Identification of Market Requirements of Smart Buildings Technologies for High Rise Office Buildings

Dr. Rabee M. Reffat
Associate Professor
Architecture Department, KFUPM, Dhahran, Saudi Arabia
Email: rabee.reffat@gmail.com
Homepage: http://faculty.kfupm.edu.sa/arch/rabee

ABSTRACT

This paper reports the findings on the identification of market requirements of smart buildings technologies for high rise office buildings in Saudi Arabia including: levels of importance of smart building technologies for office buildings, current practices of utilizing hi-tech smart building technologies in office buildings, required additional features of smart building technologies for office buildings, challenges for integrating smart building technologies for office buildings, major benefits of hi-tech smart buildings technologies for office buildings, and priorities of smart building technologies based on current usage. The paper also reports on key parameters of the comparison of smart office building technologies between Saudi Arabia and developed countries which are based on the survey results for the former and literature review for the latter. This comparison provides in a nutshell a conclusion of the complete survey analysis conducted in this research and at the same time provides an indication on the utilization level of smart office buildings in Saudi Arabia compared to the current practices in developed countries.

INTRODUCTION

Various studies (Drewer and Gann 1994; Kim 1996; So and Wong 2002; Clements-Croome 2004; Synetrix 2004) have addressed the concept and technologies of smart buildings in various dimensions. A smart building can be viewed as "one that provides a productive and cost-effective environment through optimization of its four basic components: structure, system, service and management and the interrelationship between them". Smart buildings encompass technology of microprocessors that operate and control building systems HVAC, power, vertical transportation, fire and life safety and security (Synetrix, 2004). The building systems rely on a network of sophisticated communication systems. Smart building technologies include networking, audio-visual systems, raised floors, intelligent cards, occupants' amenity, office automation and energy efficiency. In essence, the components of a smart building must include building management system for real time control, utility functions, energy efficiency/energy management, security and life safety systems and computer/internet integration. The initial cost of developing smart buildings might appear expensive; however, the total life-cycle cost for smart buildings is generally lower than the cost for conventional buildings. Hi-tech smart buildings stir cost savings to building tenants and owners. Today's "smart building technologies" support and operate various aspects of a building and its infrastructure, including lighting; heating, ventilation, and air-conditioning (HVAC); energy management; security; elevators; life-safety systems; communications; and building condition monitoring. The technologies used in these "wired" buildings seek to improve the building environment and functionality for the occupants while controlling costs. Improving end-user security, comfort, and accessibility all help productivity and user comfort levels (Suttell, 2002).

The real estate market in Saudi Arabia is gradually adopting smart technologies in their buildings. The ongoing construction boom and the competitive environment in Saudi Arabia is paving ways for the integration of smart building technology in commercial and multifunctional buildings. At present this technology is mostly used in large scale and high budgeted projects however, smart technology vendors and companies that provide professional consultancy in this field are beginning to establish a stable market for this technology in the country.

The remainder of this paper addresses the findings on the identification of market requirements of smart buildings technologies for high rise office buildings in Saudi Arabia including: levels of importance of smart building technologies for office buildings, current practices of utilizing hi-tech smart building technologies in office buildings, required additional features of smart building technologies for office buildings, challenges for integrating smart building technologies for office buildings, major benefits of hi-tech smart buildings technologies for office buildings, and priorities of smart building technologies based on current usage. The key parameters of the comparison of smart office building technologies between Saudi Arabia and developed countries are also introduced.

IDENTIFICATION OF MARKET REQUIREMENTS OF SMART BUILDINGS

In order to investigate and identify the market requirements of smart building technologies for high rise office buildings in Saudi Arabia, an initial questionnaire was developed aiming at elucidating key parameters that pertain to current experiences and future potentials for incorporating smart building technologies. As a pilot study for collecting feedback on the clarity of the questions, duration to complete the questionnaire, and others issues of concern that the questionnaire should address, the initial questionnaire was assessed by two technical engineers who are involved with building systems at two headquarter office buildings. There are more than 90 major headquarter office buildings in various cities of Saudi Arabia which were contacted via email and phone calls and were invited to participate in conducting the survey. The target contacts at these headquarter office buildings were technical managers of operation and maintenance. A total number of 34 contacts expressed their approval to participate in this survey but only 26 actually completed the survey online.

