDI practices will need to keep pace with such disruptions in this marketplace. Chart ES 5 provides an overview of the key contributing factors for IBDI breakdowns and failures.

Chart ES 5: IBDI Breakdowns and Failures: Key Contributors

IBDI projects fail to deliver on their strategic goals in four key primary areas. While secondary contributing factors propagate these failures further, these primary factors are often the triggers that perpetuate a cycle of process breakdowns, typically with little scope for course correction in place.

Lack of Partner Alignment

49%

of participants experienced the impact of this factor in negative project outcomes

Unclear Vision & Strategy

51%

of project participants agree to this as a key contributor to IBDI failure

Disjointed Planning & Processes

56%

of the overall respondents attribute IBDI breakdowns to this factor

Inability to Monitor, Test & Adapt

58%

agreed to the inability to rectify problems or change course during the execution phase

Remediation of such challenges calls for consensus building among IB value chain partners, including owners and occupants, to deploy corrective techniques and comply with them in an objective manner. The best practices identified in successful IBDI projects point to the fact that given strong will and commitment from the project partners, these are highly achievable and are easily instituted for the IB industry at large. In order to make these mainstream components of the IB industry, it is important that these are adopted more commonly across projects, as opposed to being experimented on some. Given the tangible benefits and outcomes that can be attributed to the adoption of these measures, there is little doubt that the IB industry has more to gain from their swift incorporation.

ES-CHAPTER 4 EVALUATION OF PROCESS OPTIMIZATION REQUIREMENTS

When evaluating the strength of an IBDI value proposition, the research found that the following elements must be considered: process optimization, interdependency of value chain partners during implementation, and best practices that stakeholders should adopt.

Figure ES 7 provides an overview of inadequacies found in traditional processes and the focus areas identified to achieve optimization and cutting-edge practices.

Value Chain Interdependency in Implementation

To optimize processes and successfully implement an IB, value chain partners share a common responsibility to understand the project objectives in detail and address the issues of coordination, communication, and project control across the entire value chain. This value chain interdependency during IB implementation is evident in the typical and collaborative models that exist in this industry. For successful execution of IBDI projects it is imperative that a collaborative approach be adopted that permits early involvement of various participants, including different contractors and systems integrators (SIs), which positions them to understand the project goals, objectives, and design specifications, while empowering them with extra room to devise creative solutions and engage in the intensive exchange of ideas that is missing, yet needed, to help them better approach the project design and implementation of an IB.

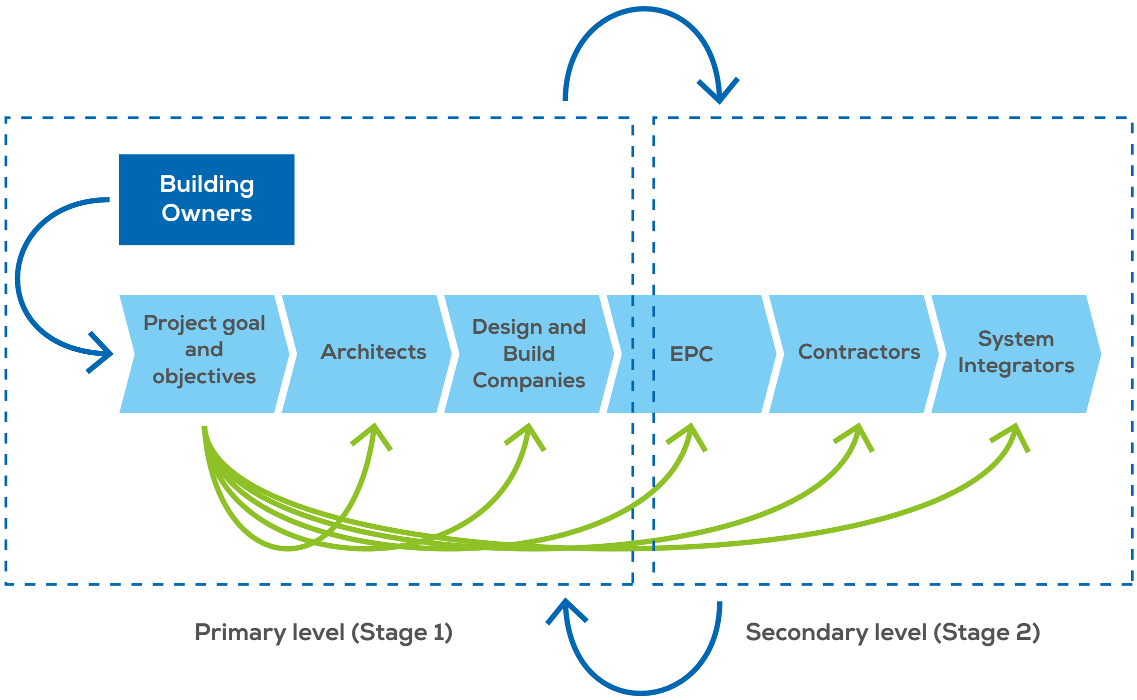
Figure ES 7: Challenges in Traditional Processes and Area of Focus

