Developing an Information Support for Low Carbon Homes Design in the United Kingdom

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Abstract : The design stage of low carbon new homes in the United Kingdom (UK) is supported by varieties of information such as the building regulations part L1A, Code for Sustainable Homes (CSH), and other design tools. However, the varieties of information are from different sources like BRE, DCLG, NHBC, and Carbon Trust.

As a result of this, a study comprising a mixed method approach of qualitative and quantitative methods was carried out to collect .primary data. The qualitative semi-structured interview was used to investigate the state of art in the use of Code for Sustainable Homes (CSH), being the most recent tool for low carbon homes design and construction in UK and to identify other current information needs of architects. Past researches, journals and reports on existing low energy design processes in the UK and at international level were also identified and analysed in order to develop a process model for low carbon homes design and construction in UK. This was followed by the quantitative data collection in form of an on line survey emailed to sustainable architectural practices identified from the Royal Institute of British Architects (RIBA) directory to investigate the extent and knowledge in the use of all the identified information.

The result among many identified deficiency of a process model for low carbon homes design in UK and recognized the Code for Sustainable Homes (CSH) as the latest tool which the UK architects lack expert knowledge of. The study is therefore proposing an information support by which the process model for low carbon homes design is acknowledged, CSH is presented in a simplified and easy to use format and principles of sustainability requirements for building elements are analysed.
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Key words: Information Support, Code for sustainable Homes,. Low Carbon Homes, Process Model, United Kingdom

1. INTRODUCTION

The UK government has made an ambitious commitment to reduce carbon emissions by at least 80% lower than the 1990 baseline level by the year 2050.(HMG,2008) Legislative frameworks necessary for legally binding interventions were provided in the climate change act,2008 act to improve carbon management and help the transition towards a low carbon economy. As buildings, are one of the priority sectors for carbon reduction which accounts for approximately 40% of the carbon emissions both in the UK and across the EU.(Carbon Trust, 2010). Tackling energy use through design and development of low carbon buildings has become a UK policy priority and on a wider level, the European commitment to reduce energy consumption (Crosbie *et al., 2010*).

This paper as part of an ongoing research at the University of West England, UK, is proposing and presenting an information support by which the process model for low carbon homes design in UK is recognized, CSH is presented in a simplified and easy to use format and principles of sustainability requirements for building elements are included. This will improve carbon management and help transition towards a low carbon economy.

2. DESIGN PROCESS AND EARLY DESIGN STAGE

The approach developed in this research builds on the research work from Crosbie *et al* (2008), Beadle (2008) and other projects on low energy design process in the UK and at international level. Beadle (2008) analysed a low energy design process for a housing project in UK and how energy demand needs to be minimised right from the early design stage rather than relying on energy curtailment behaviour. Crosbie, *et al* .(2010) argued that carbon reduction in the built environment demands more Informed early design planning in order to support improvements in the selection of materials used in the construction of buildings in terms of their impact on energy performance and embodied energy from the occupiers .

A number of studies have since demonstrated that indeed, early decisions in the design process have the largest impact on the sustainability of the final design. Such literature includes Neuckermans (1992); De -Groot and Mallory Hill (1999); Reed and Gordon (2000); Ellis, *et al., (*2001); Pearl (2004); Zhu *et al*., (2007); Weytjens (2008); Sodager and Fieldson (2008); Fieldson*, et al*., (2010) and many more. All these and more justifies the focus on the development of the process model at the early stage of design.

Ellis and Mathews (2002) also suggested that new tools and in this case, the proposed information support at the early stage of low carbon homes design should be structured and designed with the stakeholders in mind, hence the use of the Royal Institute of British Architects (RIBA) directory for the online survey in this study. Architecture has been identified as a means to capture early design decisions touching upon functional as well as non –functional aspects. The early design decisions are important since their ramifications are felt in all subsequent phases. In this sense, architecture forms a bridge between a system's definition and a system's design. (Bass, *et al.* 1998) The essence of these two, system definition and design from Bass, *et al* (1998) usually meet in architecture since the design of buildings is a complex task for a variety of reasons.