Levels of Importance of Smart building Technologies

The survey results showed that 77% of the 26 surveyed headquarter office buildings expressed that smart building technologies for office buildings in Saudi Arabia is important with various levels that range from somewhat important, important, to very important as shown in Figure 1.

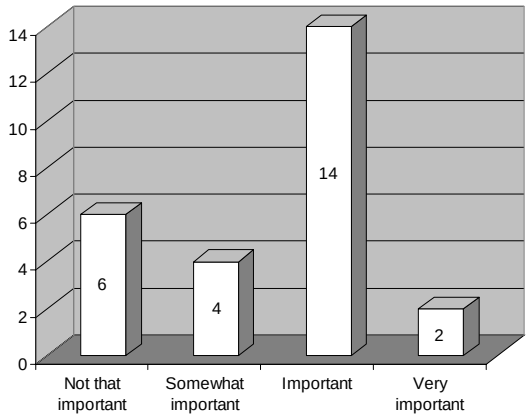

Figure 1. Distribution of importance levels of smart building technologies for office buildings in Saudi Arabia.

Current Practices of Utilizing Hi-Tech Smart Building Technologies

Level of integration of smart building technologies in office buildings in Saudi Arabia.

The survey results indicate that 50% of the 26 surveyed headquarter office buildings as illustrated in Figure 2 has smart building technologies that are either fully or partially integrated. While the other 50% has smart building technologies as standalone systems that are not integrated within a comprehensive or even a partial automated system that is used to manage the operation of office buildings services and functions.

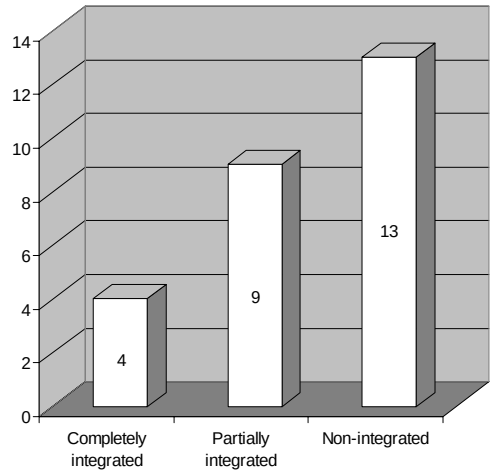

Figure 2. Distribution of integration levels of smart building technologies in office buildings in Saudi Arabia.

Types of configuration for office buildings systems in Saudi Arabia.

The types of configurations for office building systems include open and proprietary systems. In open systems all major components adhere to certain standards. These major components can be interchanged with similar components manufactured by others to the same standards. Alternatively in proprietary systems all major components are from one manufacturer and the standards are often specific to that system and are developed by the manufacturer. The survey results showed that 84.6% of the 26 headquarter office buildings surveyed are equipped with open systems configuration as reflected in Figure 3 while the rest have proprietary systems.

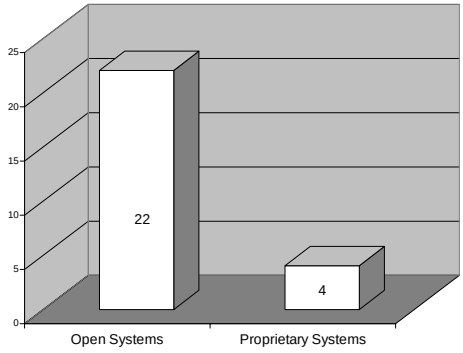

Figure 3. Distribution of configuration types for office buildings systems in Saudi Arabia.

Types of building systems control for office building systems in Saudi Arabia.

