Constructing sustainability: connecting the social and the technical in a case study of school building projects

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Abstract

This thesis traces the political interpretation of sustainability, and its translation into practice in English school building programmes during the period 2000-2010. Social power theory is used to analyse the complex network of decisions, and their consequences, through case studies of policy development and of building projects.

The thesis describes how the control of appointments to task forces and of the issues considered allowed Government to manage the framing of the policy agenda while seeming to validate industry perspectives. The process led to a political interpretation of sustainability that translated into two main technical solutions: improved operational energy efficiency and low-carbon energy technologies. Within construction projects the potential power of professional experts to produce alternative solutions is also demonstrated, through the example of the successful introduction of cross-laminated timber to reduce embodied carbon. Outcomes are therefore shown to have been substantially influenced by the exercise of both political and professional power.

The thesis also shows the unintentional power effects of procurement processes and design tools in defining and limiting possibilities, the restricting power of the professional systems within which the actors operate, and the power of numbers to provoke unreflective trust. These effects are shown to have led to some irrational solutions, with the thesis demonstrating that the energy technologies installed in three projects are likely to produce higher, not lower, carbon emissions.

These multiple power effects have therefore constrained thinking and possibilities for the interpretation of sustainability for construction, have limited the subsequent translation into practical solutions, and have had a substantial and at times negative effect on the material performance of the resultant buildings. In addition the technologies and numbers have not only been used, and therefore governed, *by* the actors but also appear to have governed *them*, limiting their actions and understanding of sustainability.

Contents

Acknowledgements **8**

List of abbreviations **9**

Foreword **11**

Chapter 1 Constructing sustainable schools **12**

1.1 Introduction 12
1.2 The contested nature of sustainable development 13
1.3 The changing construction industry 19
1.4 School buildings 26
1.5 Summary, structure and approach 29

Chapter 2 Relationships of power **34**

2.1 Introduction 34
2.2 Theories of power 35
2.2.1 Introduction 35
2.2.2 The first and second dimensions of power 37
2.2.3 The third dimension: Lukes and others 38
2.2.4 Foucault 40
2.3 Applications of power 42
2.3.1 Introduction 42
2.3.2 Policy formation 42
2.3.3 Expertise 45
2.3.4 Numbers 47
2.3.5 Technologies 51
2.4 Summary and Conclusion 54

Chapter 3 Research design and method **57**

3.1 Introduction: case study research 57
3.2 Research design 58
3.2.1 Introduction 58
3.2.2 Hypotheses 59
3.2.3 Units of analysis 59
3.3 Development of case studies 63
3.3.1 Policy case study 63
3.3.2 Preparatory and exploratory studies 63
3.3.3 Identification of school projects 65
3.4 Data 67

3.4.1 Linking data to hypotheses 67
3.4.2 Sources and methods 68
3.4.3 Development of questions and interview process 72
3.4.4 Data analysis 76
3.5 The language of schools' procurement 78

Chapter 4 Policy: pressure, advice and assessment 81

4.1 Introduction 81
4.2 UK policy: sustainability, energy and carbon 83
4.3 From sustainable communities to zero carbon buildings 88
4.4 Sustainable Schools 96
4.5 Policy networks and special interest groups 107
4.6 Conclusion: power and sustainability in school building 111

Chapter 5 Projects 1 and 2 - Processes and tools 116

5.1 Introduction 116
5.2 Backhouse School Case Study 117
5.2.1 Introduction to the Backhouse School and building project 118
5.2.2 Design development 118
5.2.3 Sustainability in design choices 122
5.2.4 Planning 129
5.2.5 The influence of the contractor 131
5.3 Eastwick Field Case Study 136
5.3.1 Introduction to Eastwick Field School and building project 136
5.3.2 Procuring the 'LEP' and design progression 140
5.3.3 Reaching 'Financial Close' 143
5.3.4 Sustainability in design 150
5.4 Conclusions: impacts of procurement and tools on sustainability 153

Chapter 6 Projects 3 and 4 – Professions and expertise 156

6.1 Introduction 156
6.2 St Augustine Case Study 157
6.2.1 Introduction to St Augustine School and building project 157
6.2.2 Design development 161
6.2.3 Sustainability during construction 169
6.2.4 The final result 174
6.3 Lane Academy Case Study 177
6.3.1 Introduction to Lane Academy and building project 177
6.3.2 Detailed design 183
6.3.3 Construction 188
6.4 Conclusions: impacts of professions and expertise on sustainability 190