This can be recognized especially in the conceptual stage; that is, in the inception phase because a small number of people make decisions that have far reaching significance that affect the result in terms of efficiency and effectiveness. (De -Groot and Mallory Hill, 1999)

Decision-making at the inception phase of design relies on available information that may be incomplete, like the maintenance costs (De-Groot and Mallory Hill, 1999) or overly complex like the code requirements of the Code for Sustainable Homes (CSH).

There is therefore need for growth in the tools and approaches to assist in supplying stakeholders with information such as green gas emissions, embodied energy, waste , recycling quantities , material

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selection (Verghese and Hes ,2007) etc, and especially from the early stage of Low Carbon Homes (LCHs) design process in the UK as being proposed in this research.

The information to design LCHs should be applied right from the conceptual design phase as argued in Elforgani and Rahmat (2010) from Coady and Zimmerman(1998) that; ' *the major environmental impacts of a building are determined at the conceptual design phase*. Also, the decisions made during conceptual design are considered to have the greatest influence on project performance and have the least associated cost' (Marsh, (1999); Beadle, (2008)

The construction industry is becoming increasingly concerned with understanding the whole life impact of buildings and customers are shifting their focus towards declaration of the green house gas (GHG), Carbon footprint or CO2 emissions, to maximise potential for reduction(Fieldson ,*et al* 2010). The whole life building carbon footprint are considered at the outset of the design process with constant revision and reflection on the impact of the design changes at the later stages of the process.

Conclusively, many of these design decisions at the early stage of design has solely been based on experience, rules of thumb, reference projects or intuition without considering the substantial consequences of those decisions. (Weytjens and Verberck (2008); Lawson, (2010) A number of studies had since demonstrated the importance of early decisions in the design process as having the largest impact on the sustainability of the final design (Weytjens and Verberck, 2008).

However, no precise data exist on the extent of sustainable building, (William and Lindsay, 2007) by which, Loh, *etal* (2010) developed a process framework for building design and an ICT system to support multi stakeholder decision-making that facilitates the inclusion of energy issues in the early design phase of buildings. This research is also focussing on the support information required by architects at the early stage of designing low carbon homes in UK to reduce architects dependence on experience, rules of thumb, reference projects, or intuition.

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.2.1.Architects role and the need for Information Support

The architect is a key player in the construction industry whose services are needed from conception stage (discussed in previous section) of the project to its final handing over' (Oyedele and Tham, 2009). 'The major environmental impacts of a building are determined at the conceptual design phase with the architects identified as the main stakeholder/actor involved in the design process of green buildings (Mohamed and Ismail ,2010)

Adeyeye, *et al.* (2007*),* ascertained the need for '*architects' views'* on the associated barriers and incentives to the implementation and sustaining energy conservation strategies in their survey of architectural design practices in UK.

For new housing to become progressively more energy efficient, leading to net zero-carbon dioxide emissions by year 2016 ,some technological changes that will entail *architects' design knowledge'* on how to design such buildings were proposed in Banfill and Peacock (2007)**.** Other disciples of architects' role in the delivery of sustainable housing projects includes Roaf (2004) and Elforgani and Rahmat (2010). Architects are the first and an important point of contact in design of buildings and are even the most involved during the whole design process, especially those involving green buildings (Ward*, et al.,* (2008); Elforgani and Rahmat (2010).

The architect is a key player in the construction industry whose services are needed from the conception stage of a project to its

final handing over (Oyedele and Tham, 2007). They have the major responsibility to get the message across in the participatory decision making processes and thereby educate other stakeholders into more genuinely collaborative roles (Ward, et *al.,* 2008)

Many researches had since shown that pressure of time had forced designers, especially architects to get projects committed to paper in order to produce relevant information rather than ponder on the actual quality of the design (Mackinder and Marvin 1982). In such circumstances, it gives little time or no time at all for designers to scrutinize alternative design solutions, and thoroughly evaluate them. Designers had been known to opt for the most obvious solution because they do not have the time or resources to develop multiple configurations (Maher, 1987). The problem is usually worst and exhibited during the early design stage of buildings by which ,there has been no shortage of information or design tools especially at the early stage of design, but architects can sometimes be overwhelmed when trying to apply the tools to decision making (Keysar and Pearce,2006) from Carmody *et al.* (2000). This prompts the interest that, there exists a wide range of information and design support tools for architects use in design of low carbon homes in UK. However, the varieties of information are from different sources and in different format not familiar to UK architects. The appropriate information at the right time and especially at the conceptual design stage is vital to ensure the desired quality of the construction projects (Ballal, *et al.*, 1996) and to reduce the negative impact of buildings on the environment. For new housing, the most important UK policy currently in use to combat climate change issue is the Code for Sustainable Homes (CSH) (Mcmanus *et al*, 2010.) which was introduced in 2007 as a replacement to Ecohomes for the assessment of new homes in UK.

