RECONCILING LOW CARBON AGENDAS THROUGH ADAPTABLE BUILDINGS

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The UK government has committed itself to demanding CO2 reduction targets. There is an expectation that significant carbon savings can be achieved in the construction and operation of buildings through the application of low carbon technologies. Current concentration on low carbon technologies to reduce operational energy requirements has overlooked the less significant gains possible in embodied energy. However, as gains in operational energy reduction are realised, embodied energy of the construction, maintenance, refurbishment and disposal cycle will become increasingly important in making further progress. In this position paper we suggest that the adaptable building agenda could complement the low carbon agenda by providing a vehicle for the reconciliation of the various facets of low carbon policy. This includes taking account of the need to reduce embodied energy, as buildings which are rendered obsolete significantly before their intended design life, or fail to adapt to increasing carbon reduction performance requirements, cannot be considered sustainable. There remains a need to explore to what extent these agendas, of adaptable, long life buildings and a low carbon society, are mutually beneficial and supporting, and the what extent they can be seen as competing and mutually exclusive.

Keywords: adaptability, low carbon, obsolescence, sustainability.

INTRODUCTION

Increasing global awareness of the need to limit green house gases and the potentially catastrophic effects of sustained and substantial climate change (Department for the Environment and Climate Change (DECC), 2010) has meant an increasing focus for policy makers on the setting of global and national targets for emissions reduction. Carbon has become a noticeably favoured metric for such targets (Marszal *et al*., 2011), perhaps because of the "simplicity, and potentially rigour" (Low Carbon Construction Innovation and Growth Team (LC IGT), 2010) its use provides. The UK's legislative commitments to carbon reduction at international (Kyoto Protocol), European (EU Emissions Trading Directive, 2003) and national (Climate Change Act, 2008) levels all provide examples of the importance of understanding carbon in order to engage in the environmental sustainability debate. This paper considers two approaches to the design of buildings – low carbon design and adaptable design, suggesting that their compatibility or otherwise will influence the achievement of an environmentally sustainable built environment.

Built environment assets (to include both buildings and infrastructure) are large carbon emitters in both their construction and operation, making them obvious targets

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for carbon efficiency measures (LC IGT, 2010; DECC, 2010). Buildings in particular are perceived as a prime target for carbon reduction measures due to the high percentage of emissions for which they account (Oreszczyn and Lowe, 2010; Hammond and Jones, 2008). UK, US and EU governments have all made commitments, or published intentions, to develop low carbon buildings in the coming decades (Marszal *et al*., 2011) and a range of legislative measures are either proposed (such as the 'Green Deal' scheme) or in action (e.g. updates to building regulations Part L requirements, the Climate Change Levy and Energy Display Certification), resulting in significant awareness of low carbon issues in the construction industry and an incentive to act to benefit from or mitigate the impact of the low carbon issues. Despite recent reductions in the onerous nature of its 'Zero Carbon' definition (Department for Business Innovation and Skills (BIS), 2011), it is apparent that the UK regulative and cultural impetuous to reduce the impact and severity of climate change has created a motivation (for a variety of reasons, held by actors at varying scales from international to individual) to reduce the energy consumption through engagement with low carbon buildings: a low carbon agenda for construction.

LOW CARBON BUILDING DESIGN

The popularity and profile of the low carbon agenda led to a surge in research and development, the result of which is that the technical aspects of (operationally) low carbon buildings are now well understood (Lomas, 2010), with the low carbon field demonstrating a large degree of consensus in its goals and methodologies. Predicted efficiency gains have not been realised as expected (Oreszczyn and Lowe, 2010; LC IGT, 2010) but it is believed this is largely due to underestimation of the significance of occupant behaviour (Oreszczyn and Lowe, 2010, Crosbie and Baker, 2010).

Low carbon buildings combine architectural considerations (building alignment for solar gains, thermal massing, passive ventilation) with building services (increased levels of insulation, efficient plant, renewable energy generation) to create buildings that require very little energy to operate and are capable of generating the energy they do require through use of renewable sources. The UK government defines low carbon through use of a hierarchical principle, whereby reduction in operational energy required is the primary consideration before the addition of renewable and other low carbon technologies (Department for Local Government and Communities (DLGC), 2008).

The low carbon agenda encompasses both the UK's considerable existing stock (retrofit) and new build, both residential and commercial property. Retrofit measures are recognised as being of considerable importance due to the high levels of existing stock (DECC, 2010) however the design and construction of new buildings offers the opportunity to maximise gains and utilise fully all relevant new techniques and technologies. There has been criticism levelled at the UK approach as overtly focussed on the new build sector (Banfil and Peacock, 2007), but recent announcements (BIS, 2011) introducing the Green Deal scheme by, 2012 specifically to encourage increased retrofit installations can be seen as an attempt to rectify this.