Chapter 7 Power, politics and numbers 195

7.1 Introduction 195
7.2 Reduction of operational energy 196
7.3 Renewable energy 201
7.3.1 Policy and projects 201
7.3.2 Ground source heat pumps 203
7.3.3 Biomass boilers 212
7.3.4 Why renewables? 216
7.4 Embodied energy and carbon 218
7.5 Conclusions: the reality of numbers 224

Chapter 8 Deconstructing sustainable construction 226

8.1 The starting point 226
8.2 Industry and policy 228
8.3 Processes and tools 234
8.4 Experts and expertise 237
8.5 The social construction of sustainability 240
8.6 Answers, limitations and recommendations 247

Afterword: Views of sustainability from two school pupils 250

Appendix A Interview details 255

Appendix B List of supporting documents 266

Appendix C Embodied energy and carbon in buildings 272

References 284

List of illustrations

Fig 1.1 Mapping of views on sustainable development (from Hopwood et al, 2005, p.41) 18

Fig 1.2 The principles underlying sustainable development (adapted from Cooper, 1995) (from Palmer et al, 1997, p.88) 23

Fig 1.3 Structure of thesis 33

Fig 4.1 All UK Public General Acts (primary legislation) with Energy, Sustainable and Climate Change in titles 86

Fig 4.2 All UK Statutory Instruments (secondary legislation) with Sustainable and Carbon in titles 87

Fig 4.3	Schools procurement routes and case studies	99
Photo 5.1	Underfloor heating pipes being laid in new atrium, connected to ground source heat pump	125
Photo 5.2	The new building being constructed on the large South site	126
Photo 5.3	640 new bike racks, allowing parking for 1280 bikes, being installed – this is by far the most common mode of transport for pupils	128
Photo 5.4	The steel frame of the new teaching block being erected	133
Photo 5.5	Willmott Dixon Playing Cards for the Future, with the ten sustainability criteria in the yellow box bellow, on wall of site office	135
Photo 5.6	The existing buildings at Eastwick Field: it was decided to retain most of these, in spite of problems with disabled access	140
Photo 5.7	Temporary classrooms installed at Eastwick Field School	148
Photo 5.8	A small area of PV panels acting as sun screens for windows below. The photo also demonstrates the cramped site in a built up area, suggesting that biomass is an unsuitable choice due to its space requirements for storage and delivery of fuel	152
Photo 6.1	Existing buildings at St Augustine	158
Photo 6.2	The timber system led to considerable interest and frequent visitors to site. This group included a potential school client and architect for a project which was later won using the same system.	171
Photo 6.3	Prefabricated timber panels meant that erection was substantially quicker than conventional systems	172
Photo 6.4	The 'green jewel' of the wind turbine, and cars parking along the kerb in an over-crowded carpark, at St Augustine School	174
Photo 6.5	The finished courtyard linking new and refurbished buildings at St Augustine. Behaviour and academic results at the school have improved.	176
Photo 6.6	The council project manager 'snagging' the building with the contractor. Her own professional expertise in civil engineering and teaching made her a very hands-on and knowledgeable client, with an excellent working relationship with the contractor Kier.	179
Photo 6.7	A space for whole school Christian worship was a key requirement of the sponsor, which caused some unhappiness with parents	184
Photo 6.8	The offsite fabrication and an innovative edge support system, shown here, obviated the need for scaffolding and greatly improved access during construction.	188

Fig. 7.1 Display of modular information for the different stages of the building assessment, BS EN 15978:2011Sustainability of construction works — Assessment of environmental performance of buildings 223

List of tables

Table 3.1 List of similar case study projects 62

Table 3.2 Exploratory studies 64-65

Table 3.3 Matrix of case studies 67

Table 3.4 Linking data to theory 68

Table 3.5 Research questions and relevant sources of data 72

Table 3.6 Interviewing: potential problems and proposed solutions 74

Table 3.7 Glossary of schools procurement terminology 79-81

Table 4.1 Membership of the Sustainable Buildings Task Group 90

Table 4.2 DfES eight doorways to sustainability 101

Table 4.3 Membership of the Zero Carbon Task Group 105

Table 5.1 Key details of Backhouse and Eastwick Field case studies 117

Table 5.2 'Renewable energy technologies' from the mechanical engineering services stage D report, Section 8 124

Table 5.3 Derived from the pre-BREEAM assessment for Backhouse School, forming part of the County Council's Supporting Planning Statements, July 2006 129

