DETAILED DESIGN ETHNOGRAPHY: ARCHITECTS EMBEDDING LOW CARBON PERFORMANCE

Gabriela Zapata-Poveda[1]

Welsh School of Architecture, Cardiff University. King Edward VII Av. Cardiff, CF10 3NB, UK

The United Kingdom is aiming to enforce nearly zero carbon buildings by 2020. The plan has been set into three-year incremental periods to facilitate the transition to zero carbon. In 2008, the Welsh Government announced its aspirations to lead the low carbon pathway in the UK by enforcing higher reduction targets and adopting BREEAM as a planning application condition for new non-domestic buildings. It is anticipated that the building industry will experience changes in its working methods. However, the routine implementation of energy regulations by practitioners remains unknown. In this context, the detailed design phase was investigated to unveil how regulatory requirements were affecting routine architecture practice. The real-time development of a small number of non-domestic projects procured by design and build route was studied by ethnographic methods. The focus was architects' work during detailed design so to reveal how they adopted official tools to embed performance in the fluidity of the process. Architects were using the official assisted to different degrees by informal tools situated in the social context of practice. Architects working on detailed design were likely to transpose, follow and learn about the energy aspirations during low carbon problem solving. Official and informal tools could occupy central, peripheral and mediating roles in the design of low carbon; affecting the articulation of energy aspirations during detailed design and delivery. The in-depth understanding of how low carbon was embedded during detailed design provides insights about how practitioners coped with energy regulations and how low carbon design process could be improved.

Keywords: energy, design, building regulation, design and build, architecture.

INTRODUCTION

Energy regulations for carbon reductions in new buildings are urging practitioners to design and deliver better performing buildings. In the United Kingdom, the decarbonisation plan to zero carbon buildings by 2020 has been divided in three-year transitional periods to gradually enforce reductions and increase the understanding of the implications of more stringent energy targets. In 2010, new buildings were enforced to reduce their carbon emissions by 25 per cent. It is anticipated that the target by 2013 will be 44 per cent. Wales has the aspiration to lead the carbon reduction pathway so it is intending to aim for a 55 per cent reduction by 2013. The Building Research Establishment Environmental Assessment Method (BREAM), a

[1] ZapataPovedaMG@cf.ac.uk

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building rating system to assess sustainability, was adopted in 2009 as a planning application condition in Wales. Welsh non-domestic buildings of an area of 1000sqm or greater should be BREEAM Very Good and satisfy the Energy criteria 1, Reduction of CO2 emissions, to an equivalent of Excellent rating.

Official instruments have been made available to practitioners to comply with energy requirements. The key instruments are the regulatory standard and the calculation methodology to estimate performance. The British mandatory energy standard in new non-domestic buildings is the Approved Document Part L2A, Conservation of Fuel and Power which outlines the minimum targets. The compliance tool is the National Calculation Methodology (NCM) which has been translated to interfaces such as the Simplified Building Energy Model (SBEM). Proprietary simulations software aligned to NCM are also available for practitioners to analyse the building performance during the design process. The deployment of these tools is intended to enable the designers' understanding of energy matters during design, calculate energy performance and facilitate regulation compliance.

Despite the variety of official instruments available for practitioners to understand and evaluate low carbon and energy efficient design, there are significant discrepancies between as-design and actual building performance during operation, probably due to the processes and cultures in the industry (Zero Carbon Hub 2010). The process of developing skills, knowledge and supply of technologies and products to achieve the mandated carbon levels is estimated to take ten to fifteen years (ECEEE 2009). The building industry will have to upscale techniques and gain understanding of the practical implications of carbon reductions during the transitional periods towards nearly zero carbon (Häkkinen and Belloni 2011; Hamza and Greenwood 2009; Osmani and O'Reilly 2009).

Given the policy aspirations and the decarbonisation timeframe, there is a need to understand how the official instruments such as the regulations and the calculation methods are being used in the fluidity of the design process and how energy performance is embedded in routine design. This understanding might inform mechanisms to facilitate the adoption of energy regulations during the transition to nearly zero carbon buildings.