The survey results as illustrated in Figure 4 that 84.6% of building systems control for the 26 surveyed headquarter office buildings in Saudi Arabia has individual control while the rest has central control. This reflects that integration of smart building technologies for office buildings in Saudi Arabia is very limited. The types of such integration within this limited set are shown in Figure 23 which distributed equally among head-end, central computer to central computer, field gateway, and hard point interface. Current distribution of types of user interface, user access, and open protocol architecture based in the survey results are shown in Figures 5, 6 and 7 respectively.

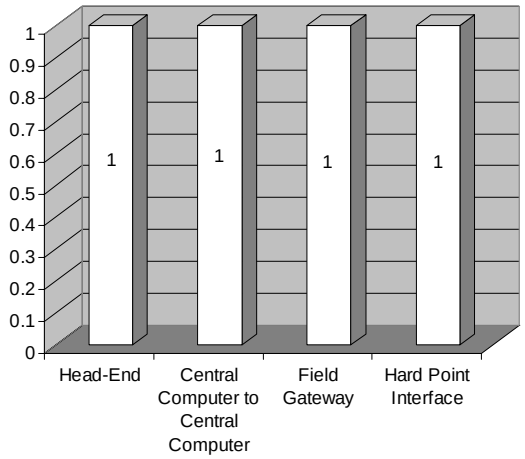

Figure 4. Distribution of integration types of smart building technologies for office building systems in Saudi Arabia.

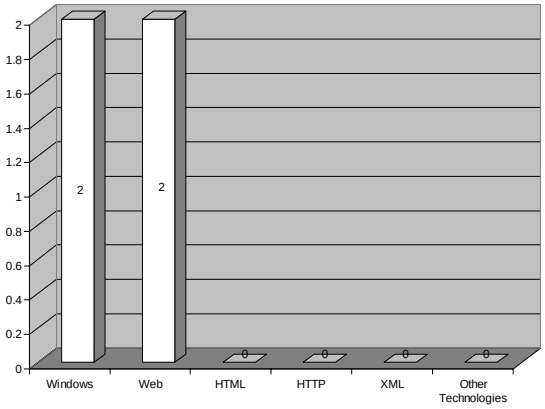

Figure 5. Distribution of user interface types in integrated smart building technologies for office buildings systems in Saudi Arabia.

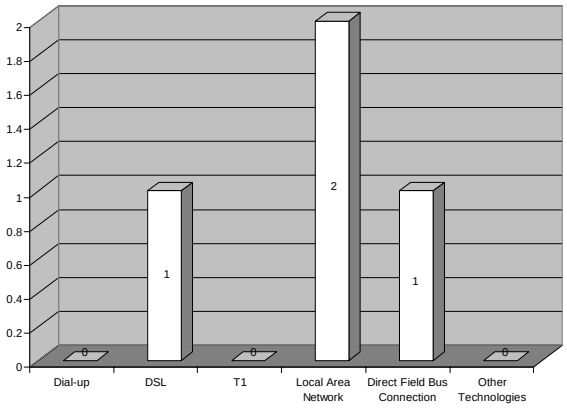

Figure 6. Distribution of user access types in integrated smart building technologies for office buildings systems in Saudi Arabia.

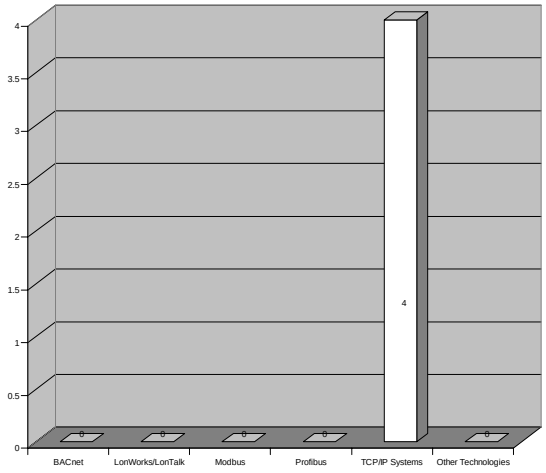

Figure 7. Distribution of open protocol architecture types in integrated smart building technologies for office buildings systems in Saudi Arabia.