Stage	Challenges in Traditional Processes	Areas of Focus
Design and Planning	• Disconnect among value chain partners • Cost-driven approach by owners • Inadequate efforts to understand stringent project specifications leading to poor design • Lack of awareness about IBDI benefits • Lack of understanding of technology advancements • Team inexperience • Over-reliance on contractor	• Collaborate with project partners. Even earlier involvement of contractors, technology partners and operation and maintenance team is needed to provide feedback during the initial phase. • Building owners should focus more on long-term and operational costs. • Insist on establishing a complete and detailed understanding of the desired goal(s) and project specifications to ensure a strong design plan. • Stay updated on the latest technological advancements and associated benefits. • Have an experienced and multi-disciplinary team to generate the perfect design plan. • Understand the functionality of various technologies.
Execution	• Identification and allocation of resources • Slow to comprehend interoperability and integration of technology • Lack of communication and collaboration among project team, vendors, and owners • Lack of in-depth knowledge of technology	• Precise material and manpower should be allocated for specific activities. • Establish an experienced team for execution. The resources should be able to quickly grasp the integration and interoperability of the devices. • Maintain open communication with all project partners, including building owners. • Education and training is needed on the application of particular technologies to ensure contractors and system integrators provide solutions as per the project standards and specifications.

Stage	Challenges in Traditional Processes	Areas of Focus
Control	• Weak project monitoring and control	• Building owners, consultants, and contractors should regularly monitor and use tools to control the progress and cost performance of the project.

Chart ES 6 illustrates the collaborative approach.

Chart ES 6: Collaborative Approach of Value-Chain Partners



EXECUTIVE SUMMARY

ES-CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

The top findings of this research validate some of the early hypotheses around the nature of complexities associated with the IBDI process, and the triggers that cause it to either fail, or perpetuate subpar project delivery. If not addressed appropriately, such faulty practices will continue to hinder market adoption rates of IB solutions and services, despite a desire of owners and occupants to experience and invest in IBs. Creating proper process flows, collaborative engagements and education will help drive focus to the right practices that both owners/occupants and the industry can adopt to bolster the market acceptance of IB solutions and IBDI practices. Figure ES 8 summarizes the key conclusions.

Figure ES 8: Intelligent Buildings: Design & Implementation: Key Conclusions

Intelligent Buildings Design & Implementation: Key Conclusions

IBDI practices are largely undefined and informal in nature. Being generic substitutions of prevalent design and procurement methods, the end results they yield does not always render desired outcomes. Among the key methods in use, the performance-linked implementation method has, by far, the highest appeal given the ability to offset upfront capital costs by the owners and occupants.

The distinct influence of various trades in the planning, design and contracting processes involved results in cost becoming the sole determinant for undertaking an IBDI project, no matter what the original schematic design called for.

A significant constraint that arises with any IBDI project is that the structure of the value chain that influences it has remained fairly static, despite the fact that technology and operational requirements of IBs have undergone considerable changes.

The incremental demand penetration for IB technologies and practices is expected to witness a 46 percent growth within the next three years, pointing to a dynamic and fast-evolving market. This makes it imperative for industry participants to adhere to IBDI best practices in order benefit from this trend.

While there are fundamental challenges in pursuing IBDI methods, adopting best practices and pursuing an integrated technology design and contracting approach from the start has demonstrated in several cases that there are tremendous opportunities for IBDI processes to evolve and be more frequently adopted.

The key recommendations of this research include the following:

- Standardize requirements for design inputs and technology specification parameters to conform to IB principles for streamlining processes
- Engage with owners, occupants and operators to capture project vision, long term goals and IB technology orientation for their cohesive inclusion
- Develop partner strategies in working with the IBDI value chain, lay down stringent guidelines, and expect satisfactory compliance from peers in implementation
- Promote better communication flow, including project records, feedback loop, and incorporation of neutral project advisors to ensure transparency at all times
- Collaborate on industry initiatives around education, training, standards, and policy

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