Table 5.4 Willmott Dixon 'Playing Cards for the Future' 134

Table 5.5 Extract from first DQI exercise at Eastwick Field School 138

Table 6.1 Key details of St Augustine and Lane Academy case studies 157

Table 7.1 Renewable energy technologies in the case study schools 203

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List of abbreviations

ANT	Actor Network Theory
ASHP	Air Source Heat Pump
BB	Building Bulletin
BCSE	British Council for School Environments
BER	Building Emission Rate
BIM	Building Information Modeling
BMS	Building Management Systems
BRE	formerly Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BSF	Building Schools for the Future
BSFI	Building Schools for the Future Investments
CABE	Commission for Architecture and the Built Environment
CAD	Computer Aided Design
CDA	Client Design Advisor
CIBSE	Chartered Institute of Building Services Engineers
CIC	Construction Industry Council
CoP	Coefficient of Performance
COP	Conference of the Parties
CSH	Code for Sustainable Homes
D&B	Design and Build
DBERR	Department for Business, Enterprise and Regulatory Reform
DCLG	Department for Communities and Local Government (from 2006)
DCSF	Department for Children Schools and Families (from 2006)
DEC	Display Energy Certificate
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DfE	Department for Education
DfES	Department for Education and Skills (up to 2006)
DoE	Department of the Environment
DQI	Design Quality Indicator
DTI	Department for Trade and Industry
DTLR	Department for Transport, Local Government and the Regions
EA	Environment Agency
EEDA	East of England Development Agency
EERA	East of England Regional Assembly
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EPSRC	Engineering and Physical Sciences Research Council

EST	Energy Saving Trust
GBC	Green Building Council
GSHP	Ground Source Heat Pump
ICE	Institution of Civil Engineers
ICT	Information and Communications Technology
I-O	Input-Output (Life Cycle Analysis method)
IPCC	Intergovernmental Panel on Climate Change
JCT	Joint Contracts Tribunal
LA	Local Authority
LA21	Local Agenda 21
LCA	Life Cycle Analysis
LEP	Local Education Partnership
LGA	Local Government Association
LZC	Low/Zero Carbon
NCSL	National College for School Leadership
NEC	New Engineering Contract
NFU	National Farmers Union
ODPM	Office of the Deputy Prime Minister
OfSted	Office for Standards in Education, Children's Services and Schools
OJEU	Official Journal of the European Union
OPM	Overall Project Manager
PFI	Private Finance Initiative
PfS	Partnerships for Schools
RAEng	Royal Academy of Engineers
RIBA	Royal Institute of British Architects
SAP	Standard Assessment Procedure
SBDU	School Building Design Unit
SBEM	Simplified Building Assessment Method
SDC	Sustainable Development Commission
SFfC	Strategic Forum for Construction
TER	Target Emission Rate
TUPE	Transfer of Undertakings (Protection of Employment)
UKGBC	UK Green Building Council
UNCED	United Nations Conference on Environment and Development
WCED	World Commission on Environment and Development
WRAP	Waste and Resources Action Programme
ZCH	Zero Carbon Hub
ZCTF	Zero Carbon Task Force

Foreword

I came to this research as a structural engineer intent on understanding why we, those working in the design and construction of the built environment, seem continually to fail to build 'sustainably', in spite of what seemed to be considerable effort and often heartfelt good intentions. I had a hunch that it wasn't just that we were getting the numbers wrong, and that maybe it was to do with people and relationships. So I started out on a study which used insights from the social sciences to look back at my world and try to re-assess it. I have meanwhile carried on working as a structural engineer, using (more or less trusted) numbers to develop a new technology, a complex collection of spreadsheets to calculate the whole life embodied carbon of a building, some of which is included in this thesis as Appendix C; while this has given me a clearer understanding of the technological decisions which I have witnessed, this part of my brain has undoubtedly struggled to fully comprehend the amazing new (to me) ideas which have emerged from my sociological research. The help of Jacquie Burgess and Peter Simmons has therefore been invaluable: Jacquie's astonishment at matters that used to seem unquestionable, Peter's stunning breadth of knowledge, and his ability to explain the most complicated social theories even to an engineer, and most importantly their ability to help me start to understand.

Other structural engineers have, of course, played a role in each of the cases studied. The vision of sustainability as embodied carbon that dominates one of the case studies is introduced and championed by the structural engineer. But now I am left wondering, what makes his interpretation of sustainability as embodied carbon any more 'right' than anyone else's interpretation? What are the numbers behind the reasoning, and the reasoning behind the numbers? Why does his solution *really* 'win' in this particular project? And who benefits?