Identification of Required Additional Features of Smart Building Technologies

The survey results showed that there is a strong need for additional features of smart building technologies for office buildings in Saudi Arabia. Such features include providing remote alerts, system intelligence, and Bluetooth technology in respective order as shown in Figure 8. Other additional features involve interoperable systems that can help in easily integrating current smart technology without substantial modification.

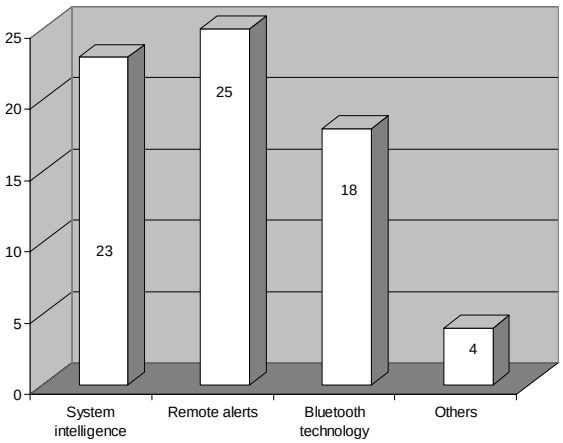

Figure 8. Required additional features and their distribution of smart building technologies for office buildings in Saudi Arabia.

Challenges for Integrating Smart Building Technologies

There are various factors that might hinder the adopting of integrated smart building technologies for office buildings. The survey results have uncovered the most pertaining challenges for Saudi office buildings. The most important challenge found in this survey as shown in Figure 9 is the lack of awareness; that is simply not being up-to-date with the advances of smart building technologies and recent high-tech developments in intelligent buildings and integrated automation. This issue might have affected the infancy level of intelligent and smart buildings in the Saudi construction industry as is portrayed by the second highest challenge of other internal factors. Further challenges of a lesser impact include high initial cost or lack of funding, lack of executive support from high administration or building owners, and immaturity of today's technology solutions.

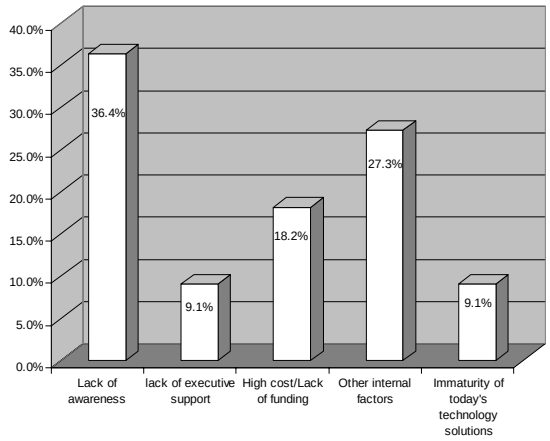

Figure 9. Most important challenges for integrating smart building technologies in Saudi office buildings.

Identification of the Major Benefits of Hi-Tech Smart Building Technologies

The survey results as illustrated in Figure 10 showed that reducing energy consumption, increasing occupant safety and security, and improving the operation and maintenance are the primary motivation for adopting the smart building technologies for office buildings in Saudi Arabia. Other benefits with lesser focus include increasing occupant safety, life cycle costing benefits, and allowing better space utilization and flexibility.

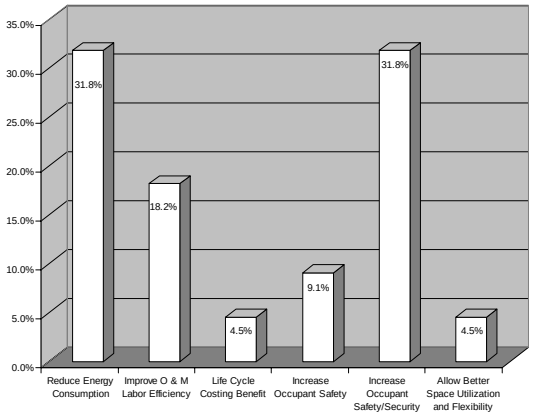

Figure 10. Identification of the major benefits of hi-tech smart buildings technologies for office buildings in Saudi Arabia.