DESIGN AS A SOCIAL PROCESS

Social constructivist theories claim that reality is influenced by the social context where it is located (Berger and Luckman 1971; Law 1991). Action and behaviour is determined by the social structure. The individuals who are part of a social group create common frames of reference and meanings due to their daily interactions which result in typifications, habitualised actions, institutionalisation and legitimation (Berger and Luckman 1971). In the light of these theories, this investigation considered low carbon design as a process of social construction where shared repertoires and goals are negotiated in the social context.

Design could be regarded as a social process of negotiation of worldviews (Bucciarelli 1994) where the social aspects are likely to be a powerful means for knowledge and information exchange. Research undertaken in project environments has highlighted the importance of 'the informal' in the outcome of projects (Bresnen *et al.*t 2003) and the need to understand tools in their context of use (Brown and Duguid 1994). It has been suggested that this awareness may facilitate the provision of better informed and suitable tools as aids for practitioners. One of the limitations of design tools, aids and official instruments is that they tend to be discrete and potentially limited for the use of a single professional or for a specific stage of the process. Both aspects might be detrimental to the continuity and common understanding necessary to solve energy matters. The social context of practice contributes to the understanding and learning as practitioners tend to develop internal routines and adopt informal strategies to achieve goals (Rowe 1987).

The social constructivist interpretation of design does not negate rational views or ideal models about the process. It acknowledges that the incorporation of official instruments may instigate conflicts or tensions within existing structures and patterns of practice (Suchman 1987). While analysing the incorporation of technology in practice, (Ihde 1990) raises attention to two flaw assumptions: that tools are merely instrumental and that they are completely determinative. He claims that both positions ignore the relativity of the relations human-technology and culture-technology. While technologies provide a 'framework for action', they are shaped by existing patterns, intentions and preferences.

The official tools for energy performance are intended to contribute to the application of low carbon in buildings though they could become a prescription imposed to practitioners if they do not get integrated as a natural part of the process. Little is known how designers are using the official in the context of periodic incremental changes. The enactment of low carbon policy aspirations by practitioners may be affected by routine patterns of practice. This research investigated how official, informal tools and patterns of practice contributed to embed low carbon performance during detailed design, with focus on the architects.

RESEARCH METHODOLOGY

The investigation adopted ethnography as a research tool to study how architects were embedding low carbon performance during detailed design since they are the practitioners likely to be involved during design and delivery phase. A detailed picture of the process was constructed by documenting the tools deployed by architects during routine project design. Four British architecture practices were recruited and four non-domestic projects were selected to study the design process during the 2010 energy regulation transition. The focus of the work was examining architect's work during conceptual and detailed design for buildings procured by design and build route, with emphasis on official, informal tools and routines for embedding low carbon design. This paper reports on the ethnographic findings of the detailed design, after the conceptual building design had been frozen and the planning application had been submitted. Detailed design corresponds to work stages E-K, according to the Royal Institute of British Architects (RIBA) Plan of Work, which is a British model of the building delivery process that outlines activities, deliverables and actors (RIBA 1998).

This study followed the contemporary ethnographic methods used in educational and medical research to investigate problems that overlap practice and policy dimensions which offer recommendations for interventions informed by the situated social context of practitioners (Delamont 2012; Hammersley 1992; Hammersley and Atkinson 1995) The data collection methods included semi-structured and opportunistic interviews, observational studies comprising non-participant observation in design and delivery team meetings and shadowing of architect's work, document analysis of project deliverables and informal documentation produced during design. Although the architects were the main research participants, other team members of detailed design were included to construct a rich picture about the low carbon design.

The research design followed a generative research model where the early findings informed the development of further phases (Strauss and Corbin 1990; Coffey and Atkinson 1996). A grounded theory approach based on social constructivist perspectives informed the research, the data analysis and interrogation. The key aspect to investigate was the enactment of policy by practitioners, facilitated by the use of official tools in the social context of practice.

The researcher, being an outsider for the practices, did not impose her research agenda to the participants. The investigation documented and compared the real-time development of four non-domestic projects to find commonalities and differences in the processes. By comparing few case studies, reflexivity was encouraged to interrogate the data. No claim for generalisation is made. This research is bounded by time and circumstances. The researcher acknowledges the asymmetry of the ethnographic immersion as an inherent limitation of the method. However, by observing few low carbon design processes, rich information was obtained about the challenges and the enactment of regulations.

