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NOTE

Sustainable construction and drivers of change in Greece: a Delphi study

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During the last decade, sustainable development issues have been gradually adopted in Greece's construction industry, changing the traditional methods and technology. The aim of this investigation is to identify potential drivers of change, to position them properly in the wider context of sustainable construction and to outline the progress to be expected in the coming decade. The methodological framework used is a Delphi technique based on a questionnaire of 20 experts (consultant engineers, construction managers and contractors). The results show that the most important influences on sustainable construction in Greece are energy conservation measures, resource conservation strategies and waste reduction. In terms of the initiatives expected in the coming decade, energy conservation measures, waste reduction measures, as well as product innovation and certification are expected to rank high. In conclusion, the results are consistent with those of previous researchers showing significant trends towards land use, energy, and resource conservation.

Keywords: Change, sustainable construction, Delphi method, Greece, construction policy

Introduction

Sustainability as a concept is most widely known in relation to sustainable development. According to the United Nations World Commission on Environment and Development, sustainable development is defined as 'development which meets the needs of present generations without compromising the ability of future generations to meet their own needs'. Sustainable development provides a framework for the integration of environmental policies and development strategies. It recognizes that development based on the efficient and environmentally responsible use of all of society's scarce resources is essential to satisfy human needs and improve the quality of life.

Sustainability is important for the construction industry because the facilities we construct have a huge impact on the environment. Sustainable construction as a concept encompasses the creation and management of a healthy built environment based on resource-efficient and ecological principles. The results of the implementation of sustainable construction practices (i.e. building practices) are defined as practices that strive for integral quality in terms of economic, social and environmental performance. Sustainably designed buildings are designed to lessen their impact on the environment and improve environmental quality through: minimization of consumption of non-renewable resources; elimination or minimization of the use of toxins; and reduction of energy consumption. The main principles of sustainable design are: understanding place, understanding natural processes, understanding environmental impact and understanding people; and, moreover, connecting with nature though embracing co-creative design processes. Understanding place helps to determine design practices, understanding natural processes contributes to setting goals on regeneration in order to eliminate depletion, understanding

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environmental impact improves the outcome of the design stage, and an understanding of people is crucial for taking into account the versatility of cultures and habits of humankind. Connecting with nature gives top priority to the designed environment and embracing co-creative design processes aims at establishing collaboration with experts and end users as a standard practice.

The facilities we construct that have a negative impact on the environment make use of natural resources during the construction stage and leave manmade footprints in the ecological environment. They are also our interface to the natural environment, protecting us from the elements and meeting the needs of humanity for shelter, status, and other functions. As a result, there is pressure to make these facilities more sustainable, so that they meet the needs of society without compromising the needs of others or jeopardizing the future survival of humanity on earth.

In Greece, the complex problems shared by cities are evidence of the impacts of urban sprawl: increasing traffic congestion and commuting times, air pollution, inefficient energy consumption, loss of open space and habitat, non-optimal allocation of economic resources and the loss of a sense of community. These combined pressures, along with the challenges faced specifically by stakeholders of the built environment, have led to a growing awareness of the need for change. In response to these drivers of change, the concept of sustainability is beginning to permeate the Greece construction industry as a possible strategy to better meet the needs of clients and owners while ensuring business success in an increasingly competitive and constrained operational environment. While a variety of initiatives have been implemented to initiate the change toward increased sustainability, some critics have begun to realize that these initiatives are insufficient to bring about the change that is needed.

According to an extensive survey at the national level, the total annual energy consumption of buildings varies from 60–500 kWh/m^2, depending on their utilization and type. More specifically, the annual energy consumption for heating varies between 30–170 kWh/m^2; for cooling between 15–90 kWh/m^2; for lighting between 10–50 kWh/m^2; and for the operation of various appliances and equipment between 10–80 kWh/m^2 (Bikas and Milonas, 1998).