Identification of the Priorities of Smart Building Technologies

Based on the usage of smart building technologies for the 26 surveyed headquarter office buildings in Saudi Arabia, it was found as shown in Figure 11 that having a number of 1-3 Fire Alarm Systems takes the utmost priority while central HVAC systems score the second highest. Tank Thermostat for Hot Water Control and HVAC Manual Control has a priority level around 50-60% while Low Energy Light Bulbs, Closed Circuit Tele-Vision Security, and Door Access Control System have a priority level around 30-40%.

In-depth Analysis of Survey Inputs (interrelationships)

The main purpose of this in-depth analysis is to identify the interrelationships between the participants' inputs in the structured online questionnaire. Such analysis might lead to a better understanding of the market requirements of smart office buildings technologies in Saudi Arabia. In order to conduct this in-depth analysis, all questionnaire questions are itemized and compared to each other to identify the regularity/commonality among participants' responses. The common responses are counted for each comparison in a matrix format then the compared items (based on the total number of common responses) are sorted into one of the following categories:

- Strong Relationship: the compared items are having more than 11 common responses.
- Intermediate Relationship: the compared items having common responses ranging from 6-10.
- Weak Relationship: the compared items are having less than 5 common responses.

In this in-depth analysis, only strong and intermediate and relationships are considered worthy for the reporting as presented in Table 1.

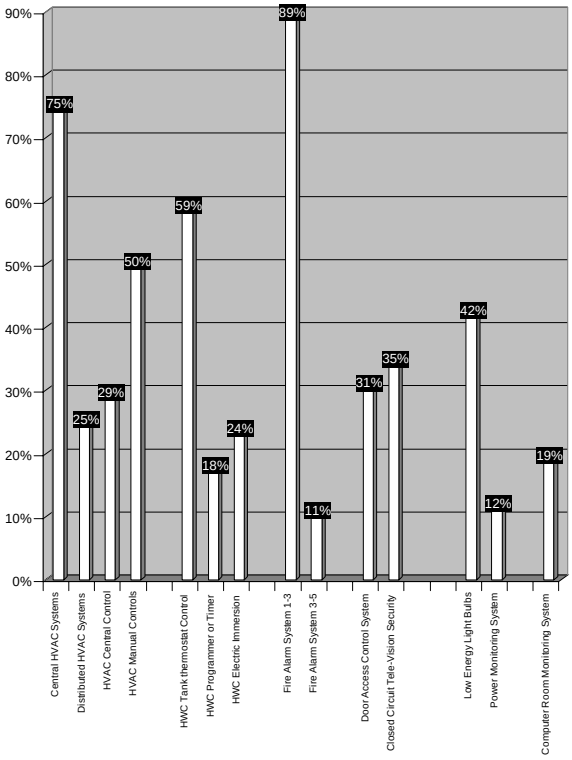

Figure 11. Identification of the priorities of smart building technologies based on current usage at office buildings in Saudi Arabia.

KEY PARAMETERS COMPARISON OF SMART OFFICE BUILDING TECHNOLOGIES BETWEEN SAUDI ARABIA AND DEVELOPED COUNTRIES

A comparison of the key parameters of smart office building technologies between Saudi Arabia (based on the survey results) and developed countries (based on the literature) was developed to identify the similarities and differences between the key parameters including: required smart building technologies, level of importance of smart building technologies, primary on-focus benefits from utilizing smart buildings technologies, current practices of utilizing hi-tech smart buildings, main challenges of integrating smart building technologies, and future directions (refer to Table 2).