3. METHODOLOGY

3.1.Mixed method approach

From the analysis of the documentary study, questions were developed to ask in the qualitative semi structured interviews and the quantitative online questionnaire survey.

The research examined the judging criteria of designing low carbon homes in the UK and the potential of CSH as a design delivery or environmental guidance for UK architects. The qualitative and quantitative methodological approach adopted in this research were :

1. Interviews and
2. Online survey

The interviews were with sustainable architects and sought to address research questions that were based on the identified and essential variables associated with low carbon /Sustainable Homes. The mixed method approach was such that the strengths of one method offset the weakness in the other. It was also necessary in order to establish the validity of the research, which in this case was the data collection through interviews of architects in practice and those in academics. The interviews were used to investigate the state of art and knowledge in the current use of CSH including its general awareness and barriers to its implementation in design of new homes in the UK. Eight (8) architects who are experts in the field of sustainable homes design were interviewed face to face. They were members of academic research institution where the research was carried out and sustainable architectural practitioners who attended an Eco –build sustainability forum in March 2011 at the London Excel. The interviews lasted between 30 to 45minutes

and provided a wider picture on the existing information and potential delivery of low carbon new homes in the UK.

The data collected were analyzed based on the themes of the topic and a series of variables that relate to low carbon homes design in UK. These were augmented with those from the quantitative online questionnaire survey administered to the sustainable architects identified from the RIBA directories of architects to cover the whole UK regions. This was done to validate the data as well as to give the UK statistical and representative information on the current level, awareness, and barriers to the use of CSH as well as the other information identified from the interview.

The design of the questionnaire survey was based on recent research studies on codes (McManus etal (2010); Sodager and Fieldson, (2008) and regulations (Imri, 2007) in the construction industry and especially those that used RIBA (Imri (2007) and Adeyeye etal (2007) for their research. The targets for this particular questionnaire survey are the practicing architects who had one time or the other designed sustainable homes in the UK. They were identified from the directory of Royal Institute of British Architects (RIBA)

Restriction of the study to architects was in twofold:

(1) Urge-Vorsatz, et al. (2007) recognized that, architects are the first point of contact for design of all buildings by which Boardman (2007) stated that; *'building sector currently contributes to approximately one-third of energy-related carbon emissions worldwide'.*

(2) There is the need for improved standards of new homes in the UK by 2016 by which .Building Regulations: Part L1A 'conservation of fuel and power' as applied to new housing focuses more on carbon emissions rather than energy consumption. There has also been gradual increase of the energy level of the building regulations partL1A from 2006 to 2010 and reflected in the CSH from 2007 and 2010. The next increase in the energy level target of the building regulations will be reflected in the CSH 2013 and finally in 2016. These changes and standards will be better achieved and implemented, through the corporation of architects and enough information on how to incorporate the current and updated sustainability measures and technologies, regulations, standards, guides, codes etc., into their design right from the onset. This was established in Roaf, et al. (2004) from Adeyeye et al. (2007), who also surveyed UK architectural design practices but targeted only the London architects.

