

Evaluating the Economic Values of Intelligent Building Designs

K CHAN, Hong Kong, China

Key words: Intelligent building designs, economic values, competitive edges, post occupation evaluations.

SUMMARY

Intelligent building designs have been a modern trend to cater for enterprises to strengthen its competitive edges in a global market. Such design will primarily involve protocols, high-speed local area networks, multimedia environments, fiber optics, satellite conferencing, and advanced information technologies. This paper aims to explore the economic values and extent of intelligent building designs that will achieve, through a case study of a deluxe commercial office tower in a central business district of Hong Kong. Qualitative approach by means of structured interviews with relevant major stakeholders will be conducted, so as to collect appropriate data to assess the needs, impacts, achievements, financial returns, users' satisfactions, post occupation evaluations for the aforesaid intelligent building designs. It is expected to cast some lights for the way forward in adopting more innovated intelligent building designs.

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1. INTRODUCTION

Intelligent Building (IB) and Smart Home have become a very popular description covering almost all new commercial and residential buildings in major cities worldwide. Generally, IB relates to buildings that contain high-speed local area networks, protocols, fiber optics, multimedia environments and even satellite conferencing. In addition, all modern IBs possess advanced Information Technologies (ITs). IB integrates most building services systems into an IT environment; whereby advanced information, control technologies, smart structure and modern management theories are adopted.

European Intelligent Building Group (EIBG, 2015) advocates that IB also involves the best available concepts, materials, systems and technologies, integrating these to achieve or exceed the performance requirements of the stakeholders whom are building owners, managers, users, and local/global community. Failure to consider the impacts of IB operation can result in poor performance and low acceptance of the design concepts and 'SMART' technologies by the occupants. Evaluation of IB performance has been developed from an existing matrix methodology for IT effectiveness and energy management; incorporating SMART building technologies and market actors in the design/operation of IBs.

In the early 80's, a building incorporating the latest technologies and automation can be considered as intelligent. Since then, the emerging technologies remain undeniable; whilst the responsiveness/adaptability of buildings towards the changing requirements of built environment become crucial. Nikolaou et al. (2015) requires IB to provide a productive and cost-effective environment through optimization of its four basic elements - structure, systems, services and management - and the interrelationships between them; incorporating the best available concepts, materials, systems and technologies that exceed the stakeholders' expectation. In this regard, IB development can be summarized below:

- To 1985: IBs are buildings automatically controlled to function.
- 1986 to 1991: IBs are buildings capable of responding to the changing needs.
- 1992 to present: IBs are buildings with features effectively satisfying the changing needs.

EIBG (2015) contends that IB is one that maximizes the efficiency of its occupants and allows effective management of resource with minimum life costs. An IB should provide a productive and cost-effective built environment through optimization of its four basic components - structure, systems, services and management - and the interrelationships between them. It focus on the benefits of owners

and their desired indoor environment to maximize the efficiency of its occupants whilst creating desired indoor environment for occupants. It also allows effective management of resources with minimum life costs, and focus on the economic impacts of creating desired indoor environment. As such, the built environment should be productive, safe, healthy, and thermally/aurally/visually comfortable; and the building should render sustainability and adaptability for future generations.

The world is changing the way they think about energy. Buyers and tenants, especially in commercial buildings, are looking for much higher energy efficiencies to avoid the growing future energy expenses. IB is perceived as a long-term and value-added investment, with the following benefits:

- Provides a better and more comfortable environment for occupants, leading to improved working efficiency with the aid of modern IT.
- Ensures lower life-cycle costs, in particular for maintenance and upgrades.
- Guarantees a greater flexibility in modifying a building's functions.
- Maintains a relatively higher value for a building in terms of marketability and productivity; thus establishes a renowned image to the public whilst fulfill users' requirements.
- Upholds the concept of an environmental friendly building.

It is believed that IB will become a major building trend in the coming decades. Asian Institute of Intelligent Buildings (AIIB, 2015) advocates that IB is designed and constructed based on an appropriate selection of Quality Environment Modules to meet the User's Requirements by mapping with the appropriate building facilities to achieve a Long-Term Building Value. Further, AIIB (2015) indicates that the Intelligent Building Index (IBI) serves as a reference in assessing the intelligent level of a building; where nine Quality Environmental Modules are developed. Under each Module, a list of Elements affecting the performance of the Modules is also defined. To facilitate comparison of IBs by the building natures or end-users needs, different weights are assigned to each Module according to its importance to type of building. Besides, So, Wong and Wong (1999) extend IB into two perspectives, i.e. the needs of building developer/owner/occupants and the enabling technologies. The integration of these two dimensions will generate measurable long-term building values such as productivity, market value, energy conservation, environmental friendliness and high working efficiency.