Realising that the real conclusion of my thesis must be, that if everyone is based within their own perspective it is fundamentally important to include as many as possible, I now regret not having interviewed school pupils in my studies. There is a lot of talk about including pupils, too, in the design process but, while the Sorrell Foundation in particular has made great strides in real action, my case studies showed that there is still very little meaningful inclusion of pupils in the design of their school buildings. As an afterword to this thesis I have added my own daughters' views of sustainability. I can't pretend that they have been unaffected by their mother's preoccupation. But I hope it helps to indicate that pupils, the ultimate clients for these school buildings, have both knowledge and understanding of many issues, and should have a voice.

Chapter 1 Constructing sustainable schools

'There are other stories to be told and other studies to be done. We have, however, demonstrated the relevance and value of an approach that escapes the confines of the human dimensions agenda and that directly engages with the localized knowledge of practitioners operating in constantly changing professional environments.'

Simon Guy and Elizabeth Shove: 'A sociology of energy, buildings and the environment', 2000

1.1. Introduction

In 1987, twenty years before this research started, the World Commission on Environment and Development wrote an extensive and influential report, *Our Common Future*. The report focused on 'the need to integrate economic and ecological considerations in decision making' (WCED, 1987, p62); this was 'sustainable development', a term which has grown out of the need to integrate two potentially conflicting priorities. While the forced marriage between two very different cultures and creeds has resulted in, at best, debate, and at worst, conflict, the force of the arguments have meant that sustainable development 'has rapidly become the dominant idea, or discourse (Dryzek, 2005), shaping international policy towards the environment' (Carter, 2007, p.208).

During the same period the UK construction industry has undergone a series of restructuring measures, in an attempt to increase productivity and reduce inefficiency. Government-commissioned reports, particularly those by Latham (1994) and Egan (1998 and 2002), and subsequent initiatives, have led to new procurement processes which aim to give clients and stakeholders a more equal say in decisions. On the other hand, innovations in design and construction methods, as well as in building services technologies, seem to imply an increased reliance on professional technical expertise. As part of the growing political focus on sustainability, particular regulations and strategies for 'sustainable construction' have also created rapid change, including the development of site-scale renewable energy options (Bergman et al, 2009).

The construction of school buildings has become a showcase for these changes for two principle reasons. Firstly school projects formed an important part of the construction work load in the first

decade of this century, due in part to the Academies and Building Schools for the Future programmes. Secondly a speech by Prime Minister Tony Blair in 2004 defined school buildings as a visible demonstration of the Government's aspirations, 'models of sustainable development' (Blair, 2004). This focus was maintained, and by 2008 the Secretary of State for Children, Schools and Families, Ed Balls, stated that schools were to be the first building type to achieve 'zero carbon' (DCSF, 2008). In the past school buildings have been shown to reflect the political and social concerns of an era (Dudek, 2000), and this political focus on building 'sustainable schools' suggests that the same may be true for the current age.

This thesis considers how the complex concept of sustainability was interpreted within the changing landscape and relationships of the UK construction sector, using school construction projects as the specific context. The primary research question asks: 'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?'

The following sections of the introduction set the scene through short reviews of the development of the concept of sustainability (section 1.2), the claimed changes of roles and responsibilities within the construction industry (section 1.3), and the impact of social and political concerns on school building programmes (section 1.4). These reviews clarify the research questions and identify a framework through which they may be examined. The research questions which emerge from the review, and the structure of the following thesis, are given in section 1.5.

1.2. The contested nature of sustainable development

The influential 1987 WCED report produced the oft quoted definition of sustainable development as: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p.43). The report states and discusses six common challenges we are facing, as: 'Population and human resources', 'Food security: Sustaining the Potential', 'Species and ecosystems: Resources for Development', 'Energy: Choices for Environment and Development', 'Industry: Producing More with Less' and 'The Urban Challenge' (WCED, 1987).

In 1992 the United Nations Conference on Environment and Development (UNCED, also known as the Rio Earth Summit) built on the WCED report with the adoption of Agenda 21, which set out an action plan covering multiple environmental and developmental objectives for the 21st century

(United Nations, 1992). The WCED and UNCED use the term sustainable development as 'a direct attempt to resolve this dichotomy [that of sustainability and development] by sending the message that it is possible to have economic development whilst also protecting the environment' (Carter, 2007, p.208). Between them they defined a wide range of concerns and endeavours for sustainable development, which included moving towards equity between different peoples and generations, the alleviation of poverty, an understanding of limits to growth due to the finite nature of natural resources, a better understanding of, and simultaneously actions towards a reduction of, the effect of human activities on climate change, and developing public participation in decisions about sustainability.

