

**Beyond the technical:
A snapshot of energy and buildings research**

Libby Schweber

School of Construction Management and Engineering
University of Reading
l.schweber@reading.ac.uk
(corresponding author)

Roine Leiringer

Dept of Civil and Environmental Engineering
Chalmers University of Technology
roine.leiringer@chalmers.se

This is a pre-print version of the article: Schweber, L. and Leiringer, R. (2012) Beyond the technical: a snapshot of energy and buildings research. Building Research and Information, 40 (4). pp. 481-492. ISSN 0961-3218. DOI:10.1080/09613218.2012.675713

The article is available at:

<http://www.tandfonline.com/toc/rbri20/40/4#.U3syIIgSwXs>

Abstract

The past decade has witnessed a sharp increase in published research on energy and buildings. This paper takes stock of work in this area, with a particular focus on construction research and the analysis of non-technical dimensions. While there is widespread recognition as to the importance of non-technical dimensions, research tends to be limited to individualistic studies of occupants and occupant behavior. In contrast, publications in the mainstream social science literature display a broader range of interests, including policy developments, structural constraints on the diffusion and use of new technologies and the construction process itself. The growing interest of more generalist scholars in energy and buildings provides an opportunity for construction research to engage a wider audience. This would enrich the current research agenda, helping to address unanswered problems concerning the relatively weak impact of policy mechanisms and new technologies and the seeming recalcitrance of occupants. It would also help to promote the academic status of construction research as a field. This, in turn, depends on greater engagement with interpretivist types of analysis and theory building, thereby challenging deeply ingrained views on the nature and role of academic research in construction.

Keywords: Energy, low carbon buildings, sustainability, construction research, interpretivist methodology, literature review, policy,

Introduction

The European Energy Performance of Buildings Directive (2002), national level policies such as UK's Climate Change Act (2008) and the associated targeting of the construction industry as a key player in the mitigation of climate change (BERR 2008, BIS 2010) have all focused policy attention on energy and buildings. *Building Research and Information's* support for a special issue on the topic of 'energy and buildings research' similarly points to the perceived importance of the topic. Following on that call, this paper explores recent trends in construction research and associated literatures. More specifically, it focuses on the treatment of 'non-technical' dimensions.

The focus on non-technical dimensions rests on two suppositions, both of which will be explored in the course of the paper. The first is that, while policymakers and scholars routinely affirm the importance of organizational, social, and behavioural issues in the implementation of policies aimed at promoting sustainable construction, these aspects remain relatively underexplored (Shama 1983, Guy 2006, Oreszczyn and Lowe 2010).

The second is that this neglect can be partly attributed to the epistemological challenges which inter- and cross-disciplinary research pose. By examining the different approaches currently being mobilized in different publication outlets, this review hopes to contribute to the expansion of research on non-technical dimensions of 'energy and buildings' by clarifying the nature of the task and identifying bases for cross disciplinary dialogue.

An additional motivation for this paper is the recognition that scholars outside of traditional areas of 'energy and buildings' research are beginning to engage with the topic. While their contribution is currently quite limited, it is growing. Evidence for this can be found in recent publications on building and the environment in highly rated mainstream journals (e.g. Georg 2006, Biggart and Lutzenhiser 2007, Hoffman and Henn 2008, Shove 2010), the creation of international networks at mainstream business schools (e.g. *'Management Studies of the Building Process'* at the Copenhagen Business School) and the inclusion of 'energy and buildings' related sessions at the 2011 Academy of Management and the 2012 Annual Meeting of the Association of American Geographers. These and associated developments offer construction researchers an opportunity to reach beyond traditional academic audiences, but they also pose challenges associated with differences in epistemological criteria.

The discussion which follows poses two questions. First, "what is the range of research objects currently being investigated under the heading of 'energy' and 'buildings'?" and secondly, "what is the range of methodological approaches mobilized in different types of publications?". Data analysis focuses on the proportion of articles addressing technical and non-technical dimensions of energy and buildings and on the range of research objects and methodological approaches adopted. Key findings include: an increase of interest in the energy-buildings nexus in general and in non-technical

dimensions in particular; a disproportionate focus on occupants and associated neglect of policy, organizational and implementation challenges; and an almost exclusive reliance on positivist methodologies. The paper concludes with an exploration of this last issue and reflection on how interpretivist methodologies might contribute to the low carbon / low energy agenda as well as to greater engagement between construction research and mainstream social science.

Mapping out the intellectual contours of a research area

Literature reviews as a genre encompass a number of different aims and related methods. These include synthetic reviews aimed at producing new knowledge (cf. Tranfield et al. 2003, Rousseau and Manning 2008) and meta-reviews aimed at documenting the state of the art (e.g. Lockett et al. 2006, Hambrick and Chen 2008, Glynn and Raffaelli 2010). Meta-reviews can be further divided into systematic or comprehensive reviews and exploratory projects which focus on a particular theme. This paper belongs to the latter category. The aim is to take a snapshot of recent publications, with a special focus on the analysis of non-technical aspects of energy and buildings and the place of interpretivist methodologies therein.

Sampling

The meta-analysis which follows uses existing academic databases to identify three potentially distinct types of journals which support work on energy and buildings. These

include: 1) journals explicitly devoted to the construction sector, including construction, real estate and housing journals; 2) mainstream business and social science journals and 3) specialist journals explicitly devoted to buildings and environmental issues. The paper reviews selected articles in each type of journal for their object of research and methodology and for their treatment of non-technical dimensions of energy and buildings.

The use of data bases and key words to sample both journals and articles is standard practice for literature reviews. Alternatives include the selection of journals by reputation or impact rating (e.g. Keegan and Boselie 2006, Lockett et al. 2006, Ke et al. 2009, Glynn and Raffaelli 2010) and the selection of articles by citations (e.g. Marsilio et al. 2011). The choice of method depends on the aims of the review. The focus on top journals is usually associated with a concern for dominance or impact. A focus on citations is usually linked to a concern to test theories of the role of informal networks in scientific development. In contrast, data bases offer a more heterogeneous and possibly representative picture of the range of questions, topics and approaches currently being published.

'Construction research' journals figure in a number of types of databases. These include databases maintained by professional bodies, such as the ARCOM database (developed for construction researchers), publisher specific databases, such as Scopus, and

commercial information services such as EBSCO. After some consideration, the latter option was chosen. The advantage of EBSCO is that it offers a relatively independent, large, comprehensive database (or rather variety of databases) from which to sample both journals and articles. Two EBSCO databases were selected: 'Business Source Complete' (BSC) which includes business, management and social science journals as well as 'construction research' journals, and a separate 'Environment Index' (EI).

Every sampling method has its limitations. In this case, the focus on published refereed journal articles necessarily limits the review to work in the public domain. As such, it excludes research projects currently underway, but which have yet to publish or which have not published in English. It also excludes trade and professional reports. This is consistent with the focus of this review on published academic research. Furthermore, the use of EBSCO necessarily limits findings to those journals included in the database. That said, EBSCO offers the widest range of journals of any available data base for this topic. Neither author could identify any obvious omissions.

Article sampling was designed to produce three separate sets of articles, corresponding to the three different types of journals. These included: a 'construction research' set, taken from journals explicitly devoted to construction research and found in the BSC database, a general 'business and social science' set, also taken from journals in the BSC database and a 'specialist' environment and building set, taken from journals in the

EBSCO's Environment Index. The classification of journals was based on EBSCO subject headings. The 'construction research' set was taken from journals explicitly labeled as 'construction and building', 'real estate' or 'housing and housing policy'. Similarly, the 'business and social science' set was taken from journals classified as 'business and management' or 'social science'. Finally, the 'specialist' set was taken from journals in the Environment Index with 'building' or building related terms in their title. For a complete list of journals see Table 1.