The high technology concept of smart buildings is introduced in United States in early 1980s; where electronics are engaged extensively in the following aspects:

- Energy efficiency
- Life safety systems
- Telecommunications systems
- Workplace automation

Over time, the four aspects have been merged into two broader ones: facilities management (energy

and life safety) and information systems (telecommunications and workplace automation). Through the wise integration of a building's services, a single system is explored to monitor the gas, electricity, water, air and steam installations. All these utilities can be tracked and monthly reports are automatically generated. These data can be accessed via a web browser, allowing immediate access to diagnostics and remote device interrogation. The integration of building services helps in the initial phases of a building's infrastructure. The management and control can be regarded holistically; whilst installation costs for cable runs and shared networks can be reduced. Remote access to such detailed diagnostics allows the facilities manager (FM) to easily track and control a building's utilities. It is amicable to preset lighting and heating controls via a web browser and alter these settings if required.

By means of careful metering and recording of a building's utilities, reporting becomes easier. It is no longer necessary to physically go to each meter and record the readings. Moreover, an intelligent metering system provides real-time data that allows FMs to easily identify trends and to mitigate/diagnose problems effectively. With the ability to capture events and greater access to diagnostics, it is simple to identify where, when and why an unusual reading occurred. For example, it is possible to determine if a power-quality problem lies with the utility supplier or within the building. Such a system can also determine if suppliers have provided equipment that adheres to specified rates. Transients, which can damage electronic equipment, can be pinpointed and power quality issues highlighted. This is particularly important in factories, hospitals, data centers, etc.; where electrical disruptions can lead to unexpected financial loss and unsafe situations. By effectively monitoring the electrical and piped utilities, equipment life can be increased and trend information can be utilized for further cost-savings.

It is equally possible to quickly identify areas where energy is being wasted. Moreover, empirical studies of metering solutions show an average 5% reduction in utility bills in different buildings. Savings of 2 to 5% can be achieved by better equipment utilization, and even upto 10% savings potential can be reached by improving the reliability of systems. FM incorporates a computerized system which controls building operations, energy and life safety. Evidence shows that operating costs typically amount to almost three times the capital cost. Maintenance has traditionally been reactive. Intelligent building-control systems can help maintenance to be proactively scheduled, budgeted, and programmed.

Modern facilities are the smart brain for these proprietary systems, providing a single point of control. A simple, intuitive icon style layout is presented to the user, removing the requirement to be a technical-master to operate these control systems. All back-end system management, regardless of complexity is reduced to uncomplicated outlook with touch control. The operator can use the system without a manual. Advanced communication system for internal/external telecommunication and office automation provide an extensive information system for providing commercial/financial information for supporting management decisions and associated commercial activities. A comprehensive and flexible building control automation system incorporate subsystems for controlling HVAC, lighting,

power, lift, fire fighting, life saving and security. Thus occupants' satisfaction will be enhanced and revenues raised.

The Advanced Control Corporation (ACG, 2013) opines that an Intelligent Building Management System (IBMS) provides integrated management features similar to a building's brain; monitoring, interacting and management for all the building's other automation system at real-time; including access control, audio/video intercom, wireless networking infrastructure, structure cabling system, CCTV/DVR surveillance system, computer room facilities, electrical distribution, lighting control and information display system, etc. Energy Savings Trust (EST, 2015) reveals that installing technology to meter and monitor energy consumption has an average payback period of less than six months. A small increase in capital expenditure can reduce operational expenditure significantly. Empirical studies of metering solutions show an average 5% reduction in utility bills in different buildings. Savings in the region of 2 to 5% can be achieved by better equipment utilization and as much as 10% can be attained by improving the reliability of systems. For new and retrofit installations, an existing ethernet network can be used. Wireless and ethernet technologies enable 'plug-and-play' and convergence to allow centralized control.

