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Innovative Dwellings in Greece: Critical Review and Construction Cost Implications

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Abstract
The term innovative dwellings denotes houses incorporating intelligent and sustainable features. Social and economic factors indicate that the number of such buildings is expected to grow from around 7% today to around 40% before 2010. In this paper innovative dwellings are reviewed and analysed in their basic constituent sub-systems in order to estimate their respective costs. From the plethora of available technologies four intelligent and three sustainable sub-systems are selected and incorporated into a model innovative building. The sub-systems satisfy independently published criteria of intelligent/sustainable buildings, are expandable to cater for future requirements and are available / supported in the Greek market. Following the development of the model, quotes were collected from suitable suppliers in Greece in order to assess their cost implications. It is shown that the cost overrun of innovative dwellings is, in most cases, less than 10%, a small percentage compared to the benefits offered to their users and the environment. As such the argument that the importance of innovative dwellings is expected to grow in the future is corroborated. The potential influences of the above to construction technology and management is finally discussed in the concluding part of this paper.

Keywords
Innovative Buildings, Intelligent Buildings, Sustainable Development, Cost Models, Greece.

1. Introduction

Buildings that use information technology to offer a responsive and supportive environment to their tenants in a cost effective manner are characterised as Intelligent Buildings (IB) (Derek and Clements-Croome, 1997). The term was first used in North America in the early 1980s (Loe, 1996) and various definitions exist in the literature today (Arkin and Paciuk, 1997; Atkin, 1988; Stelcner, 1998; Chun *et al*, 2000; CABA, 2002 etc.). Even the concept of intelligence in buildings is viewed differently in Europe, Asia and America (So *et al*, 1999). For a thorough survey of intelligent buildings literature reference is made to Zakhaiou (2002).

As "sustainable", on the other hand, are characterised the buildings that are specially designed to adapt to their local climatic conditions in order to economise on energy consumption and protect the environment (Tsipiras, 2000; Tompazis, 2002). In Greece, sustainable buildings appeared in the mid-1970s, mainly as the result of Government funded initiatives.

As both intelligent and sustainable buildings aim at reducing energy consumption, protect the environment and offer advanced comfort and facilities to their users, the term "intelligent" is sometimes used interchangeably to denote both types of buildings (see, for example, the definition given by CIB, 2001, the definition of the European Intelligent Building Group – EIBG, Hamilton and Nelson, 2002 etc.) To be able to make the distinction, the term "innovative" is used in this paper to denote collectively an intelligent AND a sustainable building.

It should be stressed, however, that the constituents of intelligent / sustainable buildings are not fixed as they change with time (Loe, 1996). As new techniques, design principles, standards and technologies emerge and become available; intelligence and sustainability perceptions change accordingly. A building with insulated walls, central heating and an elevator may have been thought of as an innovative building a few decades ago; the same does not hold true today. "Innovativeness" is a quantifiable property of a building and different measurements of "innovativeness" have been proposed (see for example Arkin and Paciuk, 1997 and the Consumer Electronics Association (CEA, 2003) for measurements of "intelligence" and the Greek Ministry of the Environment & Public Works, 2003 for measurements of "sustainability"). Furthermore, the costs associated with the erection of innovative buildings vary as prices of sensors, microprocessors, control panels and other electronic-related technologies lower significantly with time.

In conclusion, the subject of this paper is a rather time-dependent one; the critical review of innovative dwellings in Greece today (a concept that will change gradually as today's innovative buildings are the non-intelligent and non-sustainable buildings of tomorrow) and the assessment of their cost implications to construction costs (a subject which again is unstable as the related costs vary significantly with time). What is then the actual purpose of this research? That of analysing current innovative dwellings to their major constituent parts, doing market research to assemble "real" cost data from Greece and, finally, that of formulating a model assessing their cost implications to construction costs. The subject is of Academic interest as similar studies in other countries suggest (see, for example, Petersen *et al*, 2001, Yang and Peng, 2001). The motivation behind the purpose is, however, different from other studies, and is twofold:

- To understand the effect of "innovativeness" to construction costs in Greece today ("Should we recommend innovative buildings to perspective house owners or should we urge them to wait?" – see also challenges and opportunities of intelligent buildings for building owners, occupants, operators and the construction team in Ivanovich, 1999), and
- To investigate the effects of innovative dwellings to construction engineering and management as a discipline ("Do innovative buildings affect the teaching and practicing of construction engineering and management?" "Is it reasonable to introduce courses related to innovative building applications and management in construction management (CM) syllabuses (see, for example, Finch and Clements-Croome, 1997, the recently designed IT based construction management executive MBA program at *http://www.pym.itu.edu.tr* etc.)?").