EMBEDDING LOW CARBON WHILE DESIGNING

Background

The case studies correspond to four non-domestic buildings; three of them located in Wales (case studies 1, 3 and 4) and one in England (case study 2). The fieldwork was undertaken between July 2010 and December 2011. Part L2A 2010 was the energy standard in all cases enforced from October 2010 and BREEAM 2008 the planning condition requirement for Welsh based projects, though all the projects aimed for BREEAM. The first regulatory gateway that practitioners faced was planning application, at the end of RIBA D. In cases 1, 3 and 4, the planning application required the commitment to BREEAM. In relation to low carbon aspects, Energy credit 1 comprised the achievement of an Energy Performance Certificate of 40. An approved calculation methodology was to be used to assess the energy performance. Due to planning application, the energy aspirations got inscribed as design requirements as part of the planning conditions. They became the energy aspirations to realise during detailed design and delivery. During detailed design, Part L2A 2010 was the regulatory instrument to be verified by building control authorities. It required a 25 per cent reduction of $CO2$ emissions. This improvement was calculated by comparing the estimated performance of a notional building and the building design. Additionally, Part L2A 2010 had 4 recommendations that include maximum thermal performance of building elements, solar overheating prevention, mechanical systems and ductwork testing and commissioning of systems. (Part L 2010)

Challenges in the process

The case study comparison suggests some potential problems arising during detailed design in relation to low carbon design and the enactment of the low carbon policy agenda. The critical instances where fragmentation was likely to occur were at the beginning of detailed design (RIBA E) and the transition between detailed design and delivery phase (RIBA J-K).

The architecture team must ensure the continuity of the energy aspirations and make the energy rational of conceptual design explicit to guide the subsequent phases. This seemed critical in cases 3 and 4 where different architecture teams (within the same office) were involved during conceptual, detailed design and delivery phases.

The transition between detailed design and delivery is another instance prone to fragmentation when the design team had to transfer the ownership of the energy aspirations to the delivery team led by the main contractor. Architects and other members of the design team expressed their concerns about not achieving the energy aspirations from design because of the delivery team's different agenda. It was suggested that the delivery phase was driven by cost and time. Architects had the perception that the competing agendas of design and delivery phases could result in the lack or poor articulation of design aspirations and on-site drivers which undermined the achievement of low carbon intentions. Value engineering exercises were considered to be critical in reengineering the energy aspirations and drivers of the project. When the energy was not an explicit requirement, the value engineering could jeopardize the final energy targets. During delivery phase, only the minimum regulatory requirements were likely to be sought even though the initial design aspirations surpassed the minimum regulatory benchmarks. Architects claimed that the design aspirations might remain as good design intentions likely to be changed if the value engineering did not factor energy as an explicit requirement. If the energy performance was not a clear client requirement, pressing issues from the delivery agenda such as cost and time, could affect the continuity of the energy aspirations.

TOOLS TO EMBED LOW CARBON PERFORMANCE

A description of the tools used by the architects to embed energy performance during detailed design are presented and grouped in three categories: transposing, following and learning, corresponding to the low carbon problem solving activities, observed to different degrees in the case studies. There is no claim that these are the only or all the tasks necessary for low carbon detailed design. This classification is an aid to briefly document the cases studies. Each category has a table that outlines the use of the tools. In the following section some points concerning detailed development, simulation use and experience-based knowledge are further elaborated.

Transposing (RIBA E-F)

It is aimed to link design and delivery phases and facilitate the continuity and ownership of energy aspirations. It embodies the notion of forecasting and inscribing the energy requirements and connect them to performance, buildability, cost and site practicalities.