A state-of-the-art IB employs many integrated mechanical and electrical systems that control the building's environment, lighting and security to maintain high-speed data networks and emergency backup power generators. Incorporating these systems into the building saves energy while increasing reliability, security and efficiency; making the building more desirable for prospective occupants. It's critical that these systems function continually and reliably. If not detected and repaired quickly, malfunctioning mechanical and electrical systems in an IB can pose serious consequences. For instance, unreliable lighting and network connections can impair worker productivity, while a malfunctioning fire or security system can potentially place human life at risk. There must be a commitment from the developer / owner to maintain a sustainable IB.

Darlow et al. (1994) opines a property market has the following characteristics:

- The market is fragmented, poorly recorded, secretive and generally unregulated;
- There is no central agency or institution;
- There is no physical focal point such as the Stock Exchange for the transaction of stocks and shares;
- It is difficult to abstract an aggregation of property transactions;
- There is an imperfect knowledge of the market and within the market there is no central price or listing (such as on-line prices, as there are for the transaction of stocks and shares); and
- There is no central registry of transactions that is complete.

Energy reduction and cost saving can be achieved in IB in the following aspects through FM:

- Programmed start/stop
- Optimal start/stop
- Duty cycling
- Set point reset
- Electric demand limiting
- Adaptive control
- Chiller optimization
- Boiler optimization
- Optimal energy sourcing
- Reduced manpower dependence
- Emergency control of elevators, HVAC systems, doors
- Uninterrupted Power Supply

In addition, the following telecom features can help tenants to maximize its business potentials:

- private telephone exchange systems,
- cablevision
- audio-visual and videoconferencing
- satellite communications and
- electronic mail, Intranets and Internet access

The following factors involved in workplace automation can help tenants too:

- Centralized data processing
- Word processing
- Computer-aided design
- Information services

An IB costs less to operate and provides a superior indoor environment, resulting in a significant financial return. Market demand for high performing IB is growing because it offers:

- Faster payback periods
- Increased productivity
- Reduced O&M costs
- Lower vacancy rates
- Decreased financial risk and a higher financial return
- Savings in maintenance costs over the a building's lifetime

2. RESEARCH METHODOLOGY

To allow for more precise analysis, the financial performance of an IB is assessed through a case study of a Grade A office building (JKL Building) in a central business district (CBD) of Hong Kong. This IB is developed by a major property developer in Hong Kong who aims to offer an environmental friendly building; with modern, technologically oriented architectural interest and economic value. This development trend begins in 1998, with one of their developments achieved the first Hong Kong Building Environmental Assessment Method (HK-BEAM) "Excellent" rating. A series of similar IBs are constructed afterwards by this developer. Such rating is based on three criteria: global issues and use of resources, local issues, and indoor issues; where Excellent rating is governed by the following factors:

- An energy efficiency program;
- Use of environmentally friendly refrigerants;
- Detection and recovery systems and halon-free fire protection systems to avoid ozone depletion;
- Facilities to maximize recycling of office materials; and
- Automatic control devices to maximize water conservation.

This JKL Building is connected to a major MTR station, via an air-conditioned, escalator-equipped underground pedestrian link, providing full convenient traffic access for its tenants. By integrating sophisticated architecture, state-of-the-art technology and modern building facilities, this IB empowers its tenants with the greatest flexibility to operate their business in their own ways through the following facilities:

- It is supported by two telephone exchanges and is one of the first property developments in Hong Kong to use diversified fiber optic cables and twin risers to ensure that tenants can operate their telecom systems with total security and confidence.
- It adopts three-compartment trunking to offer design flexibility with floor, ceiling and curtain wall trunking for telephone, power and computer cabling respectively.
- By utilizing direct digital control under a building automation and energy management system, all plant and security systems are monitored on a 24-hour basis.
- The sophisticated air-conditioning system is designed to cater for a population density of about 8m² per person. Additional cooling capacity for tenants' computer equipment is also provided.
- Ample main power supply is provided via two risers.
- In the event of unforeseen power failures, all security systems and essential services can be sustained indefinitely by an emergency power supply.
- A loading capacity of 100 lbs./sq. ft. is designed to accommodate heavy items such as safes.

Structured interviews (regarding five major performance indicators, namely the performance of Built Environment, Responsiveness, Functionality, Economic Issues and Suitability) with major stakeholders e.g. developer, facilities manager, tenants will be launched. Details also include the building features that influence these performance indicators (such as People, Systems, Critical devices, Hazard

Protection, Process of Building Management, Design Practice). The questionnaire is designed primarily to gather tenants' view towards:

- Satisfaction of the working environment
- Satisfaction of the building environment
- Satisfaction of the building facilities
- Satisfaction of the performances of these building facilities

and developer's view of the leasing situation and facilities manager's view of the operating costs of JKL Building.