The UNCED also introduced the international Framework Convention on Climate Change, which led to the Kyoto Protocol, an inter-nation agreement to restrict emissions of gases which were likely causes of climate change, which was passed in Japan in December 1997. The following multi-national Conference of the Parties (COP) series of talks between all nation signatories to the Protocol were set up to address and carry forward the 1992 Framework. Meanwhile the reports of the Intergovernmental Panel on Climate Change, particularly those of 2001 and 2007 (IPCC, 2001, 2007), gave increasing evidence that climate change was due to the man-made emissions of greenhouse gases, and that the potential effects could be globally devastating.

Within the European Union the multiple aspects of sustainable development were endorsed, but effectively separated again through the adoption in 2000 of the Lisbon Strategy focusing on social and economic pressures at a European and sub-regional level, and the following EU Sustainable Development Strategy in 2001 which focused on global environmental issues (European Commission, 2001). The UK was the first nation to publish a sustainable development strategy (Department of the Environment, 1994), which was updated in 1999 (DETR, 1999) and in 2005 (Defra, 2005). The UK Strategy identified four priority areas of action; in the 2005 Strategy, climate change was described as the biggest threat.

In 2006 Sir Nicholas Stern was commissioned by the UK Chancellor of the Exchequer to write a review on *The economics of climate change* (Stern, 2006). While Shipworth (2007, p. 479) noted that Stern was concerned with the wider issues of health, education and the environment, and included both intra- and inter-generational equality, the focus of the report was clearly on

mitigating climate change through reducing carbon emissions. Stern accepted that economic growth had driven emissions of greenhouse gases, but he also believed that stabilization of emissions was not inconsistent with continued growth, as long as immediate and strong action was taken globally towards both mitigation and adaptation. Specifically he encouraged market mechanisms, such as the EU carbon emissions trading scheme and regulation through national building regulations and local planning, and he stressed the need for technological innovation (Stern, 2006, p. xvii). Stern was a former Chief Economist at The World Bank, and the commissioning of someone with such a strong reputation and authority were a clear indication that politicians endorsed his views (Shipworth, 2007). The review indeed had a noticeable impact on many of the emerging policies in the EU and UK.

Although Stern did include considerations of the social implications of climate change, the emerging policies which he had encouraged focused on technological solutions and had the potential to detract from the wider aims of sustainable development. In their briefing for the House of Commons Environmental Audit Committee in July 2010, the National Audit Office state:

> 'Climate change is a particularly significant consequence from unsustainable development. However, whilst the links between climate change and sustainable development are strong, interventions that act on climate change do not simultaneously offer a solution to all aspects of sustainable development, as they do not, for example, tackle social injustice, depletion of natural resources or endangered ecosystems. So a commitment to sustainable development implies that climate change policy should be pursued as just one issue within the wider framework of pursuit of sustainable development.' (National Audit Office, July 2010)

Stern was clear that climate change was a global issue, and that global actions were needed. Similar concerns of the world-wide impact of environmental degradation, and the socio-economic inequalities between the rich 'North' and poor 'South' world nations, have led to a progression towards the globalisation of institutions and political agreements on sustainable development (Martello and Jasanoff, 2004, p.3). However Local Agenda 21 (LA21) also recognised the important role of local Government on the implementation of sustainability principles. The two recommendations made by LA21 were:

> 'first, that the local authority will take a leading role in planning and facilitating change; secondly, that sustainable development requires ongoing consultation and partnership with a wide range of actors in the local community' (Carter, 2007, p.311).

'Sustainable development' has therefore become an imperative for governments across the globe, and at regional, national and local levels, and has been arguably a particular focus for the UK. As a 'symbolic commitment' (Baker, 2007) it has also become a normative aim, 'the overarching objective of human development' according to Jordan (2008, p.18). Its very breadth allows 'programs of environment or development; places from local to global; and institutions of government, civil society, business, and industry to each project their interests, hopes, and aspirations onto the banner of sustainable development' (Kates et al,2005, p.9). Sustainability might therefore be considered to bridge across different national and industrial interests, as a uniting cause that gathers everyone together in its support. However many authors from a wide range of fields (see for example Rydin et al (2003), Willams and Millington (2004), Watts and Stenner (2005), Baker (2007), Connelly (2007), Carew and Mitchell (2008), Kagan (2010)) emphasise the complexity, value-laden and context-based nature of the term, and describe the ongoing contests over both the interpretation of sustainability and the focus of actions to address it. Sustainability and sustainable development are therefore 'fuzzy buzzwords: terms that appear to encapsulate a discrete notion but which actually have multiple interpretations.' (Palmer et al, 1997, pg 88). Although appearing to unite different interests, in fact they do no such thing. Hopwood et al (2005) suggest that 'confusion about sustainable development …is further complicated because, as in many political issues, some people may say one thing and mean another.' (p.47).