Hence, the use of RIBA database as done in Adeyeye, et al. (2007): Imri (2007) and Imri (2009) but in this case the target are the sustainable architects identified from the 3000 registered practices in UK

The RIBA directory of architects became necessary in this research so as as to get the sustainable architectural practices names, contacts, locations, areas of expertise and services provided. The following were used as search criteria for selection of the sustainable architectural practices from the RIBA directory of chartered practices:

a. Location: All

b. RIBA region: All 14 Regions on the database: East, East Midlands, London, North East, North West, Northern Ireland, Scotland, South, South East, South West, Wales, Wessex, West Midlands, and Yorkshire.

c. Domestic Projects: Domestic Projects <£100

d. Project Sector: Houses and Housing-General

e. Architectural Services: Sustainable Designs

4. RESULTS

4.1 Interview

The interviews show the diverse nature and experience of those architects who participated in the process. Analysis from the interview on the state of art on CSH, its awareness, barriers to its implementation and probability of producing credible route map to the zero carbon targets for new homes by 2016 shows that, architects in practice are more aware of the CSH than those in academics

On the CSH producing credible route map to zero carbon homes by 2016, majority of the interviewee believed that, the CSH could not do this by 2016. .Interviewee 'C' specifically answered 'No' by which he was further asked what the barriers to the zero carbon targets by 2016 are, in addition to the barriers listed in the interview templates, which are:

Country Economy, Real or Perceived affordability, Lack of Information knowledge from Architects' point of view, Limited availability of products and skills of services and Technology, Lack of an informed system to check for current and emerging information. .

Interviewee 'C' further acknowledged, '*Economical, Social people not asking for it, misunderstanding about what sustainability is and what is involved, Existing Housing Stock needs to be retrofitted first (There is no strategy to retrofit existing housing stock)*', as additional barriers to Zero Carbon Homes target by 2016.

Interviewee 'E' answers to the list of barriers in addition to the provided list are: '*20th Century industry, skills, confidence and competence ,financial structure and unwillingness to change to sustainability earlier, with people now more willing when it is just less than 5 years away. The way housing is being delivered in the UK through the volume house modelling makes it more difficult for delivery.*

Interviewee' H' answer to the question in addition to the provided lists was that; '*the whole concept of the route map was a brilliant idea (refers to what zero carbon hubs has done) but with problems in the code 6 achievement, which is sort of dead, definition of Zero carbon is not very clear yet. (It is a credible route map, but it still has problems). 'Theory of route map is good but how you achieve it is the problem'.*

From the eight (8) interviewees, the response given by more than 50 per cent of the interviewees in relation to CSH can be summarized as follows:

- Code level 4 of the CSH is the current practice and practical enough to achieve.
- Code level 5 may be practical by 2016 for new homes while Code level 6 is not practical at all for achievement by 2016
- Half of the interviewee have heard, know and use CSH .Less than half do not like the present format of the CSH and only two (2) of the interviewees like the CSH present format .
- More than half, (With exception of 'F' that has no response and 'D' that said –'I don't know,) agreed that CSH could not produce credible route to zero carbon target for new homes by 2016.

In conclusion, Level 4 of the CSH is found to be the most current level that architects in UK have designed to in the year 2011/2012 followed by level three..

On the information support for low carbon homes, some of the interviewed architects favoured the support system to cater for

information at all stages of designing low carbon homes, hence the process model developed in this research for all stages of low carbon homes design in UK. However, the main focus of the information support is on those needed by architects, only at the pre design and design stage of the model. However, from the analysis done on identification and type of information from the interviewed architects, especially those that have experience greater than twenty (20) years, there was requirement for the support system to address the sustainability issue right from the onset of LCHs design.

All the interviewed architects support the inclusion of design tools, CSH, and other regulations like the building regulations part L1A to be included in the support. More than half of the interviewee support inclusion of materials and component information, and case studies while .half of those interviewed support design guides to be in the information support.

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4.2 Questionnaire Survey

Responses were received, out of which 70.5% were fully completed. The numbers of total responses are small but acceptable for this analysis given the targeted area of expertise. SPSS 19 was used for analysis of the results.

All the respondents are sustainable practicing architects by which 25(43.1%) are directors, 16(27.6%) are partner/principal, 4 (6.9%) are sole practitioners and 13 (22.4) are employees.