Aiming at a sustainable built environment requires a shift in the way we approach time, cost and quality constraints, forcing us to take a much broader look than previously was the case. The potential drivers of change (PDC) should be identified in order to arrive at a prediction of change. This prediction of change is necessary in order to identify further the (new) set of sustainable performance construction indicators (Augenbroe *et al*., 1998).

The present paper aims at ranking the most important drivers of change using the results of a Delphi study (Nakou, 2004). Twenty experts were provided with the PDC and asked to rank them according to their contribution to sustainable construction in Greece. Moreover, they were asked to predict progress in the topics related to the PDC and their importance for achieving sustainable construction in Greece. For the most part, these PDC were extracted from the literature (Augenbroe *et al*., 1998; Augenbroe and Pearce, 1999). Some of them however, had already been identified in an earlier study of ours (Manoliadis and Tsolas, 2004).

Drivers of change

PDC towards sustainable construction have been proposed by the Levene Efficiency Scrutiny into Construction Procurement by Government (Cabinet Office Efficiency Unit, 1995), Vanegas and Pearce (2000), Egan (1998), Augenbroe *et al*. (1998), Augenbroe and Pearce (1999), the United Kingdom National Audit Office (2001) and Winch and Courtney (2001).

The Levene Efficiency Scrutiny into Construction Procurement by Government (Cabinet Office Efficiency Unit, 1995) proposals focus on the improvement of the procurement and management of construction projects and include: better communication with the construction industry to reduce conflict; adoption of a more commercial approach; negotiation of deals justified on 'value for money' grounds; and increased training of civil servants in procurement and risk management.

Vanegas and Pearce (2000) opine that drivers for change should centre around: resource depletion; degradation and the increasingly noticeable impacts of the built environment on human health. Egan (1998) proposes five key drivers: committed leadership; focus on the customer; integration of process and team around the project; a quality driven agenda; and commitment to people. It should be noted that, further to these drivers, four key processes that had to be significantly enhanced and seven quantified targets for the level of improvements to be achieved are also presented.

Augenbroe and Pearce (1999) and Augenbroe *et al.* (1998) propose the following 15 PDC: energy conservation measures; land use regulations and urban planning policies; waste reduction measures; resource conservation strategies; indoor environmental quality;

environmentally-friendly energy technologies; re-engineering the design process; proactive role of materials manufacturers; better ways to measure and account for costs; new kinds of partnerships and project; adoption of performance-based standards; product innovation and/or certification; adoption of incentive programmes; education and training; and recognition of commercial buildings as productivity assets.

Recommendations made by the United Kingdom National Audit Office (2001) include the need for government departments to develop more sophisticated performance indicators and to actively measure improvements in construction performance. In this framework, change needs to be led by clients who demand better value and improved performance from suppliers. In return, clients must demonstrate that they will act as good employers and will procure work in a way that allows best value to be delivered and provide fair rewards for good performance.

According to Winch and Courtney (2001), amongst the most important drivers for change are: introduction of new forms of procurement and contract arrangements; use of whole-life costing in the assessment of project proposals; a move towards more integrated supply chains; industrialized construction systems; lean construction; research programmes in the areas of new forms of management and the use of IT systems; and the introduction of client-orientated performance indicators.

In this paper, the PDC that are expected to influence the sustainability of the built environment in Greece in the coming decade are those proposed by Augenbroe *et al.* (1998) and Augenbroe and Pearce (1999). They were included in a list of the important factors of change that was conveyed and similar meanings were combined.

The rest of the paper is organized as follows. In the following section, the methodological framework of the Delphi method is reviewed. The next section presents the preparation of the Delphi study, followed by the results. The final section provides a summary and conclusions.

Methodological framework

The Delphi concept was developed by the American defence industry. A project named Delphi was a study undertaken by the Rand Corporation for the US Air Force in the early 1950s (Helmer, 1967a, 1967b; Robinson, 1991). The procedure was designed to obtain the most reliable consensus of opinion of a group of experts by a series of intensive questionnaires interspersed with controlled opinion feedback, and with the results of each round being fed into the next round (Linstone and Turoff, 1975).