In practice global actions towards the achievement of sustainable development have been beset by contests over influence and resource allocation. The COP talks have demonstrated the difficulties of consultation on such a scale; the 'sharply opposing negotiating positions' of the many nation states (Carter, 2007, p.251) have led to the talks being fraught with tension, criticism and failure (Haug and Berkhout, 2010). Furthermore the 'unresolved dialectic' (Jasanoff, 2004, p. 49) between global and local approaches has itself threatened the achievement of sustainability. Fogel argues that the "global gaze" of the Kyoto agreement, 'marginalized the leaders, cultures and knowledges of local communities and downplayed the risks they face.' (p.121, Fogel, 2004).

In return the local communities are at risk of becoming disengaged from the real threat that climate change poses to them. As Jasanoff and Martello argue, 'the expectation that politics can be legitimated by appeal to an autonomous, free-standing, 'independent' science [has] proved to be untenable.' (Jasanoff and Martello, 2004, p.338).

Williams and Millington (2004) suggest that at the root of these conflicts is the 'environmental paradox' that is the gap between the demands made on the Earth and its resources, and its ability to supply those resources. This provokes two fundamentally different approaches, often described as 'weak' and 'strong' sustainability. The first of these is a focus on finding ways in which to expand the supply of resources or to increase the efficiency of their use. The second approach, 'strong' sustainability, looks instead to reduce the demand on resources: 'In this view… rather than adapt the Earth to suit ourselves, we adapt ourselves to meet the finitude of nature' (Williams and Millington, 2004, p. 100). While 'strong' sustainability involves social change (Hansson, 2010), Palmer et al describe weak sustainability as concerned only with environmental aspects of sustainable development, and a view in which 'new resources will be found to replace those that are exhausted, new methods of energy generation will remove human dependency on fossil fuels, and cleaner methods of production will resolve problems of pollution. Technological innovation will save the day and the planet.' (Palmer et al, 1997, p.90). Hopwood et al (2005) provide a map which plots multiple views on axes of 'Increasing socio-economic well-being and equality concerns' against 'Increasing environmental concerns' (Hopwood et al, 2005, p.41), and divide the plot into three concentric arcs of 'Status quo', 'Reform and 'Transformation'. At present, they conclude with Kothari (1990) that policy is dominated by the status quo, and that 'policies…. have used the phrases of sustainable development to continue with and justify business as usual.' (Hopwood et al, 2005, p.48).