CONCLUSIONS

This paper investigated the market requirements of smart building technologies for high-rise office buildings in Saudi Arabia. Some of the major findings articulated in this study include:

- The level of importance of smart building technologies for office buildings in Saudi Arabia is quite high in which 77% of the surveyed headquarter office buildings expressed that smart building technologies are important with various levels that range from somewhat important, important, to very important.
- The current practices of utilizing high-tech smart buildings in office buildings in Saudi Arabia is still at the early stages of development wherein 50% of the surveyed headquarter office buildings has smart building technologies that are either fully or partially integrated while the other 50% has either smart building technologies as standalone systems that are not integrated within a comprehensive or partial automated systems.
- The major types of building systems control for office building systems in Saudi Arabia is the individual control (84.6 % of the surveyed headquarter office buildings), while the minor type is the central control.
- There is a strong need (based on the survey results), for additional features of smart building technologies for office buildings in Saudi Arabia. Such features include providing remote alerts, system intelligence, and Bluetooth technology in respective order. Other additional features involve interoperable systems that can help in easily integrating current smart technology without substantial modification.
- The most important challenge for integrating smart building technologies for office buildings in Saudi Arabia (based on the survey results), is the lack of awareness; that is simply not being up-to-date with the advances of smart building technologies and recent high-tech developments in intelligent buildings and integrated automation. This issue might have affected the infancy level of intelligent and smart buildings in the Saudi construction industry as is portrayed by the second highest challenge of other internal factors. Further challenges of a lesser impact include high initial cost or lack of funding, lack of executive support from high administration or building owners, and immaturity of today's technology solutions.
- The major benefits of hi-tech smart buildings technologies for office buildings in Saudi Arabia are reducing energy consumption, increasing occupant safety and security, and improving the operation and maintenance. Other benefits with lesser focus include increasing occupant safety, life cycle costing

benefits, and allowing better space utilization and flexibility.

- The priorities of smart building technologies based on current usage include having a number of 1-3 Fire Alarm Systems takes the utmost priority while central HVAC systems score the second highest. Tank Thermostat for Hot Water Control and HVAC Manual Control has a priority level around 50-60% while Low Energy Light Bulbs, Closed Circuit Tele-Vision Security, and Door Access Control System have a priority level around 30-40%.

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Table 1. Identified strong and intermediate relationships among participants' responses of the questionnaire items.

Response	Relationship Type	With other responses
Integrated Building Automation Systems (IBAS) is "not that important to the company from the company's strategic management perspective".	Intermediate	• Configuration of building systems is "open systems" • The office building system control is "individual control - not integrated".
Integrated Building Automation Systems (IBAS) is "important to the company from the company's strategic management perspective".	Strong	• Configuration of building systems is "open systems" • The office building system control is "individual control - not integrated". • Never replaced their HVAC Control System. • Did not perform a major upgrade for the building HVAC Control System. • Never replaced the building Fire Alarm System.
	Intermediate	• The office building is partly integrated with unknown non-integrated systems. • Lack of awareness hinders the company from adopting integration. • Increase occupant safety/security (is) (would be) the main reason for installing an IBAS. • The office building has centralized Air-conditioning. • The office building has Manual Heating Ventilation & Air-Conditioning (HVAC) controls. • Did not perform a major upgrade for the building Fire Alarm System (FAS). • Number of Fire Alarm Systems installed ranges from 1-3.
The office building is partly integrated with unknown non-integrated systems	Intermediate	• Configuration of office building systems is "open systems" • The office building system control is "individual control - not integrated". • The office building has centralized Air-conditioning. • Never replaced the building HVAC Control System. • Did not perform a major upgrade for the building HVAC Control System. • Never replaced the building Fire Alarm System. • Did not perform a major upgrade for the building Fire