The comparison of intellectual content in the three sets provides an opportunity to explore the contours of research on energy and buildings. More specifically, it provides evidence for the relative integration or compartmentalization of public academic conversation(s). In comparing publications across the three types of journals it is important to keep in mind the range of considerations which go into authors' decisions where to submit their work and editors' decision on whether to accept their offerings. Different journals target different audiences. Editors' play an important gatekeeper role, supporting and encouraging certain academic conversations and potentially excluding or minimizing others. Similarly, authors develop an image of the type of work which particular journals support, which, in turn, informs their publication strategies. The result of this two sided dance is a public academic conversation - or set of conversations - accessible to scholars well beyond its immediate participants. An important focus of this literature review is the extent to which articles in the three types

of journals examine a similar range of research topics and deploy a similar range of approaches.

The sampling of articles was based on the presence of two keywords - 'energy' and 'building'- in the abstract. The terms were taken from the title of the special issue call. A broader sample using related keywords was trialed, but rejected on practical grounds. This decision biased the selection to articles which focused on homes and commercial buildings as opposed to energy supply, large engineering projects or urban renewal. It also excluded more general articles on environmentalism or sustainability, which may have addressed energy and buildings in the body of the paper, but did not privilege them in the abstract. Finally, and perhaps more disturbingly, this approach excluded articles which used terms such as 'carbon reduction' or 'mitigation' or 'green buildings' rather than 'energy' in the abstract. While this would be a problem if the review made claims to being comprehensive or even statistically representative, given the more modest aim of comparing research profiles in different types of journals, it was deemed tolerable.

Articles from the 'construction research' and 'business and social science' journals were sampled for the period January 2000 – 2011. Articles from the 'specialist' environmental and building journals were selected for 2011 only. For the first two types of journals, the year 2000 was selected as a reasonable starting point, coming as it did

before the EU building directive (2002) and subsequent national translations, thus providing enough time for the identification of trends. For the third, 'specialist' type of journals, sampling was limited to 2011. This was due to the very large number of articles with 'building' and 'energy' in the abstract. Since the primary focus of this review was on construction research and since the specialist environmental and building journals were only there to compare research profiles, the limitation of one year was deemed acceptable. The three samples were limited to refereed academic journals and to articles of 7 pages or more. The (sub-) list of journals with articles containing the keywords 'building and 'energy' in the abstract is provided in Table 1.

Once each set of articles was assembled, the two authors reviewed each abstract to make sure that the article was genuinely about energy and buildings (rather than about 'building a conceptual framework' or 'having the energy to motivate a team'). This led to a handful of exclusions from each set. The final sample of articles was thus composed of three separate sets of articles: 1) a 'construction research' set (CR) for 2000-2011, with 211 articles taken from 'construction journals' in the BSC data base; 2) a 'business and social science' (B&SSci) set for 2000-2011, with 145 articles taken from BSC data base; and 3) a 'building and environmental issues' (B&EI) set for 2011 only, with 259 articles taken from the EI database.

*Insert Table 1 somewhere here *

Data analysis

Data analysis focused on the objects of inquiry and research methodologies deployed in each article. This focus reflects the underlying interest of this literature review in the intellectual conditions of possibility for dialogue between construction researchers and mainstream social scientists as well as in the treatment of non-technical dimensions (deemed critical to the achievement of low carbon policy goals). The distinction between research object and research approach or methodology is standard in social research text books (e.g. Bryman 2004).

For the purposes of this paper, the term 'research object' will be used to refer to those components of each author's ontological model about which questions are asked and data is collected. 'Research approach' or methodology will be used to refer to the epistemological principles deployed. Stated differently, 'research objects' refers to what authors study, while 'methodology' refers to how they do it. When it comes to the latter, the standard distinction is between 'positivist' and 'interpretivist' methodologies. As explained below, 'positivist' research takes natural scientific method as a model; research in this approach generally focuses on the identification of patterns in the relations between variables. Interpretivist research, in contrast, assumes that human behavior is mediated by meaning and seeks to identify types of processes and their expression in particular contexts. While some authors associate the distinction between

positivism and interpretivism with a second distinction between quantitative and qualitative research, this conflation is confusing, since qualitative data can be analysed from both a positivist and an interpretivist approach. The terms 'quantitative' and 'qualitative' have thus been limited to qualify types of data. The term 'non-technical' has been defined broadly to include political, economic, organizational, social and psychological dimensions of the energy-building nexus.

Coding of the data was divided into three stages. In a first pilot stage, both authors reviewed a set of abstracts taken from the ARCOM database. This more limited sample was used to develop an initial coding scheme, including a classification of research objects, see Table 2. In the second stage, each article was coded based on its abstract. Articles in the CR set were independently coded by both authors and results were compared. Articles in B&SSci and B&EI sets were coded once, but any questions were referred to the other author for a second reading.

Insert Table 2 somewhere here

The third stage of the coding involved a more in-depth examination of those articles with non-technical dimensions and was based on the full text. Selection in this final stage focused on articles which actively explored non-technical dimensions. Articles which mentioned users or policies in passing, but did not analyse or discuss them were

excluded from this final stage of analysis. Using these criteria, the B&SSci set had the greatest proportion of non-technical articles (84 out of 145, or 59%), the CR list had the second greatest proportion (69 out of 211, or 33%) and the B&EI list had the smallest proportion (only 12 out of 247 contributions, or 5%). The paucity of non-technical dimensions in the B&EI set may be a bit surprising; however, it reflects the technical character of *Energy and Buildings* and *Building and Environment* and their dominance in that set. As a result, analysis of non-technical dimensions was limited to the CR and B&SSci sets.

The aim of the third stage was to examine the research approach or methodology deployed in articles with non-technical dimensions. Methodologies were classified in a number of different ways in an attempt to find the most insightful and discriminating distinctions. This included: the social dimension analyzed, level of analysis, types of data, type of research method, type of analysis and methodology, see Table 3. The discussion which follows summarizes the insights that this analytic framework produced. The results are presented as proportions of the relevant set of articles. This simple form of statistical analysis is in keeping both with the aims of the paper and limitations of the sampling procedure. More sophisticated statistical techniques would only provide an aura of scientificity, which would be misleading.

Insert Table 3 somewhere here

Findings

An initial review of the articles in the CR set attest to a regular increase in the absolute number of publications on the topic since 2003 with a sharp increase in 2010, see Figure

1. This latter effect can be ascribed to increases in two journals: *Building Services Engineering Research & Technology* (BSERT) and in *Building Research & Information* (BRI), fueled, in part, by a number of special issues in BRI.

Figure 1 somewhere here

Turning to the B&SSCI set, there is a step change in the number of articles with ‘energy’ and ‘building’ in the abstract from 2006 onwards, from less than 5 per year before 2006 to 20 and over in subsequent years, see Figure 2. While this shift is partly explained by an increase in the number of issues of *Energy Policy* in 2006, it would also seem to point to a general trend.

Figure 2 somewhere here

Types of Research Object

The distribution of research objects in the three data bases reveals a number of predictable trends and some less expected ones, see Figure 3. If one now asks whether

these lists correspond to distinct research agendas, the answer is: “not as much as expected”. All four types of research object (technical developments, formal tools, energy supply and energy demand) are represented in each of the three sets. This, in turn, suggests a greater integration across journal types than was initially predicted.