Table1. Transposing: tools to embed performance and their use

Tools	Use
Experienced based advice	To understand performance. Indicators: U-values of build-ups (all cases); G-value (case 1 and 3). It could start before detailed design though informal dialogue, workshops and meetings. The advice was given to architects by architects experienced in delivery, mechanical eng. and energy consultants.
Simulation (energy calculation tools)	To assess the detailed design and improve the accuracy of the model. In case studies 1 and 3, the model was factored against cost so to prioritise the more cost-effective low carbon strategies. In case 2 SBEM was used for compliance. In none of the cases architects deployed any quantitative method to evaluate performance, simulation was used by the mechanical engineers.
Dialogue with manufacturers and suppliers	To examine the suitability and compliance of specific details, related to thermal performance (all cases). However, the U-value might not be achievable when being delivered on site.
Details retrieval	To develop details, previous details were consulted informally. No general detailed documentation database was found in any of the cases.
Annotation on drawings	To clarify the performance of the elements in terms of U-values and G-values (case 1 and 4). Sequence of detail construction was included in case 4.
Tender packages completeness	To prevent changes on site, rigour of information was necessary ('bullet-proof' information). The indicators were U-value (all cases), G-value (cases 1 and 3), airtightness (cases 1, 3 and 4). In case 4, 3D details were developed with a suggested sequence of construction.
Workshops to contractors bidding	To make the energy rationale explicit, inscribe the energy targets so to make the delivery team aware of the design aspirations (case 1, 3)

Following (RIBA F-K)

This could be developed during delivery phase when the architecture team gets novated and become part of the contractor’s delivery team. It implies the assessment and monitoring the suitability of site proposals and changes to deliver the energy aspirations on site, as inscribed in the tender packages and specifications.

Table 2. Following: tools to embed performance and their use

Tools	Use
Experienced based advice	To understand performance in the light of buildability, cost, workmanship and delivery so to recommend or dismiss a site change. (all cases)
Simulation (energy calculation tools)	To articulate detailed design, energy aspirations and site work. It was invoked as a design aid to inform decisions (cases 1, 3 and 4); as a tool to negotiate with the contractor changes suggested by value engineering (cases 1 and 3) and as compliance tool to produce compulsory evidence for regulation (all cases)
Construction diary	To document the implementation of details and track changes on site, part of a specific investigation about thermal performance.
On site tests	To verify airtightness and mechanical systems performance (all cases). Results unlikely return to the architecture firm to inform the design assumptions made.

Learning

It implies the reflection about the process has the potential to contribute to learning and dissemination of practical low carbon knowledge based on experience. The experience gained from designing could inform skills and enhance practical capabilities. However, this was unlikely to happen.

Table 3. Learning: tools to embed performance and their use

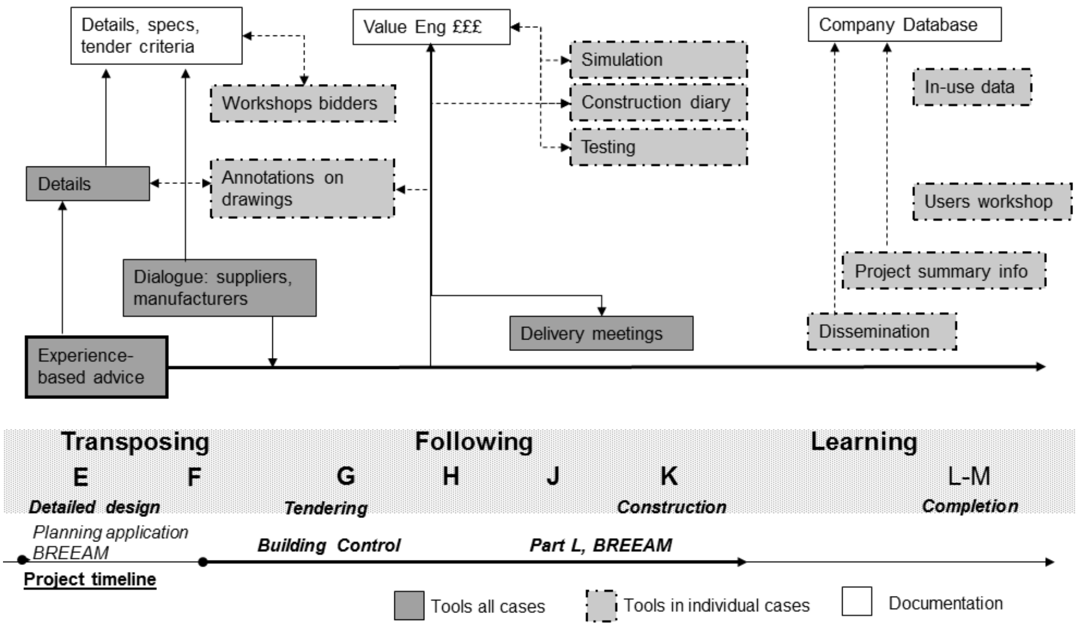
Tools	Use
In-house presentations	To disseminate information about targets and design experience in the office by presenting the projects to colleagues in the company (all cases)
Project summary info	To summarise information including energy aspects such as BREEAM rating, renewable sources, passive design. It was part of the database of projects.
In-use data (monitoring exercise)	To obtain the energy usage of the building. Only the clients in case 3 requested a specific target as contractual requirement (27kgCO2/m2year). In other cases, the metering reading was a referential value to record.
Users workshop	To inform about the operation of the building, use and maintenance of the systems. In case 3, there was an emphasis on educating the users about energy reduction. In all cases, a manual of operation was produced for the facilities manager.