2. The Importance of Innovative Buildings

Irrespective of whether innovative buildings' subjects should be introduced to CM courses, it has been estimated that the IBs market will rise to € 3 billion in the European Union (EU) alone by 2005 (JBR Hellas, 2002). Equally, the market of sustainable buildings will inflate accordingly as EU directives suggest that buildings' energy consumption should be reduced by 8% before 2005 and by 20% before 2010. The 6th EU Environmental Action Program 2001-2010 introduced a number of relevant programs ("Thermie", "Futurehome", "NNE-Joule C", "Environment 2010"and "Brite / Euram") whose overall target was to achieve the adoption of innovative features by 40% of the buildings in the EU by 2010. Greece is by enlarge in line with the EU directives as the necessary modifications to the legislative framework have been made (TCG, 1998). In addition, a number of Greek commercial companies and of state subsidized research organizations are actively involved in the area. All these resources and effort devoted to innovative buildings clearly indicate that the related technology is under revision; a fact expected to pertain a large part of the 21st Century. A word of caution though; consumers need further awareness and training in modern technologies (computers, networks, internet, satellite dishes, cable TVs, PDAs etc.) before they integrate them fully into their everyday lives and, in effect, into their homes (see Eurobarometer Surveys, 2003).

3. Research Methodology

The research methodology entailed a thorough literature survey on intelligent and sustainable buildings (presented briefly in the introductory section above) and also:

1. A survey of innovative buildings in Greece.
2. The description of a model innovative building incorporating features that (i) can be considered innovative based on published measurements (e.g. CEA, 2003) and (ii) can be bought, installed and supported in Greece.
3. The development of a cost model based on actual construction market data in Greece quantifying the impact of the innovative features on the total construction cost.

4. Survey of Innovative Buildings in Greece

A number of articles and web pages related to the subject have been published in Greece. An indicative list includes Tombazis and Preuss, 1999, Kavalaris, 2001, Kouzis, 2001, Technical Selection, 2001, Chrissomalides, 2002, Greek Data Base of Sustainable Buildings, 2002, Konstantinides, 2003, Portfolio Bioclimatic Projects, 2003 etc. From this survey it became apparent that the number of sustainable dwellings in Greece is heading the respective figure of IBs, but in recent years the latter are following hard on the formers' trail. There is also evidence that sustainable and intelligent features are gradually converging in the construction of buildings; a fact justifying the integrated view of innovative buildings adopted by this paper.

5. Description of the Model Innovative Dwelling

Based on an extensive literature survey, studies of existing buildings in Greece and interviews with companies and organizations active in the area (see section 6 below), the following systems were selected to be incorporated into the model: Distant building management systems, distant security control systems (fire prevention and alarm), energy saving systems (lighting and electrical appliances control) and distant lighting and temperature regulating systems. These systems form the necessary infrastructure to classify the building as intelligent, while at the same time, they are expandable to include, if and when required, systems such as Closed-Circuit TV, satellite TV, home theater etc. The initial construction of the infrastructure (structured cabling, sensors, controllers, panels etc.) is in line with the recommendations of CABA, 2002. The model also included a number of sustainable features which have a limited cost impact on the construction cost such as the appropriate placement of windows in the building shell, passive heating/cooling and solar thermal systems. These systems are the most commonly used sustainable features in Greece by 85% of the buildings according to the Greek Data Base for Sust. Buildings, 2002.

It should be noted that a building incorporating the above features scores 21 out of 30 in the CEA, 2003 intelligent measurement tables and is "typically" sustainable according to the Greek Ministry of the Environment & Public Works, 2003.

Once the innovative features were selected, a number of dwelling floor plans were analyzed to estimate the quantities of the required sensors (fire, temperature, lighting, alarm, floor etc.), the length of UTP cables and the number of sockets, controllers, panels etc. This analysis was made for different sizes of dwellings ranging from 60 to 500 m^2.

6. A Cost Model for Innovative Dwellings in Greece

Tables 1 and 2 present a register of the major companies active in the area of intelligent and sustainable buildings respectively in Greece. These companies were contacted to seek information and advice in the construction of the model innovative building and to collect quotes for the products and services required for the model innovative building.

Table 1: Major Companies offering intelligent building equipment & services in Greece

Internet Link	Description	Activities
http://www.abb.gr/	ABB Representative	Integrated Solutions
http://www.adamco.gr/	Greek company, AMX Representative	Integrated Solutions, Professional Training
http://www.adamsnet.gr/	Greek company established since 2000	Integrated Solutions
http://www.advantech.gr/	Greek Branch of Advantech (http://www.adnantech.com)	Fiber Optics, Automation Systems
http://www.automate.gr/	Greek company established by Fourlis S.A. since 2000	Integrated Solutions, Building Automations
http://www.cbnetworks.gr/	Computer Bank Networking Group	Structured Cabling, Telecommunications
http://www.cisco.gr/	Greek Branch of Cisco Systems	Networks, Fiber Optics, Wireless LANs
http://www.eka.com.cy/	EKA	Intelligent Buildings
http://www.kapassakis.gr/	Kapassakis S.A.	IB Applications, Energy Saving Technologies
http://www.optronics.gr/	Optronics & Siemens Rep. since 1990	Integrated Solutions
http://www.panou.gr/	Greek company established since 1990	Structured Cabling
http://cim.pennnet.com/	Pennet Representative	Networks, Fiber Optics
http://www.smartdom.com/	Belongs to Petzetakis Group – Product name "Smartdom"	Integrated Solutions, Structured Cabling
http://www.synet.com.gr/	Synet Representative	Integrated Solutions
http://www.teable.gr/	Representatives of Industrial Automation Systems since 1985	Integrated Solutions, EMS, Automations