Figure 3 somewhere here

As could be expected, articles on technical developments are more common in the CR and B&EI sets (20% for each) than in the B&SSci set (4%). Less expected is the interest in energy demand across all three sets (18% for CR, 25% for B&SSci and 20% for B&EI). However, this focus can be ascribed to the central role which building occupants play in energy policy discourse, often at the expense of institutional and organizational factors. In analyzing energy supply, the coding scheme distinguished between external social inputs (policy, regulations etc), external physical inputs (climate change, weather patterns) and production and distribution effects, see Figure 4. This breakdown in the type of research objects highlights the greater attention of the B&SSci set to external social inputs, such as regulations, financial incentives and market conditions. While this is partially to be expected, given the inclusion of *Energy Policy* in the list, it also points to a relative neglect of institutional factors in the CR literature.

Figure 4 somewhere here

Approaches to the study of Non-Technical Dimensions of Energy and Buildings

The third stage of the analysis focused on the levels of analysis and methodologies used to explore non-technical dimensions of energy and buildings in the CR and B&SSci sets.

As suggested above, interest in non-technical dimensions has been increasing across both sets, see Figures 1&2. Over the entire period, 33% of the CR set and 59% of the B&SSci set included discussion of non-technical dimensions. A comparison of the objects and approaches deployed in these non-technical discussions reveals a number of differences, see Figure 5.

Figure 5 somewhere here

One striking feature of this distribution is the proportion of non-technical analyses in CR journals devoted to occupants, e.g. studies of thermal comfort, occupant behavior and occupant satisfaction. As can be seen, 51% of the non-technical contributions to CR journals such as *BRI*, *BSERT* and *Construction, Management and Economics (CME)* are about occupants, while only 21% of the non-technical articles in the CR set examine the construction process (design, procurement, construction, operation, maintenance and demolition combined). This distribution is surprising. If there is any area where construction researchers have something special and unique to contribute, it is in the appreciation of the social, financial, organizational and institutional opportunities and

constraints shaping the industry's engagement with issues of energy and buildings. That relatively little scholarly attention has been focused in this direction points to a missed opportunity for construction researchers; especially as this research space is beginning to be occupied by organizational theorists and scholars in general business schools. The same can be said for the relative neglect of policy issues within the CR set (9%) compared with the B&SSci set (32%).

Interestingly, the distribution of types of data and methods of analysis across the two sets is roughly similar, see Figures 6 and 7. One impressive finding is the proportion of articles with a non-technical dimension drawing on primary data (55% for CR and 39% for B&SSci). This attests to the empiricist bent of both lists as well as to the relative paucity of secondary data on the social dimensions of energy and buildings, e.g. data on costs or savings associated with energy efficiency measures, evaluations of the effect of energy efficiency on property values, evidence of technology and policy uptake and data on occupant behavior, etc. The main difference in methods of analysis can be found in the greater proportion of studies based on qualitative data in B&SSci (14% in CR vs. 25% in B&SSci.) and the higher proportion of work based on quantitative data in the CR set (49% in CR vs. 24% in B&SSci).

Figure 6 somewhere in here

Figure 7 somewhere in here

The most striking methodological feature of non-technical analyses concerns the deployment of positivist versus interpretivist approaches (Figure 8). In both the CR and B&S&Sci lists, just over three quarters adopt a positivist approach, even when qualitative data is being used. This bias can be seen in the use of interviews to produce information and facts which can be counted and in the heavy reliance on financial data to model social behavior. A more in-depth analysis of the interpretivist articles with a non-technical dimension draws attention to an incipient area of research with the potential to contribute to policy issues and to bridge construction and mainstream social science research.

Figure 8 somewhere in here

Interpretive approaches

Of the 153 articles within the B&S&Sci and CR non-technical sets, only 19 were identified as adopting interpretivist approaches of one kind or another, see Table 4. This in spite of a particularly generous definition of interpretivist approaches being adopted to maximize the number of articles examined in this category. Of the entire set identified, 13 were interpretivist in the strict sense of the term, while the other 6 were closer to position papers which reviewed the state of the field and made a case for the contribution of interpretivist studies to energy and building research.

A quick review of the social dimensions, types of data, data collection and methods in these papers reveals a fairly even spread across the different types. Social dimensions studied include: occupant lifestyles and satisfaction; the effect of regulations and policies on energy efficiency in buildings; design, construction and management processes and technological innovation and uptake. However, while these topics were distributed evenly across the B&SSci set, the majority (6 out of 8) of interpretivist articles in the CR set dealt with thermal comfort and occupant satisfaction.

It follows from the above that it is not the topic or level of analysis which dictates or even necessitates the adoption of interpretivist over positivist approach. Instead, a number of other features distinguish interpretivist studies. These include: their focus on process and meaning; their attention to practices and technologies in use; their attention to variations and multi-dimensional configurations; their concern with questions of 'how' and 'why' rather than patterns and correlations; their explicit use of theory; and, in some instances, their concern to (also) contribute to theory development. In terms of energy and building, these features draw attention to: the social construction of problems such as energy inefficiency (Biggart and Lutzenhiser 2007) and thermal comfort (Chappells and Shove 2005, Healy 2008, Gram-Hanssen 2010, Williamson et al. 2010); to variations in the meaning of green building labels (Gram-Hanssen et al. 2007); and to differences in the impact and uptake of policies

(Toke 2000, Lowe 2009, Koski 2010, Tambach et al. 2010, Van Schaack and Ben Dor 2011) and technologies (Andersen et al. 2004, Rohracher 2006, Stevenson 2010); and to the implications of sustainable construction for design and construction teams and their ways of working (Sorrell 2003, Zimmerman and Kibert 2007, Fischer and Guy 2009, Robichaud and Anantatmula 2011).

Many of the interpretivist studies frame their research in terms of a critique of rational and individualist types of theorizing. According to these authors, much of the literature on energy and buildings works with the assumptions: 1) that individual and organizational behaviour is best explained in terms of economic rational calculation (Biggart and Lutzenhiser 2007, Gram-Hanssen et al. 2007); 2) that policies are designed by rational independent experts to support efficient energy decision making (Toke 2000); 3) that formal characteristics of new technologies dictate their use (Rohracher 2006, Gram-Hanssen 2010); and 4) that innovation follows a linear path of development (Rohracher 2006, Van Schaack and Ben Dor 2011). Another critical thread in this set of articles concerns dominant assumptions of homogeneity and generic needs and a disregard for variations across cases (Healy 2008, Williamson et al. 2010).

Interpretivist studies of both individuals and policies suggest that particular outcomes can only be understood by the way in which multiple factors come together in particular settings. This in turn calls for case studies and comparative research, designed to flush

out variations in the effect of isolated factors or dimensions and for generalization of processes and configurations rather than individual variables. In accordance, the articles turn to other types of theories to guide them. Even in this very small sample, the range is wide. They include: socio-technical systems analysis (Rohracher 2006), transition theories (Tambach et al. 2010), sociological theories of everyday life (Gram-Hanssen et al. 2007, Gram-Hanssen 2010), constructivism (Chappells and Shove 2005, Williamson et al. 2010), discourse analysis (Toke 2000, Healy 2008), new institutional economics (Sorrell 2003), economic sociology (Biggart and Lutzenhiser 2007), theories of intermediaries (Koski 2010), and various diffusion theories (Andersen et al. 2004, Tambach et al. 2010). A distinctive feature of many of these studies is their focus on the interaction – and ongoing mutual constitution – of social, political, organizational and technical dimensions in specific institutional contexts.