This method involves the selection of procedures for suitable experts, development of appropriate questions to be put to them and analysis of their answers (Cabanis, 2001; Outhred, 2001). The desired outcome is that, by using such an iterative forecasting procedure, on reaching the final round the experts will have achieved unanimity on the issues put before them.

The main features of the Delphi method are anonymity, iteration with controlled feedback and statistical response (Dickey and Watts, 1978; Adnan and Morledge, 2003). Panel members remain unknown to one another and respond to a series of questionnaires. The iterative nature of the procedure allows them to modify their assessments and project them beyond their own subjective opinions. It can represent the best forecast available from consensus of experts (Corotis *et al.*, 1981). The process is continued until a consensus is reached on the various issues under consideration, or until it becomes evident that no further consensus can be achieved. Generally, the number of rounds varies between two and seven while the number of participants ranges from three to fifteen (Rowe and Wright, 1999; Adnan and Morledge, 2003).

The method involves posing a number of rounds of appropriate questions on the specific subject area to a group of suitable pre-selected experts. Each one of the experts responds expressing his/her opinion and the collected results (answers) of this first stage are analysed. These results are then collated and fed back to the respondents in an anonymous or non-attributable way, along with the second round questions. Each one of the participants is then able to take into account the opinions of the other participants when responding to the second round of questions. This process is then repeated for each subsequent round and, it is hoped, that by the final round a consensus of opinion on the issues put before them will have been reached. The process is typically carried out by remote correspondence, such as mailed questionnaires, rather than involving face-to-face group discussions. This enables all participants to respond individually and reduces the impact of group dynamics on the resulting consensus.

The method is based on the judgements of the selected experts, and does not rely on previous historical data being available. Moreover, the method is typically intended to provide a judgement or opinion on the specific subject area, rather then producing a quantifiable measure or result. Because of this, the method can easily work well in new areas that are frequently subject to unpredictable forces, which are not easily quantifiable in most of the cases. Another key factor is the anonymity of the participants, which permits them to express their opinions freely.

The major difficulties of Delphi, however, lie in maintaining the high level of response and in reaching and implementing a consensus. It is important that panel members treat the work seriously, devote the time necessary to provide thoughtful and reasoned responses to the questions and that they contribute to each round of Delphi (Robinson, 1991).

Preparation of a Delphi study of the Greek construction industry

The key issues in preparing a Delphi study are:

- the definition of experts and their selection;
- the number of rounds; and
- the questionnaire structure (i.e. number of questions) in each study round.

An expert may be defined as someone with special skills or knowledge evident through his or her leadership in professional organizations, or someone holding office in a professional organization, a presenter at national conventions or who has published in recognized journals (Cabanis 2002).

Once an expert panel has been identified, an additional problem is to maintain their input throughout the rounds of the study. The study is organized into a greater number of rounds in order to distil greater consensus of the participants and gain better forecasting accuracy. Moreover, the number of questions in each round is closely related to the time required from the participants to complete each round.

Experts selection

The following criteria were devised in order to identify eligible participants for the present Delphi study:

(1) practitioners who have extensive working experience in the construction industry in Greece;
(2) experts should be involved in the management of construction projects in Greece and
(3) experts should have a detailed knowledge of the whole procurement process.

A list of the panel members and their type of occupation are shown in Table 1 (experts names and their organizations are not reported to respect their anonymity).

Description of the adopted Delphi Method

The Delphi method adopted in this study consisted of the following two rounds. The first round questionnaire consisting of 15 factors was sent out in December 2003. The experts were asked to answer four questions. In round two, the experts were provided with some modifications arrived at via the experts comments from the first round. They were given the numbers of response of each factor based on the scale of criticality again. To achieve consensus in the statements added by the panel during the first round, the experts were directed to review their rating again in terms of their criticality. The second questionnaire was sent in March 2004 and the questionnaires were collected by the end of June 2004. At this stage, most of the experts had reconsidered and made adjustments to their score.