		Alarm System.
The office building is completely non-integrated and with no automation systems	Intermediate	• Configuration of office building systems is “open systems” • The office building system control is “individual control - not integrated”. • The office building has manual Heating Ventilation & Air-Conditioning (HVAC) controls. • Never replaced the office building HVAC Control System. • Did not perform a major upgrade for the office building HVAC Control System. • Never replaced the office building Fire Alarm System. • Did not perform a major upgrade for the office building Fire Alarm System.
Configuration of office building systems is “open systems”	Strong	• The office building system control is “individual control - not integrated”. • The office building has centralized air-conditioning. • The office building has manual Heating Ventilation & Air-Conditioning (HVAC) controls. • Never replaced their HVAC Control System. • Did not perform a major upgrade for their HVAC Control System. • Never replaced their Fire Alarm System. • Did not perform a major upgrade for their Fire Alarm System. • Number of Fire Alarm Systems installed is ranging from 1-3.
	Intermediate	• Lack of Awareness hinders their company from adopting integration. • Other Internal Factors hinders their company from adopting integration. • Reduce Energy Consumption is the main reason for installing an IBAS. • Increase Occupant Safety/Security is the main reason for installing an IBAS. • Number of HVAC Control Systems installed is ranging from 1-3. • The office building has no Graphical User Interfaces (GUIs) for HVAC Control Systems. • The office building has Tank Thermostat only for Hot Water Supply. • Fire Alarm Systems were installed between year 2000 & 2006. • No Graphical User Interfaces (GUIs) for Fire Alarm Systems. • Closed-Circuit Television (CCTV) systems were installed between year 2000 & 2006. • The office building has some Compact Fluorescent Low (CFL) energy light bulbs
Lack of Awareness hinders the company from adopting integration	Intermediate	• Never replaced the office building HVAC Control System. • Did not perform a major upgrade for the office building HVAC Control System. • The office building has a Tank Thermostat only for Hot Water Supply. • Never replaced the office building Fire Alarm System. • Number of Fire Alarm Systems installed is ranging from 1-3.

Table 2. Key parameters comparison of smart office building technologies between Saudi Arabia and developed countries.

No.	Key Parameters	Saudi Arabia – based on the survey results	Developed Countries Experiences
1	Required smart building technologies	• Basic building systems • Systems integration • User interface • Web oriented • Open protocol architecture • Automatic work order generation	• Basic building systems • Energy management • Building condition monitoring • Common communications infrastructure • Integrated communication • Standards and protocols • Intelligent controllers • Current integration technologies
2	Level of importance of smart building technologies	The level of importance is measured on a scale of 1-5, where 1 is highly important • Basic building systems (1) • User interface (2) • Open protocol architecture (2) • Automatic work order generation (2) • Systems integration (3) • Web oriented (3)	The building technologies are changing and developing everyday and their essence too. Firstly, the basic building systems are the most important then the condition monitoring energy management of those systems. Secondly, it is the integration of systems with the integrated communication and its infrastructure, and also standards and protocols. Finally, intelligent controllers and smart sensors play a vital role.
3	Primary on-focus benefits from utilizing smart buildings technologies.	• Reduced energy consumption • Increase occupant safety and security • Improve operation and maintenance labor efficiency	• Reduced cost and increased productivity • Simple upgrade modifications of control systems • Increased individual environmental control • Ability to manage building independently and securely
4	Current practices of utilizing hi-tech smart buildings	Saudi Arabia is still far behind in utilization of hi-tech smart technologies. In this survey, the buildings were: • 15 % with appropriate utilization • 85 % without appropriate utilization	All new commercial buildings and probably luxurious domestic buildings are being designed with a common goal – to become intelligent buildings (IB). In the USA, an IB is categorized by four basic elements, namely building structure, building systems, building services and building management. In Europe, the stress is on information technology and the real need of users. In Singapore and China, it appears that “automation” has been dominating with a great emphasis on hi-tech building technology.
5	Main challenges of integrating smart building technologies	• Lack of awareness • Company’s internal factors • High cost / Lack of funding	• Financial impact of life cycle costing. • Requires an integrated design with construction processes. • Ability to upgrade functional capabilities.
6	Future directions	• Bluetooth communication • Alerts sent remotely via phone line • Intelligence with sensors having fuzzy logic	• Systems interoperability • A single operator interface with control over all systems • Remote interaction with mobile communications