Discussion

Future research directions

Industry practices do not develop independently of governing institutional structures, nor do research agendas. Scholars have been working on energy and buildings since the 1970s. However, the significant increase in the number of publications on energy and buildings in past few years reflects a clear policy push coupled with a growing recognition of the importance of the topic in different areas of academe, as well as in industry. This literature review began from an expectation that different publication

outlets would support different types of research. It was surprising to discover a notable degree of overlap, especially in the set of methods and types of analysis deployed. This is promising as it points to a shared intellectual culture and basis for greater integration between research streams. However, as the findings presented above suggest, there are also differences within and across types of journals.

A first observation is that, in the context of energy and building research, comparatively little attention has been given to construction processes or production more generally. This seems strange given the increasing recognition of the organizational challenges involved in embedding low carbon agendas and the historic relation between construction research and industry. The lack of emphasis on the realisation phase and the processes supporting the introduction of, for example, new technologies or management tools has been noted (cf. Rohracher 2006, Oreszczyn and Lowe 2010) and it is clearly an area in which more work can be located.

A second observation concerns the neglect of energy systems as a research object in the CR set of articles. As the presentation of findings indicates, there are very few papers that deal with energy systems. While this may reflect the adopted sampling strategy – articles on energy systems do not always include the term ‘building’ in the abstract – it also points to a key area for future research. The challenge is: how to integrate insights from a growing body of work on energy supply – including the impact of climate change

and policies on the energy infrastructure and managing the variability of energy networks – with research on buildings and the built environment. Conventional divisions in industry and academe treat these topics as separate research areas. The result is that much of the current literature focuses on building level developments, be it new or improved technologies, materials processes or tools. But climate change and an associated systems approach to energy reminds us that developments in one part of the system have consequences for elements in other parts.

A third observation concerns the relatively narrow understanding of the ‘social’ in research on energy and buildings. This limitation is particularly evident in the contributions to the CR set, where most of the non-technical articles involve individualist analyses of occupants and occupant behaviour. While this focus can be partially explained by pragmatic considerations such as access to data, time and available resources, it also reflects somewhat narrow policy focus on discrete technical innovation and atomized individual users. Quite clearly, while occupants are important, they alone cannot be blamed for the current situation; more importantly, they do not act independently. Instead current consumption practices are supported by organizational and structural conditions – including financial incentives, policy structures and employment and market conditions. Similarly, the uptake of new technologies is not wholly a function of market demand, but instead is mediated by the property and construction sectors and influenced by a whole range of stakeholders and their vested

interests. Incorporating these constructs into research designs adds significant complexity, but it is certainly not beyond the scope of what the social sciences have to offer. As the interpretivist articles in the B&SSci set suggests, scholars know how to design these kinds of studies. What they often lack, however, is access to the industry and an inside appreciation of the ways in which different factors combine, creating barriers and – hopefully – introducing opportunities. Construction scholars are well placed to contribute here.

The role of theory

A key finding to emerge from the comparison of the CR and B&SSci sets concerns the place of theory in research. There are two reasons for construction researchers to engage more directly and explicitly in a dialogue between theory and empirical research. The first concerns the place of construction research in academe. As this literature review shows, scholars in organization theory, innovation studies, socio-technical network analysis and transition management theory – to name but a few – are increasingly turning their attention to environmental issues, sustainability, buildings and the built environment. Their work is beginning to be published in high impact business and social science journals. From a pragmatic point of view, construction researchers should welcome the space that is being created and take advantage of it. But to do that, they will have to engage in theory – or rather in a much more self-conscious, explicit dialogue between theory and empirical work.

A second and fundamentally more important reason to take note of the place of theory stems from the challenges which climate change, and in continuation energy and buildings, poses for researchers, industry and policy makers. The notion that climate change is a 'wicked problem' (Rittel and Webber 1973) is increasingly repeated in the scholarly literature and in the press (Lazarus 2009, Brown et al. 2010). But what does this mean? On the one hand, it means that it is complex, multi-leveled, dynamic and ever changing. On the other hand, it means that dominant engineering and management styles of reasoning, with their focus on linear thinking, tools and protocols and rational actors are insufficient. While they may identify important variables supporting or inhibiting the success of particular interventions, they cannot, on their own, explain why policies are not delivering on their promise and why assessment tools and management systems have not transformed current practices.

An uncritical response to the challenge of a low carbon / low energy built environment is to plough on ahead, developing ever more elaborate technical tools. A more thoughtful response would be to examine the underlying assumptions on which this approach relies, consider alternate ways of thinking, and explore what understandings and insights those other styles of reasoning suggest. In other words, creativity in research depends on breaking with the common sense assumptions of policy makers and senior management and trades people, looking at the world through a different lens

and returning to professional communities with new insights. This is what theory – and by extension, research - at its best can and should provide.

Conclusions

This paper has sought to take stock of the published research on 'energy and 'buildings'. The main focus has been to explore the relative attention currently being given to technical and non-technical dimensions and the range of research objects and methodological approaches currently being deployed. Whilst not in any way exhaustive, several conclusions can be drawn from this focused literature review. First of all, it is clear that there has been an increase of interest in the energy-buildings nexus in general and in non-technical dimensions in particular in the past decade. Secondly, it is equally clear that, up until now, positivist methodologies have dominated the academic output in the public domain. Third, in terms of the content of the research on non-technical dimensions, there has been a disproportionate focus on occupants. While this topic is important, it should not come at the neglect of policy, organizational and implementation challenges.

Based on these findings it is contended that the ability of construction research to meet the challenges of the low carbon / low energy carbon agenda depends on a better articulation of theory and empirical research, in particular in researching non-technical dimensions. It is acknowledged that positivist research approaches (for the purpose of

this argument also usefully thought of as ‘the engineering paradigm’) have contributed to significant advances in engineered systems over the last half-century. These approaches and the work which they support remain critical. However, as has been argued, the research challenge that lies ahead goes beyond a fixed state scenario or hypothetical modelling. In the rapid and unpredictable development of energy and buildings, there is a need for research which examines the processes, understandings and motivations which produce observed patterns and systems.

Thus, what is needed is an expansion of the current scope of construction research to embrace interpretivist approaches to complement those that are already in use. This means widening the scope of the research undertaken to problems of how to explain and thus support the uptake, diffusion and use of new technologies, materials, systems and processes. This also means complementing positivist research into the correlation between discrete variables and systems modelling with interpretivist studies into the way in which meaning, practices and institutional environments shape supply and demand for energy and different characteristics of the built environment. It calls for studies of the social and economic conditions which ‘lock’ users into certain patterns of energy use, such as workplace flexibility and infrastructure supports.^[1] It points to the need for detailed inquiry into the relation(s) between the diffusion of innovations, on the one hand, and the business of design, procurement, construction, handover,

^[1] The authors thank Dr. Jacopo Torriti for underlining the importance of this point.

maintenance and demolition, on the other hand. Finally, it calls for studies into the relation between those different phases, to better understand the obstacles and opportunities for more integrated whole life, whole system approaches

As these different topics suggest, interpretivist approaches direct attention to research into variations in the response of actors and firms to seemingly similar pressures, to case studies comparing the configuration of similar types of factors in different contexts and towards generalization on processes rather than outcomes. This calls for a shift in cognitive gears amongst construction researchers. It also means persuading industry partners of the benefits of more long-sighted research.