Table 1 List of the panel of experts for the Delphi study

Experts/type of firm	Number
Civil engineers	5
Mechanical engineers	4
Chemical engineers	1
Electrical engineers	2
Surveying engineers	3
Architects	2
Economists	1
Contractors	2
Total	20

Development of the questionnaire

The questionnaire refers to the drivers for change that have emerged as a result of the international and national construction industry's response to sustainability. The final drivers of change selected for consideration are presented in Table 2. Experts were asked to answer the following questions:

- Question 1: what is the most important driver in sustainable construction in Greece?
- Question 2: what is the contribution of the driver to sustainable construction in Greece?
- Question 3: to what extent will be the progress of the driver in the next coming decade?
- Question 4: how are the drivers prioritized in accordance with achieving further sustainable construction in Greece?

Results

The first round of the Delphi questionnaire was sent via e-mail to the panel experts. Table 3 shows the outcomes of participants' perceptions (mean values) in response to the survey questions of round one and their relative rank. As far as the first question is concerned (what is the most important driver in sustainable construction in Greece?), energy conservation ranked

Table 2 Selected drivers of change

	Drivers of change
1	Energy conservation
2	Waste reduction
3	Indoor environmental quality
4	Environmentally-friendly energy technologies
5	Resource conservation
6	Incentive programmes
7	Performance-based standards
8	Land use regulations and urban planning policies
9	Education and training
10	Re-engineering the design process
11	Sustainable construction materials
12	New cost metrics based on economic and ecological value systems
13	New kinds of partnerships and project stakeholders
14	Product innovation and/or certification
15	Recognition of commercial buildings as productivity assets

first followed by resource conservation and land use regulation and urban planning policies. As for the answers to the second question (what is the contribution of the driver to sustainable construction in Greece?), energy conservation ranked first followed by waste reduction and education and training. In answer to the third question (to what extent will be the progress of the driver in the next coming decade?), energy conservation ranked first followed by waste reduction and product innovation and/or certification. Question four (how are the drivers prioritized in accordance with achieving further sustainable construction in Greece?) was answered in the following order: energy conservation first, followed by resource conservation and land use regulation and urban planning policies. Table 4 shows the outcomes of participants' perceptions (mean values) in response to the survey questions of round two and their relative rank:

- First question (what is the most important driver in sustainable construction in Greece?): a change was recorded in the ranking after the ninth factor of change.
- Second and third questions (what is the contribution of the driver to sustainable construction in Greece?; to what extent will be the progress of the driver in the next coming decade?): no change was recorded in the ranking while a slight difference was recorded to the mean values of grading the factors of change.
- Fourth question (how are the drivers prioritized in accordance with achieving further sustainable construction in Greece?): a change in the ranking between the fifth and the sixth factor of change was recorded as well as the 14th and 15th change of factor.

On the basis of the slight changes in the results of both initial rounds we concluded that consensus had been reached. A third round, therefore, was not carried out.

Discussion

The completion of the two rounds of Delphi questionnaires took about five months. For each round of Delphi, reminder letters were sent by e-mail to the non-respondents. Sometimes further reminder calls had to be made to convey the objectives of the study to the panel of experts.

The results of the Delphi study presented here indicate that the most important factors of change in Greece are energy and resource conservation as well as land use regulation and urban planning policies. These findings are supported by the fact that energy and resource conservation are, in fact, becoming of increasing concern in Greece in recent times.

In Greece, energy consumption in buildings is mainly for heating, cooling and lighting purposes. Moreover, electrical appliances and office equipment also consume significant amount of energy (Bikas and Milonas, 1998). Construction materials commonly used in Greece for residential and office buildings are reinforced concrete for the structural framework and brick and mortar for internal and external walls. Almost all of the construction activities (i.e. digging, drainage and prevention, H&V transport, safety measures, formwork, connecting reinforcement, pouring concrete, vibrating concrete, controlling the hardening, curing and finishing) are energy consuming, though also important is the consumption of water and admixtures for a lot them. The life span of this type of construction is more than 80 years (Bikas and Milonas, 1998).