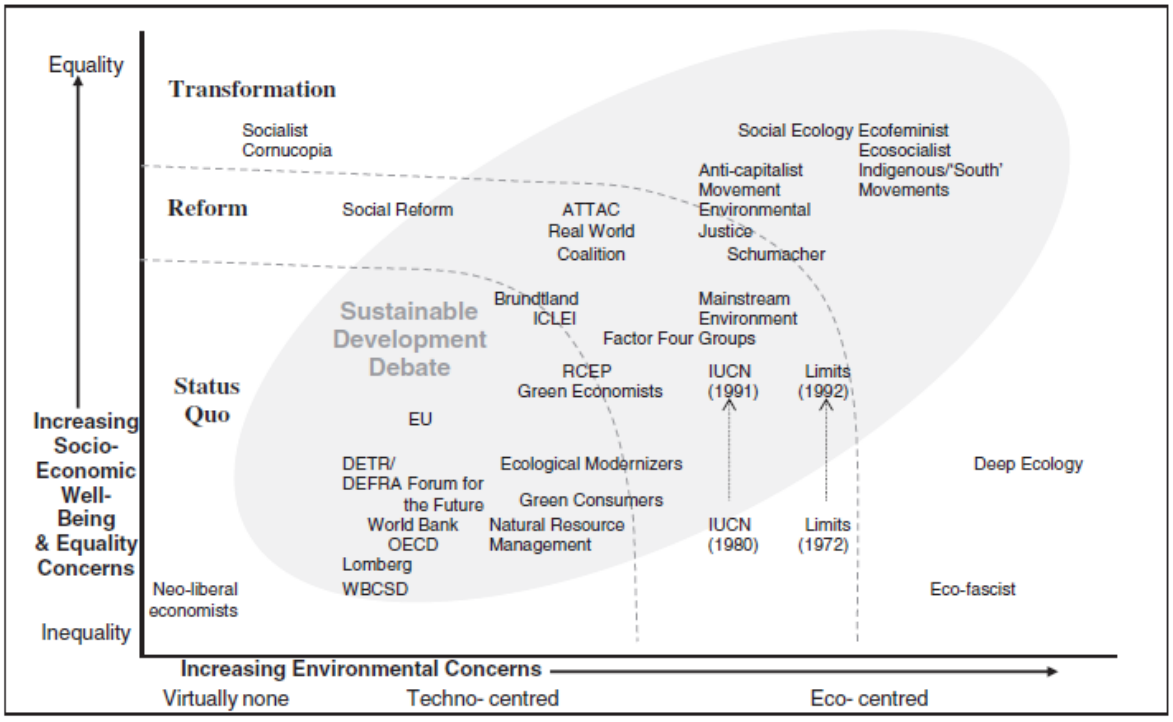

Fig 1.1 Mapping of views on sustainable development

(from Hopwood et al, 2005, p.41)

Within the EU, the effective separation of socio-economic concerns from environmental concerns has caused discord due to the 'inherently conflicting objectives and contending lobbies' (O'Riordan and De Smedt, 2009, p.3). Steurer et al (2010) find that actions for sustainable development, beset by conflict, have become 'fragmented processes driven by a few administrators' (p.82). O'Riordan claims that 'despite the efforts by the United Nations …. and by the group of eight rich nations …. there is no serious and sustained global direction in favour of truly sustainable development.' (O' Riordan, 2007, p. 325). Carter claims that 'progress towards sustainable development is slow, piecemeal and insubstantial' (Carter, 2007, p.356), and Jordan reports a 'very acute feeling…that things have got worse not better' since the 1987 WCED report (Jordan, 2008, p.17).

The concept of sustainable development is therefore inherently complex, with infinite sites of application and a resultant multiplicity of interpretations. What is clear is that sustainability means different things to different people, and that it is therefore frequently a site of conflict. Hopwood et al (2005) argue that 'a deep connection between human life and the environment

and a common linkage of power structures that exploit both people and planet' imply 'the need for fundamental change' (p.49). However such change seems unlikely, unless conflicts can be resolved through the development of an interpretation which engages and includes the views of all stakeholders.

1.3. The changing construction industry

In 1987 *Our Common Future* highlighted the important role of industry in moving towards sustainable development due to its position 'on the leading edge of the interface between people and the environment… [being] perhaps the main instrument of change' (WCED, 1987, p.329). The report advised that:

> 'industries and industrial operations should be encouraged that are more efficient in terms of resource use, that generate less pollution and waste, that are based on the use of renewable rather than non-renewable resources, and that minimize irreversible adverse impacts on human health and the environment.' (WCED, 1987, p.213).

Construction was seen as a particularly key industry, but had long been perceived to suffer from a range of problems. Saint sees these as innate, describing the industry as '…hard to classify, even harder to reform…how to make construction efficient, let alone civilized, has taxed brains from [Adam] Smith's day to the present.' (Saint, 2007, p.492). The difficulties of encouraging an industry 'which stresses conservative, traditional solutions and emphasises reliability' (Manseau and Seaden, 2001, p.5) to change itself, let alone be an instrument for change in others, are well-rehearsed. Senaratne and Sexton (2009, p.198) note that one problem is that 'knowledge flows are very much centred on tacit knowledge and experience of project personnel' and that such knowledge, internalised from accumulated experience by individuals and groups, is particularly difficult to transfer to others (see also Nonaka and Takeuchi, 2004, Teerajetgul and Charoenngam, 2007, Dulaimi, 2007, Arif et al, 2008). Tombesi (2008) suggests that the inherently fragmented structure of the construction industry, acting across dispersed sites and through temporary organisations, fundamentally limits its ability to change. A survey and series of workshops conducted by the International Council for Research and Innovation in Building and Construction (CIB) in their 2001 study on *Re-engineering Construction*(Courtney and Winch, 2002) revealed many issues common to the construction industries across all 22 countries who took part; these

included: 'a concentration on initial costs [rather than whole life costing], fragmentation of responsibilities, poor design management, lack of long-term relationships, a culture of conflict, poor construction quality, failure to meet time and cost targets, inadequate briefing, low profitability, poor working conditions and safety, poor image of construction, and a low use of technology and information technology' (reported by Barrett, 2010, p.269).