These developments are by no means trivial, but it is important to remember that construction researchers bring to social science discussion intimate knowledge of the industry and technical know-how that is far superior to stereotypical understandings that are commonly mobilised. Hence, if the challenge of interdisciplinary engagement is embraced and appropriate measures are taken to improve the quality, relevance and impact of research, then construction scholars will have an invaluable opportunity to contribute to broader high profile academic debates, thereby enhancing their profile in international scholarship. Much more importantly, however, it will mean that construction research will have much to contribute to the future development of a sustainable built environment.

Table 1: Journals with articles on 'energy' and 'building' in the abstracts**'Construction Research' journals**

Appraisal Journal
 Journal of Real Estate Portfolio Management
 Journal of Real Estate Finance & Economics
 Journal of Property Management
 Journal of Property Research
 Journal of Architecture
 Journal of Facilities Management
 Journal of Construction Engineering & Management
 Journal of Composites for Construction
 Facilities
 Engineering Construction & Architectural Management
 Cornell Real Estate Journal
 Construction Management and Economics
 Building Research and Information
 Building Services Engineering Research & Technology

Business & Social Science journals

American Behavioral Scientist
 American Economic Review
 Cornell Hospitality Quarterly
 Economic Development Journal
 Energy Economics
 Energy Policy
 Engineering Economist
 European Environment
 International Journal of Consumer Studies
 International Journal of Environmental Technology & Management
 International Journal of Project Management
 Journal of American Planning Association
 Journal of Business Research
 Journal of Corporate Real Estate
 Journal of Environmental Assessment Policy & Management
 Journal of Environmental Planning & Management
 Journal of Management in Engineering
 Journal of Sustainable Tourism
 Journal of the American Planning Association
 Land Economics

Landscape Journal
Leadership & Management in Engineering
Policy studies journal
Public Administration
Resource and Energy Economics
Review of Policy Research
Sustainable Development
Technology Analysis & Strategic Management
Urban Studies

'Building and Environmental Issues' journals

Indoor and Built Environment
Energy and Buildings
Building and Environment

Table 2: Coding scheme for the analysis of Research Objects

Technical Development

(Formal) Standards/ Assessment Methods/ Decision Making Tools

Energy System : Supply

- External social inputs (policies, finance mechanisms)
- External environmental inputs (including climate change effects, wind, oil reserves etc)
- Production and distribution systems

Energy System: Demand

Other

- Essay,
- Material properties,
- Construction process,
- Policy effects

Non-technical dimension

- Yes/No

Table 3: Coding scheme for the analysis of articles with non-technical dimensions

SOCIAL DIMENSION

Policy

Policy (energy), Building Regulations, Barriers (policy), Policy uptake

Economic

Costs, Market, Productivity, Business Model

Technologies

Innovation, Barriers (technology), Diffusion/Uptake

Construction Process

Design, Construction, Handover, Maintenance/Management, Demolition, Barriers (organizational)

Occupants

Satisfaction, Behaviour, Consumption/Lifestyle, Thermal Comfort

LEVEL OF ANALYSIS

Individual, Household, Technologies, Building, Stock, Project, Sector, Market, Cultural

TYPE OF DATA

Hypothetical, Empirical Primary, Empirical Secondary, Literature Review, Formal Tool, None

TYPE OF METHOD

Survey, Interviews, Observations, Modelling/Simulations, Literature Review, Analysis of Existing Data Base, Analysis of Official Document, Conceptual

METHODOLOGY

Positivist, Interpretivist, N/A

Table 4: Articles adopting an interpretivist approach to the analysis of non-technical dimensions of energy and buildings

Articles in Construction Research Set

- Gram-Hanssen, K. 2010. Residential heat comfort practices: understanding users. *Building Research and Information*, 38(2): 175-186.
- Healy, S. 2008. Air-conditioning and the 'homogenization' of people and built environments. *Building Research and Information*, 36(4): 312-322.
- Stevenson, F. 2010. Developing occupancy feedback from a prototype to improve housing production. *Building Research and Information*, 38(5): 549-563.
- Lowe, R. 2009. Policy and strategy challenges for climate change and building stocks. *Building Research and Information*, 37(2): 206-212.
- Zimmerman, A., & Kibert, C. J. 2007. Informing LEED's next generation with The Natural Step. *Building Research & Information*, 35(6): 681-689.
- Thomsen, A., & Van der Flier, K. 2009. Replacement or renovation of dwellings: the relevance of a more sustainable approach. *Building Research and Information*, 37(5/6): 649-659.
- Williamson, T., Soebarto, V., & Radford, A. 2010. Comfort and energy use in five Australian award-winning houses: regulated, measured and perceived. *Building Research and Information*, 38(5): 509-529.
- Chappells, H., & Shove, E. 2005. Debating the future of comfort: environmental sustainability, energy consumption and the indoor environment. *Building Research and Information*, 33(1): 32-40.

Articles in Business and Social Science Set

- Biggart, N. W., & Lutzenhiser, L. 2007. Economic Sociology and the Social Problem of Energy Inefficiency. *American Behavioral Scientist*, 50(8): 1070-1087.
- Robichaud, L. B., & Anantatmula, V. S. 2011. Greening Project Management Practices for Sustainable Construction. *Journal of Management in Engineering*, 27(1): 48-57.
- Koski, C. 2010. Greening America's Skylines: The Diffusion of Low-Salience Policies. *Policy Studies Journal*, 38(1): 93-117.
- Toke, D. 2000. Policy Network Creation: the case of energy efficiency. *Public Administration*, 78(4): 835-854.
- Rohracher, h. 2006. Sustainability as a matter of social context: information technologies and the environment. *International Journal of Environmental Technology & Management*, 6(6): 539-552.
- Andersen, P. H., Cook, N., & Marceau, J. 2004. Dynamic innovation strategies and stable networks in the construction industry: Implanting solar energy projects in the Sydney Olympic Village. *Journal of Business Research*, 57(4): 351-360.

- Tambach, M., Hasselaar, E., & Itard, L. 2010. Assessment of current Dutch energy transition policy instruments for the existing housing stock. *Energy Policy*, 38(2): 981-996.
- Sorrell, S. 2003. Making the link: climate policy and the reform of the UK construction industry. *Energy Policy*, 31(9): 365-378.
- Fischer, J., & Guy, S. 2009. Re-interpreting Regulations: Architects as Intermediaries for Low-carbon Buildings. *Urban Studies*, 46(12): 2577-2594.
- Gram-Hanssen, K., Bartiaux, F., Jensen, O. M., & Madeleine, C. 2007. Do homeowners use energy labels? A comparison between Denmark and Belgium. *Energy Policy*, 35(5): 2879-2888.
- Van Schaack, C., & Ben Dor, T. 2011. A comparative study of green buildings in urban and transitioning rural North Carolina. *Journal of Environmental Planning & Management*, 54(8): 1125-1147.