3. FINDINGS

A tenant M major in electronics, enlisted in Fortune 500 list of companies, is committed to lease five floors comprising 75,000 sq. ft. at JKL Building. There various business groups and departments in Hong Kong are moving together under one roof at JKL Building. By working together in an open office design, it stimulates greater interaction and experience sharing among all staff, thus enabling them to better serve the customers.

Another tenant N focusing on finance confirms 83,500 sq. ft. office space, making it the largest tenant in at JKL Building; who contends that this building is an ideal address for regional flagship headquarters. The group needs more space in Hong Kong as base for their business expansion in Asia Pacific. The staff will benefit from this building's hub location and added-value facilities.

A tenant O, majoring in securities servicing, believes Hong Kong is a critical location for rapid growing of their securities servicing and alternative investment businesses. They are investing in a top-grade office to better position themselves to service their respective clients.

Another tenant P, focusing in software industry, opines that technology plays a key role to support their growth/development, to better serve customers and partners, supporting them to advance their business growth with innovative technology.

A tenant Q, offering integrated business, corporate and investor services in Asia, will consolidate its two nearby separated offices to JKL Building to optimise its operational efficiency. They consider that this building is a well-equipped modern Grade-A commercial development located at the CBD of Hong Kong with latest design features and state-of-the-art technology. The efficient layout can help consolidate all operations into just four floors and each core business will have its own floor.

Moreover, three other tenants (one from global investment, one from fund management, one from banking industry) have committed to rent over 38,000 sq. ft. One of them admits that JKL Building

offers the largest floor plate with raised floors in a new/modern/well-designed building. Further, the following financial figures e.g. rental income and outgoing/operation costs are obtained to justify the economic values of this IB:

Item Description	Income (\$US)	Outgoings(\$US)
Rental income	1494987	
Air-conditioning charges	475446	
Additional air-conditioning charges	79476	
Car park and other income	79305	
Gross income	2129214	
Building maintenance		5750
Building services		16651
Lifts and escalators repairs and maintenance		24703
Air conditioning repairs and maintenance		9950
Chilled water charges		41991
Electricity charges		56774
Cleaning		21891
Staff payroll costs		105998
Rates		19425
Insurance		4315
Portfolio marketing		1236
Estate expenses		1343
Management office costs		5528
Tenancy improvements		3165
Car park expenses		15313
Amortization of deferred expenditures		47103
Tenants work		14991
Total Outgoings		396127 (18.6%)
Net rental income		1733087 (81.4%)

The total outgoings is about 18.6% of the gross income, which is well under the market norm; whilst the net income is about 81.4% which is above the market norm. These figures justify that the IB developments can minimize outgoings while maximize income as discussed above.

4. ANALYSIS AND DISCUSSION

The market demand for high performance IB is growing because they offer:

- Faster payback periods
- Increased productivity
- Reduced O&M costs

Many organizations seek to enhance the performance of their buildings and reduce operating costs. Emerging automation control technology enables companies to satisfy the seemingly conflicting goals. Unlike non-integrated and partially-integrated systems in modern buildings, which are characterized by separate control, scant data exchange and high operating costs; facility integration in high performing IB enables the inter-action between building management (for energy management, HVAC, utilities, etc.), security and fire safety systems. A fully integrated system provides a common platform to develop applications that are scalable, inter-operable, available and manageable from a single point — a PC. This facility brings substantial benefits e.g. peer-to-peer control, full data management, centralized events storage, lower operating costs, reduced risk and improved functionality/efficiency.

A further step can then be taken to an enterprise-wide integration, which supports the transition from sharing to managing information. A common, enterprise-wide business model supports workflow processes, complete systems inter-relationships, central alarm management and maximum control, security and fire safety. It supports performance improvement — and all without any detriment to service provision. It will also enhance lower vacancy rates and decreased financial risk and a higher financial return. Savings in maintenance costs over the lifetime of IB is vital. For property developers, it is a clear-cut case. Smart buildings are proven to be good revenue boosters (with higher revenue) as they can be let more quickly than traditional buildings.