Figure 1 illustrates the tools in their context of use. It is a 'snap-shot' of detailed design. It relates activities for low carbon problem solving, tools to embed performance, building delivery and regulation. It reads top-down and it includes:

1. Tools for embedding performance: The dark grey boxes represent the tools observed in all the case studies while the dotted light grey boxes represent the tools that were found in few cases. The white boxes represent the deliverables or documents produced by the time the tools were deployed. The arrows represent the relations between them. The tone of the arrow (dark, light and dotted) shows the role of the tool. The darker the arrow, the more central the tool was. The dotted arrows indicate the incipient use of the tools.

1. Low carbon design tasks: transposing, following and learning;
2. RIBA Work Stages referring to activities for project design and delivery
3. Project timeline with corresponding regulatory gateways

Figure 1. Tools to embed performance during detailed design



DESIGN PRACTICE AND REGULATION

In this section, three aspects will be further discussed: the use of simulation, detail development and experiential knowledge and heuristics use during detailed design. They were selected to highlight the relations between simulation as the compliance tool and informal processes to develop detailed design and embed performance.

1. Use of simulation during detailed design

A rough model was available at the beginning of detailed design as evidence for BREEAM energy requirements due to planning application condition, however, design teams considered that this model based on conceptual design could be referential due to lack of the accuracy. As the detailed design progressed, simulations were invoked to produce evidence for building control compliance (Part L2A). Case study 2 only used SBEM to produce Part L2A evidence. In case studies 1 and 3, simulation was a design aid that aligned performance estimation, accuracy while factoring cost. In case study 4, although simulation was used during detailed design, it was intermittently invoked. Simulation was also triggered by the value engineering exercises that recommended changes in the design. In this circumstance, simulation enabled to understand the consequences of the changes and present evidence-based arguments to decline or support changes.

Architects expressed their distrust to simulation as a design aid due to the perception that it was an ‘academic exercise’ with limited accuracy, a time consuming task where ideal scenarios were represented but no certainty in the accuracy of the data input. The results were considered to be uncertain and probably ambiguous. For some, simulation was a regulatory requirement but not a design tool to estimate performance and inform the design. In such situation, simulation was regarded as an alien element that was not rooted in the process. If energy calculation tools and official tools to estimate performance were regarded as extraneous elements, their acceptance within teams did not seem to be based on their role as regulatory instruments. Calculation tools’ legitimacy seemed to rely in its position within the process. The social aspects underlying trust and partnering relations between architects who designed and mechanical engineers or energy assessor who created the simulation model had an effect on the regard of simulation by architects. When simulation was consistently invoked in the process as a design aid to monitor the aspirations and inform decisions, then architects seemed to trust the results. If simulation was only used to produce compulsory evidence for compliance, then results showing poor performance were criticised and simulation was perceived as a 'theoretical exercise'. The continuous use of simulation as part of the design process gave it legitimacy and trust.