As far as land use regulation and urban planning policies in Greece are concerned, the existing institutional framework is in a process of evaluation. Moreover, it should be noted that the population in Greece is not normally distributed (urban 62%; rural 38%), and most of it is concentrated in large cities (i.e., Athens, Thessaloniki, Patras) (Bikas and Milonas, 1998).

Conclusions and policy implications

In order to identify the factors of change seeing through the adoption of sustainable construction aspects in

Table 3 Delphi study: round one results

Driving forces	Question 1		Question 2		Question 3		Question 4	
	Mean*	Rank	Mean*	Rank	Mean*	Rank	Mean*	Rank
1 Energy conservation measures	3.43	1	9.10	1	8.13	1	3.41	1
2 Waste reduction measures	4.00	4	8.00	2	8.00	2	4.53	6
3 Indoor environmental quality	6.00	10	5.70	13	5.50	13	6.21	11
4 Environmentally friendly energy technologies	4.23	5	7.50	5	7.13	4	4.35	4
5 Resource conservation strategies	3.80	2	7.70	4	6.38	9	3.51	2
6 Adoption of incentive programmes	5.23	7	6.70	9	6.75	8	5.44	8
7 Adoption of performance-based standards	5.77	9	6.50	11	6.00	11	5.69	9
8 Land use regulations and urban planning policies	3.87	3	7.20	7	5.63	12	4.03	3
9 Education and training	4.77	6	8.00	3	7.13	5	5.26	7
10 Re-engineering the design process	5.40	8	7.30	6	6.88	7	4.35	5
11 Proactive role of materials manufacturers	6.87	14	5.20	14	5.25	14	6.45	12
12 Better ways to measure and account for costs	6.00	11	6.60	10	6.38	10	5.86	10
13 New kinds of partnerships and project stakeholders	6.67	12	5.20	15	7.13	6	6.91	14
14 Product innovation and/or certification.	6.73	13	6.90	8	7.25	3	6.49	13
15 Recognition of commercial buildings as productivity assets	6.30	15	6.30	12	4.88	15	7.05	15

*Mean value of scores from 1–10. *Source*: Nakou (2004). *Notes*: Question 1: what is the most important driver in sustainable construction in Greece? Question 2: what is the contribution of the driver to sustainable construction in Greece? Question 3: to what extent will be the progress of the driver in the next coming decade? Question 4: how are the drivers prioritized in accordance with achieving further sustainable construction in Greece?

Greece a survey was conducted based on drivers of change that concluded the work of previous researchers as conveyed to the specific area. Twenty experts, mainly consultants and contractors, were employed in the research. The method used was the Delphi method comprising two rounds. By using two rounds, a consensus was reached in the experts response ranking of the factors of change.

The results of this research indicate that the most important factors of change were energy and resource conservation as well as land use regulation and urban planning policies which are justified by the fact that energy and resource conservation are of increased concern in Greece lately. Also, as in the case of land use regulation and urban planning policies, there is a process of evaluation of existing institutional frameworks. As the main contributions to sustainable construction ranked first energy conservation followed by waste reduction and education and training. This can be attributed to the fact that the latter factors are perceived to be, according to the experts, the drivers to sustainable construction in Greece. Progress in sustainable construction in the coming decade is expected, except for energy conservation and waste reduction, through product innovation and/or certification. Therefore, the overall ranking of factors in achieving sustainable construction in Greece is (1) energy conservation, (2) resource conservation and (3) land use regulation and urban planning policies.

The results of the present paper are consistent with those of Augenbroe and Pearce (1999), who claim that their results show a significant trend towards the traditional priorities for change – i.e. land use, energy and resource conservation – whereas education also scores as a high priority issue.