List of Figures

Figure 1: Articles with 'building' and 'energy' in the abstract in the Construction Research Set, 2000-2011

Figure 2: Articles with 'energy' and 'building' in the abstract in Business & Social Science Set, 2000-2011

Figure 3: Distribution of Research Objects in Construction Research, Building & Social Sciences and Building & Environmental Issues Sets

Figure 4: Distribution of Research Objects on the Energy System across the Construction Research, Business & Social Science and Building & Environmental Issues Sets

Figure 5: Non-technical dimension in Construction Research and Business & Social Science Sets

Figure 6: Distribution of types of data in the study of non-technical dimensions across Construction Research and Building & Social Science Sets

Figure 7: Distribution of types of analysis in the study of non-technical dimensions across Construction Research and Building & Social Science Sets

Figure 8: Distribution of methodological approaches in the study of non-technical dimensions across Construction Research and Building & Social Science Sets

Figure 1: Articles with 'building' and 'energy' in the abstract in the Construction Research Set, 2000-2011

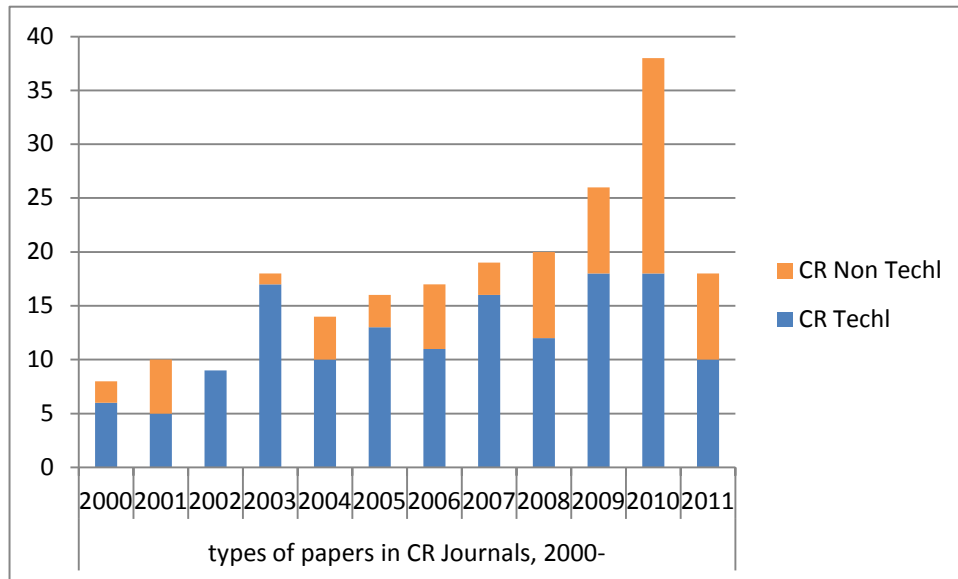


Figure 2: Articles with 'energy' and 'building' in the abstract in Business & Social Science Set, 2000-2011

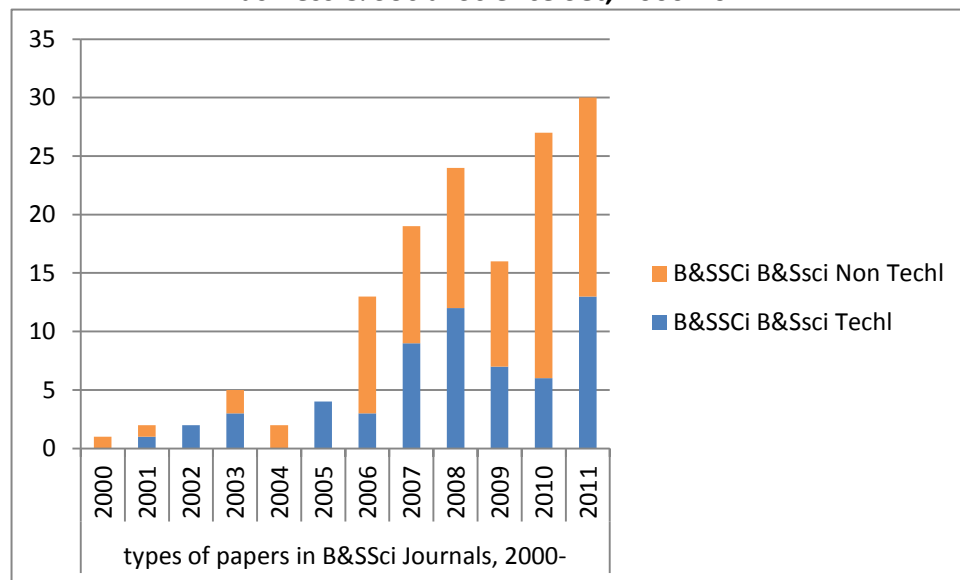


Figure 3: Distribution of Research Objects in Construction Research, Building & Social Sciences and Building & Environmental Issues Sets

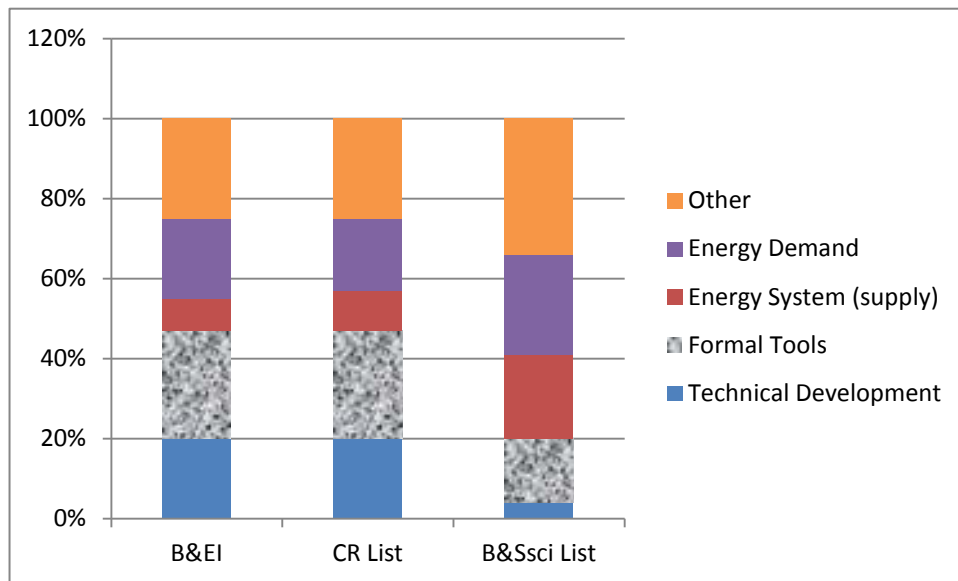
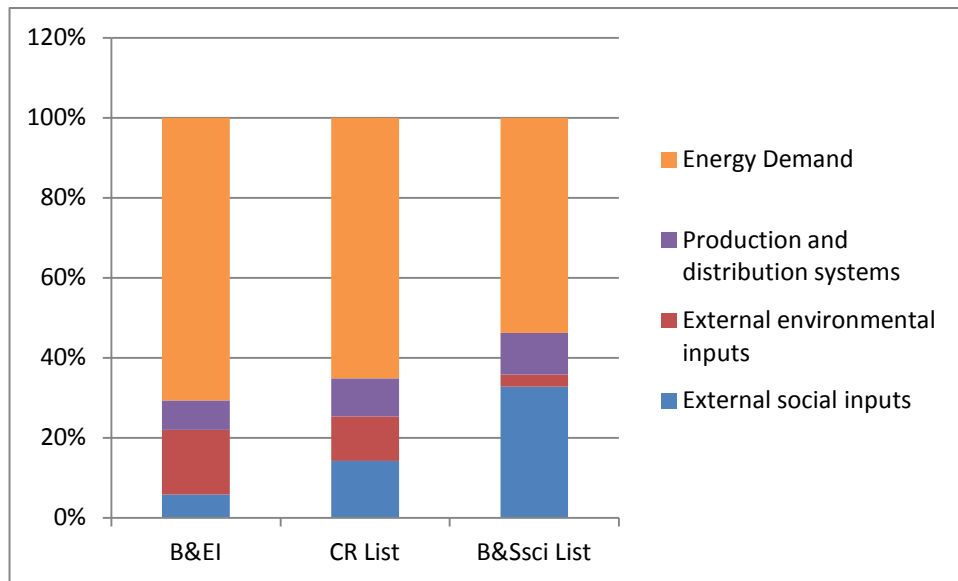