2. Details development and details retrieval

Teams were prone to consult details used in previous projects as a basis for solving the new details. However, none of the case studies had an officially organised database to facilitate the detail retrieval or a repository of detailed documentation from previous projects. Unlike the widespread use of databases archiving project templates containing project summary information, no similar database was found for organising previous projects' details. The use of past details seemed to be central to detailed design but their retrieval was as an informal procedure. No official database or knowledge management system facilitated the reuse of details. Architects expressed that they consulted their colleagues who had worked in the past on similar projects to find out more information for details’ development.

Changing requirements seemed to be encouraging earlier considerations in the development of the details. Detailed design knowledge was invoked before detailed design during RIBA D to inform preliminary proposals and understand the possible energy performance. Although the details were unlikely to be developed before planning application submission; experience and technical knowledge about details informed the conceptual design and generally occurred before officially starting detailed design.

3. Experiential knowledge and heuristics

None of the architects in the case studies deployed any quantitative tools to assess performance despite all of the practices included in the study had expertise and experience in sustainable design. No evidence suggested that the energy calculation tools were part of the design aid toolkit used by architects. In order to understand performance, architects consulted colleagues to discuss about performance. This understanding was based on experience and feel for performance, encapsulated by rules of thumb and basic principles that had not been officially articulated nor tested quantitatively. Architects invoked experience based advice from architects and other team members such as the mechanical engineer and the energy consultants. Experiential knowledge also seemed to guide the analysis of simulation results. It was recurrently used to understand performance, even when energy calculation tools had been incorporated in the process.

CONCLUSIONS

It was observed that no design aids to quantitatively estimate performance were used by architects during detailed design. Architects relied on heuristics and experiential knowledge to assess the proposals while partnering up with the mechanical engineers to get feedback about the performance target achievement. Given the central and pervasive role of experiential knowledge and heuristics, they should be examined to assess their suitability to deliver the expected performance during delivery.

Additional detailed design tools could be available for the performance understanding during delivery. Embedding performance during detailed design might be incomplete and aspirations might not be achieved if the understanding is not informed by the actual performance obtained on site. Theoretical models, heuristics, experienced based knowledge linked to site test results might raise the practical performance understanding and enable the identification of discrepancies and limitations of design assumptions. The dynamic nature of problem solving where the official and the informal interact should be potentialised to contribute to the integration of the official in routine practice. The informal could mediate the adoption of the official in the fluidity of the process so the official is not imposed as a compulsory element.

Information related to details and site delivery does not tend to return to the studio to inform architects' detailed design and delivery assumptions. Design changes that occur on site are unlikely to be documented comprehensively. The chain of changes is rarely tracked, reducing the opportunities to learn about the design in the light of delivery phase evidence. Intended learning and reflection to link different stages of design and delivery remain peripheral in the process though experiential knowledge and heuristics were central to understand performance in the fluidity of the process. The lack or poor reflection could be detrimental to learning. Increasingly higher energy regulation targets demand teams to understand the possible performance earlier in the process and embark on a learning process that connects different stages of development.

Further areas of work include the provision of mechanisms that facilitate intentional learning and the identification of key indicators and instances in the process to learn from designing. Such mechanisms should be part of the process to not disrupt design tasks nor interrupt the process.

While official tools contribute to low carbon design, they could become prescriptions to the process if they do not get appropriated in routine practice. The informal tools and the social context of practice might have a supporting role for the uptake of the official and the design of low carbon. Although simulation might be the central tool for compliance, it might not be incorporated in the design process as a natural part of it. The lack of integration undermines the effective deployment of simulation on the relevant instances of the process where the energy aspiration is understood and negotiated within the design teams. Embedding performance is not only matter of calculating the energy target. It is a process of negotiation where tensions and potential fragmentation has to be overcome. If simulation is only deployed as a regulation tool to produce compulsory evidence, then the tool is unlikely to inform low carbon design. Informal tools and social practices could support the understanding, negotiation and achievement of energy aspirations as mediators in the process. The social context where the process is situated is likely to affect the adoption, acceptance, integration, trust and tacit legitimacy of official calculation tools, such as simulation, that otherwise may be considered elements prescribed in the process.

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