Parameters such as the number of houses or housing projects that the practices had designed in the last three years, the percentage of those designed houses that have been based on CSH, their current

Please, rate the level of your knowledge of the following regulations code

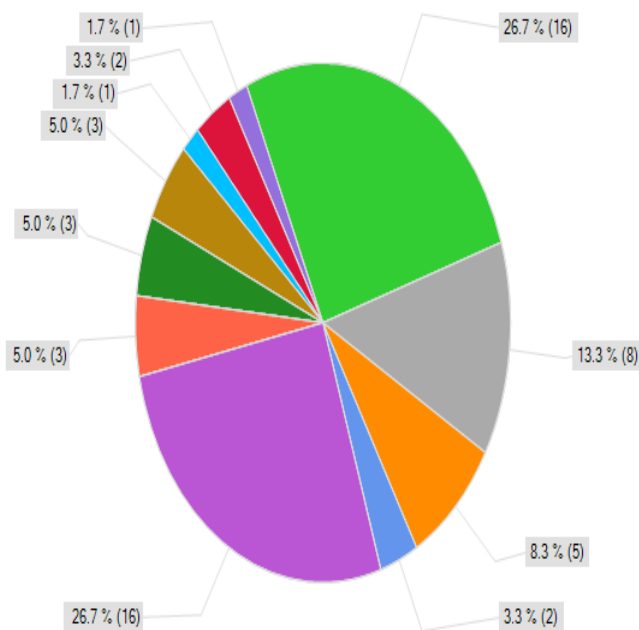### What is the geographical location of your organisation?

Table 1: Geographical location

	Frequency	Percent	Cumulative Percent
East	5	8.2	8.5
East Midland	2	3.3	11.9
London	15	24.6	37.3
North East	3	4.9	42.4
North West	3	4.9	47.5
Northern Ireland	3	4.9	52.5
Scotland	1	1.6	54.2
South	2	3.3	57.6
South East	1	1.6	59.3
South West and Wessex	16	26.2	86.4
Wales	4	6.6	93.2
Yorkshire	4	6.6	100.0
Total	59	96.7	
	2	3.3	
Total	61	100.0	

5. DISCUSSION

Table 2 shows the developed process model derived from the analysis of the existing design processes for LCHs.

Table 1: Process Model

The Process Model Action	Identification
• Project Planning and Setting Goals: Set and Agree on Principles and the desired level of the CSH	Identified from all the reviewed design processes
• Design Team -1: Select and assemble top-level multi-disciplinary design team	Identified from all the reviewed low energy design
• Design Team -2: Select and assemble other members of the project design team, by which they should also be multidisciplinary.	Identified from Federal Energy Management Building design guidelines (FEMP)
• Educate the project team on goals, costs and benefits of LCHs	Identified from Pearl (2004), FEMP
• Design Brief	Identified from Beadle (2008)
• Design Developments	Identified from all the reviewed low energy processes
• Specification and Material Selection	Identified from all the low energy design process
• Set up 'Site waste management Team'	
• Check actual performance of energy standard and evaluate	
• Occupancy, Operation and Maintenance	
• Post Occupancy Evaluation (POE)	

The section of the *CSH simply explained* tackles issues, not in the order laid out in the Code for Sustainable Homes Technical Guide (2010) which can be downloaded from the Communities and Local Government website, but in the nine groups of credits that have impact on one another and developed after the NHBC. They are:

1. Energy sources, internal lighting, and Dwelling Emission Rate (DER)
2. Easy-win and stand-alone credits
3. Site waste management and flooding
4. Construction and supply chain management
5. Potable water, grey water and rainwater use, and sustainable drainage systems (SUDS)
6. Internal space design ,site plan and site layouts
7. Specification and materials selection
8. Lighting – windows, doors, and external lights
9. Building fabric

Dwellings that are specifically designed to meet the requirements of the Code are usually more robust, as they will depend more on the building fabric to deliver the performance over the whole lifetime rather than on less-established technologies, which may require replacement from time to time.

6. CONCLUSIONS

The interview identified lack of an informed support to check for current and emerging information by which the on line survey was used to clarify the extent of knowledge on the identified information from the interview. Analysis from past research works on low energy design processes were then used to develop a sustainable information support framework. This was modeled after the RIBA plan of work stages being the framework familiar to architects and the general construction industry in the UK.