Figure 4: Distribution of Research Objects on the Energy System across the Construction Research, Business & Social Science and Building & Environmental Issues Sets



**Figure 5: Non-technical dimension in
Construction Research and Business & Social Science Sets**

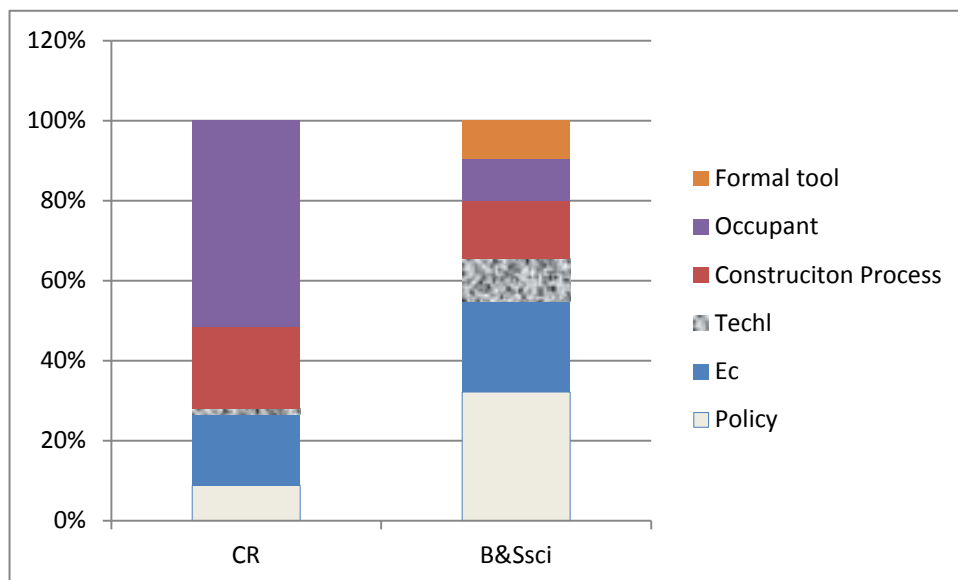


Figure 6: Distribution of types of data in the study of non-technical dimensions across Construction Research and Building & Social Science Sets

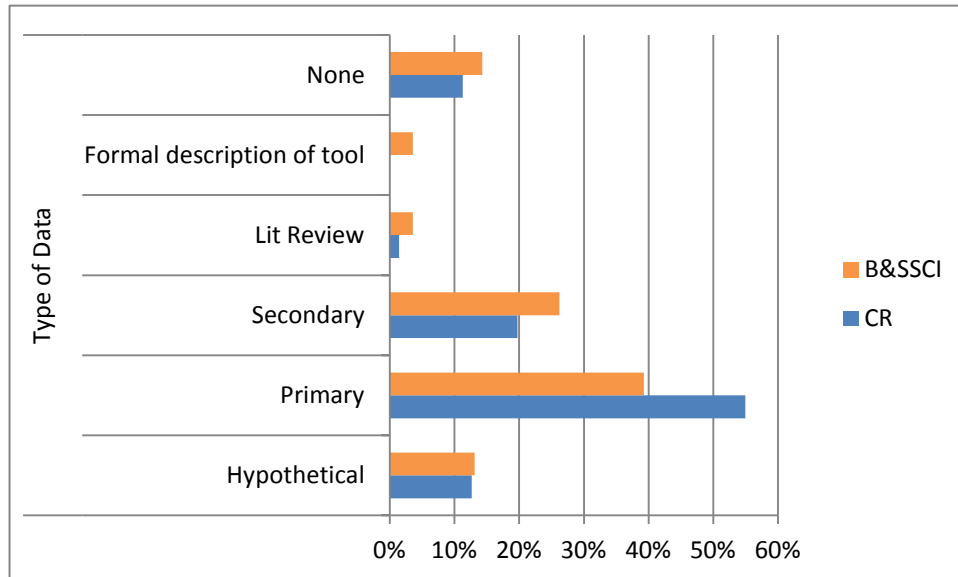


Figure 7: Distribution of types of analysis in the study of non-technical dimensions across Construction Research and Building & Social Science Sets

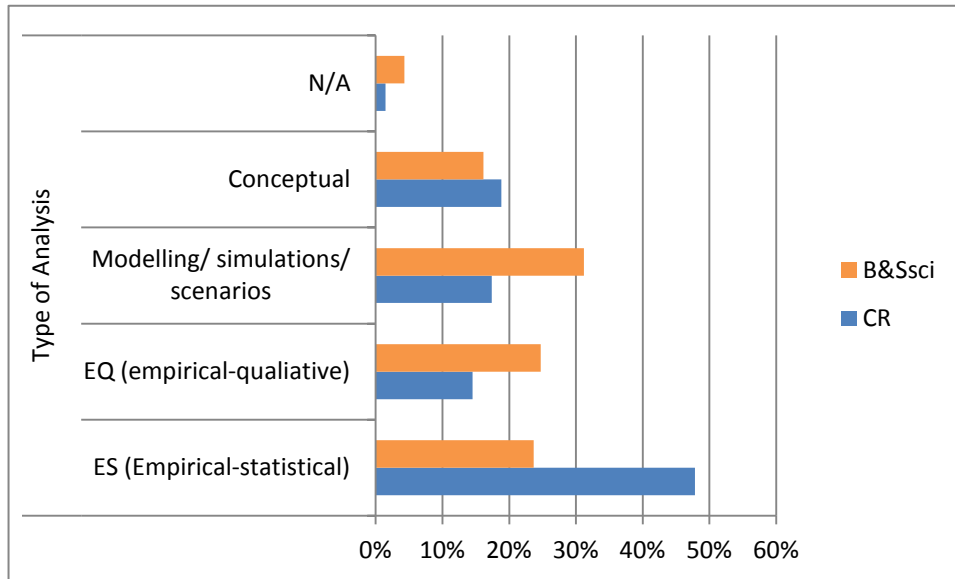
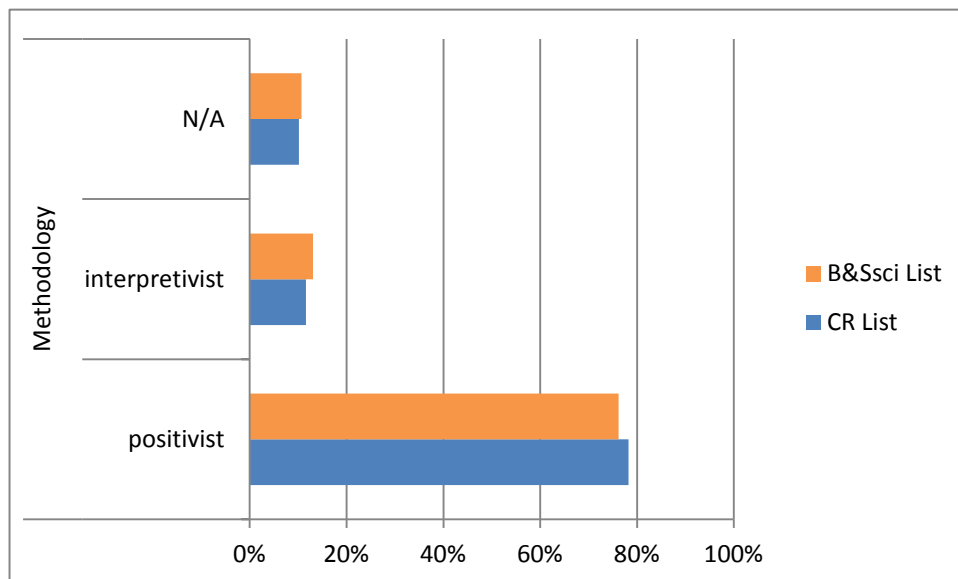