It is apparent that progress on the delivery of low carbon is gaining momentum: a recent survey by the Carbon Trust (2011) shows UK business leaders see the 'green economy' as a potential opportunity, there has been strong interest in low carbon measurement and recording procedures (Cole, 2005), and a number of programmes designed to popularise the agenda's benefits in terms of energy efficiency and material waste reduction savings exist (e.g. Energy Savings Trust, Better Buildings

Partnership, Code for Sustainable Homes). While the operational energy focus of the agenda has created a noticeable bias towards end user/owner benefits, this has not prevented the construction industry from capitalising on the increased demand through a diversification in its product offering, particularly by the industry's smaller enterprises or SMEs. There is still a substantial inertia to implementing changes however, with the Low Carbon IGT (2010) recently remarking "the biggest challenge that exists, as a barrier to action, is the lack of customer demand", while others identify further barriers such as the aversion to increased cost and risk (Hakkienen and Belloni, 2011).

In summary it is suggested that low carbon is a 'big' agenda, a concept benefiting from widespread familiarity and supported by a significant legislative backing, with an abundance of assessment methodologies, marketing techniques and technical products now available to support and promote its ideals.

ADAPTABLE BUILDING DESIGN

In comparison to the high profile nature of low carbon design, adaptability (to mean adaptable design) is a 'small' agenda, it's disparate approaches and conflicting definitions being confined largely to academic study and application in limited scale demonstration, proof of concept, projects. This paper considers the adaptable design agenda to include all those approaches to the design of buildings that align with concepts of change: enabling buildings to change physically or functionally, or buildings which have the capacity to absorb contextual change for instance.

There are predominantly two streams to the adaptability literature, that dealing with the adaptation of an existing building (adaptive reuse), and that considering adaptability in the design of new buildings (adaptable design). Examples of adaptive reuse are well represented in the literature (see, for example, Kincaid, 2000; Ball, 1999; Bullen, 2007), with the conversion of office buildings being a particular focus due to the surplus compared with residential supply (Gann and Barlow, 1996). Adaptable design operates in the context of the literature and practical knowledge developed from reuse, but is a largely separate field characterized by various approaches (see Table 1) which are appropriated, combined and employed in varying manners to establish design methodologies for new buildings.

Long life approaches are notably prolific, centred on ensuring continued utilisation and longevity of the existing building stock without detriment to the productivity of the occupier. This is reflected in the suggested benefits of adaptable design such as reduced whole life costs (Duffy, 1990; Arge, 2005), reduced disruption during maintenance and refurbishment periods (Slaughter, 2001) and greater saleability (Israelsson and Hansson, 2009), all of which rely on a long term perspective to building ownership.

Problems with enacting the adaptable building agenda have striking similarities with those of low carbon: a separation of provision and benefit, where the developer pays and the user benefits (Arge, 2005), users underestimating the value of adaptability and clients perceiving high upfront costs to its provision (Slaughter, 2001). A number of barriers are somewhat more unique however, with a lack of awareness (Israelsson and Hansson, 2009) of adaptability as a design consideration and a lack of consensus on approach (i.e. how adaptability can be achieved) creating a greater inertia against change than is evident for low carbon design.

Table 1: Approaches to adaptable design

Approach	Examples	Characteristics
Layering / Separation	Open Building (Kendall, 1999) AF DSM (Schmidt *et al*., 2009) Brand (1997)	Building viewed as a series of systems, subject to change at different rates Justification of a strategy for identifying layers proposed Interactions between layers to be minimised/controlled so as to allow flexibility
Uncertainty	Redundancy and Loose-fit (Gorgolewski, 2005) Design for multi-functionality (for an example see p80, Kronenburg, 2007)	Acknowledge inherent uncertainty of future No attempt at prediction of change Allowances made for general, unspecified changes
Decomposition / Reversibility	Design for Disassembly (CSA, 2007; Guy and Shell, 2003) Diversified Lifetimes (Fernandez, 2003)	Elements removable without damage to themselves or surroundings, building decomposable into constituent parts Compatible with layering approaches, but often employed without reference to them Modularisation, standardisation, recycling
Technical Solutions	Standardisation / mass customisation (Davison *et al*., 2006) Kit of parts (Schmidt *et al*., 2008) Moveable components (for examples, see Schneider and Till, 2007)	Application of a 'solution' to the building problem, adaptability achieved through the use of technology Often synonymous with industrialisation of construction process Marketable products

SYNERGIES IN THE AGENDAS

Considering a sustainable built environment to be one in which our use of resources is minimised to such an extent as to be indefinitely possible, while the utility of our buildings is maximised simultaneously (as compatible with Murakami *et al*.'s (2011) definition of built environment efficiency) it is apparent there is the possibility for synergies between the pursuit of adaptable and low carbon buildings. For this synergy to be apparent a consideration of energy resource is required.