Based on the findings of this paper, a number of measures could contribute in initiating the process of entrenching sustainable construction in the Greek construction industry. These measures can be classified into two broad categories related to general or specific policy (i.e. construction policy): general policy measures and construction policy measures

The general policy measures should focus on sustainable urban development, development of educational training programmes. Construction policy

Table 4 Delphi study: round two results

Driving forces	Question 1		Question 2		Question 3		Question 4	
	Mean*	Rank	Mean*	Rank	Mean*	Rank	Mean*	Rank
1 Energy conservation measures	3.37	1	9.10	1	8.13	1	3.03	1
2 Waste reduction measures	3.87	4	8.00	2	8.00	2	4.40	5
3 Indoor environmental quality	5.83	9	5.70	13	5.50	13	6.17	11
4 Environmentally friendly energy technologies	4.03	5	7.50	5	7.13	4	4.13	4
5 Resource conservation strategies	3.50	2	7.70	4	6.38	9	3.23	2
6 Adoption of incentive programmes	5.47	7	6.70	9	6.75	8	5.53	8
7 Adoption of performance-based standards	5.90	10	6.50	11	6.00	11	5.83	9
8 Land use regulations and urban planning policies	3.60	3	7.20	7	5.63	12	3.63	3
9 Education and training	4.90	6	8.00	3	7.13	5	5.33	7
10 Re-engineering the design process	5.63	8	7.30	6	6.88	7	4.53	6
11 Proactive role of materials manufacturers	6.87	14	5.20	14	5.25	14	6.43	12
12 Better ways to measure and account for costs	6.13	11	6.60	10	6.38	10	6.13	10
13 New kinds of partnerships and project stakeholders	6.67	12	5.20	15	7.13	6	7.20	15
14 Product innovation and/or certification	6.77	13	6.90	8	7.25	3	6.90	13
15 Recognition of commercial buildings as productivity assets	7.43	15	6.30	12	4.88	15	7.10	14

*Mean value of scores from 1–10. *Source*: Nakou (2004). *Notes*: Question 1: what is the most important driver in sustainable construction in Greece? Question 2: what is the contribution of the driver to sustainable construction in Greece? Question 3: to what extent will be the progress of the driver in the next coming decade? Question 4: how are the drivers prioritized in accordance with achieving further sustainable construction in Greece?

measures, amongst others, should include the introduction of energy and resource conservation measures, appropriate legislative framework regarding sustainability in construction and land use with respect for green areas and open space and, waste reduction measures. Moreover, other issues such as the introduction of quality standards for the whole building environment, eco-labelling standards and life-cycle considerations in product development, support for environmentally friendly materials, planning for renovation of the existing building stock and, integration of environmental studies in building construction.

Sustainable urban development should aim at placing green building projects within easy access of public transportation and other facilities (i.e. medical, shopping areas) contributing to the improvement of quality of life by decreasing the need for automobiles. Moreover, green buildings should blend into the community, preserving natural and historical characteristics, and should utilize the existing infrastructure to reduce sprawl.

Education and training in sustainable construction concepts and methods are probably the most important ways of facilitating the adoption of sustainable construction practices. Therefore, the existing educational and training programmes should be upgraded to ensure that they include and take advantage of the existing knowledge base.

Energy and resource conservation measures should be based on the use of proper siting and airtight construction and the installation of energy-efficient equipment and appliances and renewable energy systems. Resource conservation measures should deal with the use of waste and recycled building materials (i.e. introduction of new materials and re-use of building materials) and water conservation (i.e. depending on the installed appliances, irrigation practices, etc.).

The legislative framework regarding sustainability in construction should be revised taking into account several issues such as urban development, integration of environmental studies in building construction and

quality and eco-labelling standards in order to support the whole process towards sustainability.

Waste reduction measures depend on the type of waste: Construction and renovation waste can be reduced by salvaging, rather than landfilling. Construction waste can also be minimized by renovating existing buildings, rather than destroying them and erecting new ones. Moreover, many construction materials such as glass, aluminum, carpet, steel, brick, and gypsum can be recycled.

We conclude that future research should be conducted using the same or other more extended questionnaires, more expert panels (e.g. two) and should involve a comparison of the results with those of other methodological approaches. An alternative methodological approach for identifying the above factors of change would be, for example, the analytical hierarchical method using pairwise comparison.

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