Table 2: Major Companies & Organizations offering sustainable building equipment & services in Greece

Internet Link	Description	Activities
http://www.cres.gr/kape	KAPE (Center for Renewable Resources) – supervised by the Greek Ministry of Development	Sustainable Buildings and Application of Intelligent Buildings
http://www.uoa.gr/physics	University of Athens, Department of Physics	Research & Design of Renewable Energy Systems
http://www.dei.gr/	DEI (Public Power Corporation)	Research & Design of Renewable Energy Systems
http://www.solar.ariadne-t.gr/manu/gr/ebhe/ebhe.htm	EVIE: Greek Industry for Solar Energy	Research & Design of Solar Energy Systems
http://www.meletitiki.gr/	Meletitiki Ltd – Tompazis & Associates	Integrated Solutions for Sustainable Buildings
http://www.alteren.gr/	Alteren S.A. established since 1992	Sustainable Building Designs, Renewable Energy Systems
http://www.helioakmi.gr/	Helioakmi	Solar Water Heaters
http://www.photovoltaic.gr/	Photovoltaic S.A.- established in1995	Photovoltaic products

http://www.pi-systems.gr/	π- Systems International S.A.	Sustainable Design Software
http://www.tsitsos.gr/	Established since 1981	Photovoltaic products
http://www.solar.ariadne-t.gr/	National Center for Scientific Research "Demokritos"	Solar and Other Energy Systems Laboratory
http://web.otenet.gr/compa	Compa Solar	Photovoltaic products

Other suppliers of intelligent and sustainable products and services in Greece can be found at *http://www.jxj.com/suppands/edseeb/select_country_class/47.html*.

The model of the innovative building and the cost data obtained were then synthesized using a simple spreadsheet program. The results are summarized in Figure 1.

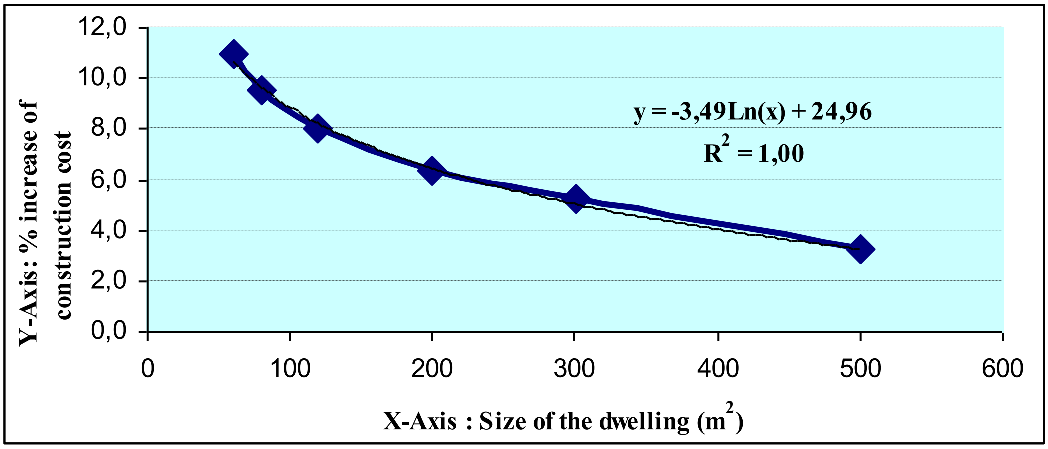

Figure 1: Relation between % increase of the construction cost and the size of the dwelling

From this figure it can be derived that the percentage increase of the construction cost for the erection of an innovative building ranges from 3 to 11%. For a typical Greek dwelling of 100 to 200 m^2 the expected cost increase is below 10%.

7. Conclusions

This research confirms the argument made by others that the number of innovative buildings will grow substantially in the near future. The state of the relevant technologies permits the erection of such buildings today provided that emphasis is put in the required infrastructure (structured cabling, appropriate placement of openings in the building shell, passive heating/cooling and solar thermal systems). Certain products (e.g. photovoltaic, cooling via the freezing of salt, dynamic insulation etc.) are still too expensive for normal dwellings and their use should be limited. Overall, innovative dwellings require specialized knowledge that should be incorporated as core in existing construction management curricula. Finally, awareness and training in IT related technologies and sustainable construction of the public at large would affect positively the client demand for innovative dwellings in the future.

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