Carbon and energy reduction

The concepts of operational and embodied energy are primarily concerned with energy and not carbon, but while it has been argued that the goal carbon reduction should be decoupled from unrealistic ideas of reducing energy demand (Herring, 2009), there exists an intrinsic link between the two in the minds of those promoting and investigating low carbon approaches - the "problem of energy demand and CO2" (Lomas, 2010). Essentially carbon reduction can be framed as a problem of energy reduction, which is further decomposable into separate problems of operational and embodied energy reduction.

Operational energy

Operational energy is "the energy used to operate a building" (Szalay, 2007), often excluding the energy consumed by appliances and other energy generation as a direct result of user behaviour (Marszal *et al*., 2011) to encourage improvement of the built product rather than the use of more energy efficient plant and appliances (Szalay, 2007). The low carbon agenda has become synonymous with a reduction in operational energy, likely because of the focus legislation has had on this approach; Szalay (2007) notes the European Union's Energy Performance Building Directive (EPBD) is rooted in operational energy reduction for example. As the reductions in operational energy are realised the gains to be achieved in operational energy will become increasingly expensive relative to the returns, such a shift is already apparent in the recent revisions to exclude unregulated operational energy from the UK's definition of 'Zero Carbon' for homes in order to "ensure that it remains viable to build new houses" (BIS, 2011). This shift is likely to alter the focus of research and regulatory effort increasingly from operational energy reduction to other means (Vukotic, Fenner and Symons, 2011).

Embodied energy

Embodied energy (or process energy) has received less attention (Szalay, 2007), perhaps due to the more difficult gains possible relative to the 'quick wins' of operational energy (Vallely, 2010), and also in part attributable to the lack of consistency in measurement (Hammond and Jones, 2008) and definition (Dixit *et al*., 2010) of embodied energy when compared to the relative standardisation of operational energy measurement. As noted above, this imbalance is unlikely to continue however, and process energy savings will become increasingly attractive in comparison to the escalating costs of operationally zero carbon structures.

Embodied energy is often differentiated into different process cycles which allows for simplification through the exclusion of ambiguous / uncertain steps. The most widely adopted boundaries for this purpose are those of 'Cradle to Grave', 'Cradle to Site' or 'Cradle to Gate' (Hernandez and Kenny, 2010), with the latter (referring to the manufacturing process up to the point of delivery) being the most commonly referenced in embodied energy studies (Hammond and Jones, 2008 in Hernandez and Kenny, 2010).

Energy and adaptable design

That the low carbon agenda is intrinsically related to energy reduction concepts is apparent from the above, and indeed provides powerful leverage for supporters of the agenda through the provision of ancillary benefits (beyond emissions reduction) such as reductions in energy bills and a reduced dependency on external energy sources. The resonance adaptability has with ideas on the minimisation of embodied energy (through reduction in material wastage resulting from demolition and rebuilding) is also apparent: maladaptive buildings result in early obsolescence (Gorgolewski, 2005) and associated increases in resource utilisation through the demolition and construction process required to replace them. Fixed building services on otherwise useable buildings will increasingly drive obsolescence as energy performance regulations are tightened and the costs of operation render them unsustainable. If we continue to choose to invest significant resource (and thus embodied carbon) in our built environment, it becomes imperative in a low carbon society that these resources are conserved through provision for their continued utility. Thus we can establish a linking of the concepts of adaptability and carbon via energy, an approach somewhat validated by a limited number of attempts to quantify the energy used in progressive maintenance and refurbishment cycles (e.g. Cole and Kernan, 1996; Thormark, 2002; Yohanis and Norton, 2002).

THE COMPATABILITY OF LOW CARBON AND ADAPTABLE DESIGN

It is tempting to define adaptable design as an agenda solely in the frame of the carbon / energy reduction, simply because the latter's prevalence in the literature makes it a viable justification for the importance of the former. This approach results in an overly narrow focus of the adaptable agenda and a limitation to those measures of value which can be justified within the low carbon ideal however, preventing consideration of the wider benefits adaptable design could present through reduction in use of natural resources (other than energy) and the economic sustainability of continued development vs. dereliction. Clearly the adaptability agenda has interfaces with others beyond that of low carbon.