Figure 8: Distribution of methodological approaches in the study of non-technical dimensions across Construction Research and Building & Social Science Sets



References

- Andersen, P. H., Cook, N. & Marceau, J. 2004. 'Dynamic innovation strategies and stable networks in the construction industry: Implanting solar energy projects in the Sydney Olympic Village.' *Journal of Business Research*, 57:4, 351-60.
- BERR 2008. 'Strategy for sustainable construction.' HM Government.
- Biggart, N. W. & Lutzenhiser, L. 2007. 'Economic Sociology and the Social Problem of Energy Inefficiency.' *American Behavioral Scientist*, 50:8, 1070-87.
- BIS 2010. 'Low Carbon Construction, Innovation and Growth Team: Emerging findings.' London.
- Brown, V., Harris, J. A. & Russell, J. Y. 2010. 'Tackling wicked problems through the transdisciplinary imagination.' Earthscan.
- Bryman, A. 2004. *Social Research Methods*. Oxford: Oxford University Press.
- Chappells, H. & Shove, E. 2005. 'Debating the future of comfort: environmental sustainability, energy consumption and the indoor environment.' *Building Research and Information*, 33:1, 32-40.
- Fischer, J. & Guy, S. 2009. 'Re-interpreting Regulations: Architects as Intermediaries for Low-carbon Buildings.' *Urban Studies*, 46:12, 2577-94.
- Georg, S. 2006. 'Preface: Mobilizing and Managing the Environment.' *International Studies of Management and Organization*, 36:2, 3-8.
- Glynn, M. A. & Raffaelli, R. 2010. 'Uncovering Mechanisms of Theory Development in an Academic Field: Lessons from Leadership Research' *The Academy of Management Annals*, 4:1, 359-401.
- Gram-Hanssen, K. 2010. 'Residential heat comfort practices: understanding users.' *Building Research and Information*, 38:2, 175-86.
- Gram-Hanssen, K., Bsartiaux, F., Jensen, O. M. & Madeleine, C. 2007. 'Do homeowners use energy labels? A comparison between Denmark and Belgium.' *Energy Policy*, 35:5, 2879-88.
- Guy, S. 2006. 'Designing urban knowledge: competing perspectives on energy and buildings' *Environment and Planning C: Government and Policy*, 24, 645-59.
- Hambrick, D. C. & Chen, M.-J. 2008. 'New academic fields as admittance seeking social movements: The case of strategic management' *Academy of Management Review*, 33:1, 32-54.
- Healy, S. 2008. 'Air-conditioning and the 'homogenization' of people and built environments.' *Building Research and Information*, 36:4, 312-22.
- Hoffman, A. J. & Henn, R. 2008. 'Overcoming the Social and Psychological Barriers to Green Building.' *Organization and Environment*, 21:4, 390-419.
- Ke, Y., Wang, S., Chan, A. P. C. & Cheung, E. 2009. 'Research Trend of Public-Private Partnership in Construction Journals' *Journal of Construction Engineering and Management*:October.
- Keegan, A. & Boselie, P. 2006. 'The Lack of Impact of Dissensus Inspired Analysis on Developments in the Field of Human Resource Management.' *Journal of Management Studies*, 43:7, 1491-511.

- Koski, C. 2010. 'Greening America's Skylines: The Diffusion of Low-Salience Policies.' *Policy Studies Journal*, 38:1, 93-117.
- Lazarus, R. J. 2009. 'Super wicked problems and climate change: restraining the present to liberate the future.' *Cornell Law Review*, 94, 1153-233.
- Lockett, A., Moon, J. & Visser, W. 2006. 'Corporate Social Responsibility in Management Research: Focus, Nature, Salience and Sources of Influence.' *Journal of Management Studies*, 43:115-136.
- Lowe, R. 2009. 'Policy and strategy challenges for climate change and building stocks.' *Building Research and Information*, 37:2, 206-12.
- Marsilio, M., Cappellaro, G. & Cuccurullo, C. 2011. 'The intellectual structure of research into PPPS: A bibliometric analysis.' *Public Management Review*, 13:6, 763-82.
- Oreszczyn, T. & Lowe, R. 2010. 'Challenges for energy and buildings research: objectives, methods and funding mechanisms.' *Building Research and Information*, 38:1, 107-22.
- Rittel, H. W. J. & Webber, M. M. 1973. 'Dilemmas in a general theory of planning.' *Policy Sciences*, 4, 155-69.
- Robichaud, L. B. & Anantatmula, V. S. 2011. 'Greening Project Management Practices for Sustainable Construction.' *Journal of Management in Engineering*, 27:1, 48-57.
- Rohracher, h. 2006. 'Sustainability as a matter of social context: information technologies and the environment.' *International Journal of Environmental Technology & Management*, 6:6, 539-52.
- Rousseau, D. M. & Manning, J. 2008. 'Assembling the Field's Full Weight of Scientific Knowledge Through Syntheses.' *The Academy of Management Annals*, 2:1, 475-515.
- Shama, A. 1983. 'Energy conservation in US buildings: Solving the high potential/low adoption paradox from a behavioural perspective.' *Energy Policy*, 148-67.
- Shove, E. 2010. 'Social Theory and Climate Change Questions Often, Sometimes and Not Yet Asked.' *Theory, Culture & Society*, 27:2-3, 277-88.
- Sorrell, S. 2003. 'Making the link: climate policy and the reform of the UK construction industry.' *Energy Policy*, 31:9, 365-78.
- Stevenson, F. 2010. 'Developing occupancy feedback from a prototype to improve housing production.' *Building Research and Information*, 38:5, 549-63.
- Tambach, M., Hasselaar, e. & Itard, L. 2010. 'Assessment of current Dutch energy transition policy instruments for the existing housing stock.' *Energy Policy*, 38:2, 981-96.
- Toke, D. 2000. 'Policy Network Creation: the case of energy efficiency.' *Public Administration*, 78:4, 835-54.
- Tranfield, D., Denyer, D. & Smart, P. 2003. 'Towards a methodology for developing evidence-informed management knowledge by means of systematic review.' *British Journal of Management*, 14:3, 207-22.

- Van Schaack, C. & Ben Dor, T. 2011. 'A comparative study of green buildings in urban and transitioning rural North Carolina.' *Journal of Environmental Planning & Management*, 54:8, 1125-47.
- Williamson, T., Soebarto, V. & Radford, A. 2010. 'Comfort and energy use in five Australian award-winning houses: regulated, measured and perceived.' *Building Research and Information*, 38:5, 509-29.
- Zimmerman, A. & Kibert, C. J. 2007. 'Informing LEED's next generation with The Natural Step.' *Building Research & Information*, 35:6, 681-89.