5. CONCLUSION

The above interviewed tenants demonstrate that an ideal office building has to provide a high service standard of powerful communications support, stable power supply and a high degree of security measures. The perceived benefits are improved productivity and reduced costs. The integration of building services control, made possible by today's innovative automation technology, offers FMs, security chiefs, building owners and occupiers huge benefits to their business. Standalone control systems for HVAC, energy management, fire protection, access control and lighting are limited, not being able to provide the full benefit possible, with the availability of information often restrict to isolated areas. Response times accordingly can be slow, with the consequence that facts become blurred.

The implementation of an holistic approach to building management eliminates those weaknesses. In an integrated system, information is shared between departments, enabling vital building functions to be centralized. An integrated solution — a data management engine, effectively — delivers to the user the big picture. This enables automated building control systems to utilize all available information within the different systems. That is when the real benefits can be realized — increasing productivity,

reducing costs (for energy, installation, operation) and mitigating risk. JKL Building is recognized as a successful commercial development, equipped with sophisticated architecture and communications technologies, which provides extra flexibility to operate business. Failure to consider the impact of the intelligent operation of IB can result in poor performance and low occupant acceptance of the design concepts/technologies too.

IB owners will perceive realistic gain often at the expense of other non-intelligent building owners owing to:

- Generation of Revenue Streams – An IB can also be a generator of revenue. A landlord can offer tenants additional value added services which the landlord may levy a charge for. These services can all be accessed by the IP phone and can include business information services or environmental services, giving the tenant more flexibility and greater control over the ambient conditions of the occupied space.
- Improved Health, Safety and Security – employees, residents or tenants of buildings can feel secure in the knowledge that their environment is monitored and controlled 24/7/365. Landlords benefit from the ability to remotely monitor their entire building portfolio resulting in greater control and efficiencies.
- Enabling Workplace productivity – FM personnel can be released to focus on other tasks as they have the ability to monitor and control sites from any location. These benefits are particularly evident for multi-site, remote environments. Security personnel can also either be reduced or re-allocated to undertake additional tasks where an integrated system has been deployed.
- Environmentally responsible – by leveraging the technology available, organizations can optimize the lighting and HVAC systems to ensure their building or development has a minimal impact on the environment through energy monitoring and energy saving, thus reducing carbon emissions
- Provide a representative range of use – IBs are mainly buildings from the tertiary sector; their volume and the integration of systems, services, RES, IT retrofitting, buildings of this sector have the potential for energy conservation and gives the market place for penetration of emerging technologies. In parallel, yet probably in a lesser extent, the residential sector consists a significant market as well; where the massive rise in Home Internet connections gives the means for energy management in this sector.
- Incorporate the main characteristics of the IBs - Although IBs are diverse in nature and engaging different techniques, they share a set of characteristics that put them apart from other buildings. These characteristics are the availability of advanced HVAC/lighting controls, structured cabling infrastructure with bandwidth connectivity, and the adaptability to changing technology and tenant increasing needs.

These perceived benefits can result in flexible/adaptable real estate developments for the land owners, property developers, global/local tenants and occupants as a whole.

Reference

- Advanced Control Corporation (ACG, 2013), Intelligent Building Management System, <http://advancedcontrolcorp.com/blog/2013/03/intelligent-building-management-systems-in-miami/>, accessed in 11/2015
- Asian Institute of Intelligent Buildings (AIIB, 2015), <http://www.aiib.net/> accessed in 12/2015
- Asian Institute of Intelligent Buildings (AIIB, 2015), *The Intelligent Building Index*, http://www.aiib.net/index_topic.php?did=248062&didpath=/248062, accessed in 11/2015
- Energy Savings Trust (EST, 2015), <http://www.energysavingtrust.org.uk/>, accessed in 12/2015
- European Intelligent Building Group (EIBG, 2015), <http://www.ibgroup.org.uk/>, accessed in 11/2015
- Darlow et al. (1994), *Transactions : property development partnerships*, London : Longman, 1994.
- Nikolaou T., Kolokotsa D., Stavrakakis G., Apostolou A. and Munteanu C. (2015), *Managing Indoor Environments and Energy in Buildings with Integrated Intelligent Systems* [electronic resource], Cham : Springer International Publishing : Imprint: Springer, 2015, 1st edition.
- So, A.T.P., Wong A.C.W. and Wong K.C. (1999), A new definition of intelligent buildings for Asia, *Facilities*, Vol. 17 Iss: 12/13, pp.485 – 491, MCB UP Ltd, <http://www.emeraldinsight.com/doi/abs/10.1108/02632779910293488>, accessed in 12/2015

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