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REFERENCES

- Adeyeye, K., Osmani, M., and Brown, C., (2007*)*, 'Energy conservation and building design: the environmental legislation pushes and pulls factors, Structural Survey, 25, 5,375-390,
- Banfill, P. F. G., and Peacock, A. D.,(2007), 'Energy-efficient new housing - the UK reaches for sustainability', Building Research & Information, 35: 4, 426 - 436
- Beadle, K., (2008), 'Analysis of the design process for low energy housing, PhD. Thesis submitted to Institute of Energy and Sustainable development, De Montfort University
- Boardman, B.,(2007) 'Examining the carbon agenda via the 40% House scenario', Building Research & Information, 35: 4, 363 — 378
- Carbon Trust (2010), Low Carbon buildings accelerators, availableathttp://www.carbontrust.co.uk/emergingtechnologies/current-focus-areas/buildings/Pages..
- Carmona, M., Marshall, S., and Stevens, Q., (2006), 'Design Codes: their use and potential, Barlett School of Planning, UCL, London.www.elsevier.com
- Crosbie T., Nashwan D. and Dean J. (2010), Energy profiling in the life-cycle assessment of buildings, Management of environmental quality, Vol.21 (1), 20-31

- DCLG (Department of Communities and Local Government) (2010), Summary of changes to the Code for Sustainable Homes Technical guidance.
- DCLG (2011), Code for Sustainable Homes Statistical Release, accessedat:www.communities.gov.uk/publications/corporate/statisticalnoticerevisionpolicy.
- De Groot, E.H. and Mallory Hill, S.M.,(1999), A Decision Support System for Preliminary Design, Proceedings of the 8th International Conference on Durability of Building Materials and Components, May 30 – June 3, 1999, Vancouver, Canada
- Elforgani, M.S. and Rahmat, I. (2010) 'An investigation of factors influencing design team attributes in green buildings, American Journal of Applied Sciences (7); 976-986.
- Ellis, M.W., and Mathews, E.H., (2001), 'A new simplified thermal design tool for architects, 'Building and Environment, (36), 1009-1021.
- HMG (2008), Climate Change Act 2008,Chapter 27: Part One, Carbon target and budgetting,London:HMSO , (http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx)
- Imri, R. (2007), 'The Interrelationships between building regulations and architects practices, Environment and Planning B :34, 5,925-943
- Keysar, E. and Pearce, A. (2006), '*Decision Support Tools for green building: Facilitating selection among new adopters on public Sector- Projects for architects and engineers working for USACE -',* Journal of Green Building, Vol.2, no.3 (America)
- Lawson, B., (2010), 'How designers think: The design process demystified, Architectural Press, Oxford, UK.
- Loh,E., Crosbie,T., Dawood,N., and Dean,J.,(2010), 'A framework and Decision Support System to increase building life cycle energy performance', Journal of Information Technology in Construction, ISSN .1874-4753, www.itccon.org
- NHBC Foundation (2009),(N15) 'Code for Sustainable Homes Simply explained' Bre Press, ISBN 978-1-84806-091-3, accessed at www.nhbcfoundation.org .
- Oyedele, L.O., and Tham, K.W.,(2007), 'Clients' assessment of architects' performance in building delivery process: Evidence from Nigeria, Building and Environment 42,2090-2099
- Reed, W.G., and Gordon, E.B., (2000), 'Integrated design and building process: what research and methodologies are needed?', Building Research and Information,28(5)325-337
- Roaf,S., Crichton, D., and Nicol,F.,(2004), 'Adapting Buildings and Cities for Climate Change, Architectural Press, Oxford
- Royal Institute of British Architects (RIBA) (2008), 'Architects' job book, London:RIBA.
- Sodager and Fieldson (2008),'Towards a sustainable construction practice', Construction Information Quaterly, Issue 3
- Ürge-Vorsatz, D. and Koeppel, S. (2007), 'Assessment of policy instruments for reducing greenhouse gas emissions from buildings', Report for the UNEP-Sustainable Buildings and Construction Initiative
- Verghese, K. and Hes, D., (2007), 'Qualitative and quantitative tool development to support environmentally responsible decisions 'Journal of Cleaner Production, (15) 81-818.
- Weytjens, L. and Verbeeck, G.(2008), 'Analysis of the impact of sustainability related design parameters in the architectural design process-A case study research, University College Limburg, Belgium.
- Williams, K and Lindsay M., (2007) ,'The Extent and Nature of Sustainable Building in England: An Analysis of Progress,' Planning Theory and Practice, Volume 8, Issue 1, pp31-49