Similarly the low carbon building agenda is just one among many, as the LC IGT (2010) notes in its final report: "building are however, commissioned for a purpose, and carbon reduction and energy efficiency ... need to be weighed against that purpose, and against the usual constraints of time, cost and fitness for purpose." What is suggested is that the low carbon agenda's current prevalence makes its interfaces of significant interest – such a pervading concept has influence beyond its immediate boundaries and provides both opportunities and problems for other issues that may be mobilised within the wider discourse of the construction industry. There is therefore a need to understand the interactions of the low carbon agendas goals and the methods with those of other agendas important to industry and wider society, considering what effect the pursuit of a low carbon economy will have, and the desirability of these effects in a wider context.

The position posited here is that the agendas supporting both low carbon and adaptable design form facets of the wider sustainability agenda, and that in order to achieve the goals of sustainability overall it is necessary to understand the interaction of the goals of the agendas mobilised within it. This presents several possibilities:

4. The agendas are distinct and unrelated - the optimisation of one has no effect on the other
5. The agendas are related and compatible - the optimisation of one has a beneficial effect on the other
6. The agendas are related but exclusive - the optimisation of one would have a negative impact on the other.

The agendas are distinct and unrelated

In instance one the agendas are unrelated and can be optimised or otherwise independently; anything done in pursuit of one agenda's goals will neither aide nor hinder the other agenda. If the assumption is that both agendas are valid and present in the construction industry, it is considered that this scenario is unlikely, both agenda's form part of the wider construction discourse and therefore will impact on one another as they are implemented by actors.

The agendas are related and compatible

Scenario two suggests the relationship between the agendas to be positive, where the pursuit of one agenda will consequentially result in the attainment of the others goals. It is possible this could be one-way (one agenda's implementation aides the other, but the relationship does not hold in reverse), or mutual in that the mobilisation of either agenda would benefit the other's uptake. Scenario two is comparable to a 'free ride', whereby one agenda gains an advantage without leveraging any of its supporting evidence and/or rhetoric. There are examples of this in the literature, for instance Bullen (2007) notes "extending the useful life of existing buildings supports the key concepts of sustainability" while Guy and Shell (2003) consider if "design to facilitate a more rapid turnover, if not for whole buildings, then for major energy-use and technology-oriented components of buildings will inherently make them more efficient to operate". It is interesting that comments relating the concepts of adaptability and low carbon are predominantly concerned with supporting the low carbon agenda; this is likely due a perceived need to justify the pursuit of adaptability in the terms of a more dominant agenda. The notable exception are comments made by Bullen and Love (2009) where they note "strategies for adaptation to climate change can also be used to adapt buildings for a change of use or refurbishment" suggesting low carbon adaptation could offer ancillary benefits of increased building adaptability.

It should be noted that this scenario is different to the positioning of one agenda by reference to the other, for example see Wong (2010), where the adaptability of a residential tower is placed in context by reference to green issues.

The agendas are related but exclusive
Scenario three suggests that optimisation of either agenda will be at the detriment of the other (with the possibilities of one-way and mutual relationships as outlined for scenario two). This portrays the agendas as possessing conflicting goals. Optimisation of the low carbon agenda might lead to overtly fixed and unchangeable buildings for instance, or carbon accounting practices could influence the affordability of refurbishment and adaptation over a buildings lifetime. If we were to regard both agendas, of low carbon and adaptable buildings as valid and desirable results, then scenario three represents a situation of unintended or unexpected consequences. There is limited evidence of this position in the literature: the LC IGT (2010) suggestion that "if operational efficiency is rewarded, and resource efficiency is not, then manufactures can be expected to develop products that form well over their life, but for which the design life will be relatively short" being a rare comment on the interplay of the two agendas.

There exists a further scenario, which is best conceived as a hybrid of those above. Considering the agendas to be composed of various facets (for instance those of operational and embodied reduction targets for low carbon), it is highly possible that the agendas are in part compatible and in part incompatible, with a number of aspects that bear no influence. For example, a reduction in embodied energy would benefit likely to be aligned to design for deconstruction/reuse adaptability principles, but this is unlikely to impact on the operational efficiency of the building and so provide only partial reinforcement to the low carbon agenda.

CONCLUSION

The 'big' agenda of low carbon and the 'small' adaptability agenda have been shown to exhibit synergies in approach when considering energy reduction, and environmental sustainability. Both potentially drive a reduction in consumption, and greater efficiency in the use of natural resources. While the green, low carbon agenda is enjoying a period of increased awareness and legislative backing, adaptability has yet to enter the mainstream construction discourse. As yet the extent to which the agendas of adaptable, long life buildings and a low carbon society are mutually beneficial and supporting and to what extent they can be seen as competing and mutually exclusive has not been explored, but, it is suggested, the adaptable building agenda offers the potential to complement the low carbon agenda, providing a vehicle for the reconciliation of the various facets of low carbon policy such as operational energy reduction, embodied energy reduction, adaptation to future predicted climate change and retrofit installation to existing properties and as such is worthy of further study.

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