Successive UK Governments attempted to address these problems at the end of the Twentieth Century through two reports on the construction industry, Sir Michael Latham's *Constructing the Team* (Department for the Environment, 1994) and then Sir John Egan's *Rethinking Construction* (Egan, 1998). Egan's report focused on five 'drivers of change' (p.13-14):

- 'committed leadership' to raise quality and efficiency,
- 'a focus on the customer', considering 'what the end-user actually wants'
- 'integrated processes and teams', including the importance of integrating the planning, design and construction processes, as well as long-term partnering between clients and construction teams, and with supply chains,
- 'a quality driven agenda' focusing on reducing waste and defects, and
- 'commitment to people', including better training, working conditions, and respect.

The report also advised construction to learn from manufacturing, 'to approach change by first sorting out the culture, then defining and improving processes and finally applying technology as a tool to support these cultural and process improvements' (Egan, 1998, p.28)

Much has been written about the impact of these reports on the individual roles and culture of the industry. Newcombe discusses the increased role of the client and wider stakeholders (Newcombe, 2003), and Kershaw and Hutchison in a publication from the Institution of Civil Engineers (ICE) state that 'The role and performance of clients is the single most important factor in determining the success of construction projects and capital works programmes' (Kershaw and Hutchison, 2009, p. VIII). New partnering contracts between clients and construction teams, and between main and sub-contractors and suppliers, have been shown to have improved efficiency (Olayinka and Smyth, 2007, Glass and Simmonds, 2007, Preuss, 2009). Pryke (2004, 2005) noted a

positive impact on relationships of integrating the design and construction processes, a view supported by Nick Raynsford, Minister for Construction at the time:

> 'Following the recommendations in the Latham and Egan reports, it is encouraging to have seen many clients, consultants, contractors, subcontractors and specialists changing from the traditional adversarial relationships and discovering the benefits to be gained from a fully integrated way of working.' (Raynsford, 2006, p.vii)

The Private Finance Initiative (PFI), first introduced in 1992 and continuing to be a key instrument for public procurement (Cuesta et al, 1999, Aritua et al, 2008, Leiringer and Schweber, 2010) has also 'affected the culture, personnel and institutional structures within which it operated' (Greenaway et al, 2004, p.507).

These changes have not been universally welcomed. Egan's industry critics said that his background in car manufacturing, with its very different economies of scale and focus on mass production, was evident in his report, in his misguided desire to make processes more mechanized, more repetitive and where possible factory-based rather than constructed in situ (Winch, 2003, Gracia 2008). Fernie et al. (2006) emphasise the need to understand the specific character of the construction industry before imposing changes adopted from other sectors. Leiringer and Schweber (2010) point out the essential variation in practice in construction, and suggest that it is necessary to 'abandon a simplistic model of centralized homogeneous firms, working in a single institutional environment, and to capture the dynamics of decentralized large firms working in multiple markets on a variety of projects' (Leiringer and Schweber, 2010 p. 141). The then President of the Royal Institute of British Architects, Sunand Prasad, is reported in Building magazine deriding '…design and build, in which the architect is treated as some sort of sub-contractor. History has shown that a direct relationship between the client [and the architect] works best and I'm afraid one of the side-effects of Egan has been to damage this relationship' (Building, 18 May 2008). Professor Alan Short, Professor of Architecture at Cambridge University, also dismissed the 'low aspirations and poor quality work of contemporary UK Design and Build contractors' (Short, 2008, p. 196). The architecture profession in particular, it would seem, finds the changing environment unappealing.

There is clear evidence that in at least one cultural aspect construction has not changed. The Construction Industry Council (CIC) published a report on diversity in May 2009 showing the disproportionately low levels of employment of women, ethnic minorities and the disabled in the construction professions compared with the general professional workforce (CIC, 2009). Engineering UK, the over-arching body regulating the engineering professions in the UK, also recently released figures showing that at 9% the UK has the lowest number of female engineers in Europe (Engineering UK, 2010), with the same percentage in civil engineering (ICE, 2009). A key reason for the continued gender imbalance is seen to be the hierarchical culture connected directly to the 'tendency for dominant engineering discourses to value technological solutions over all others' and combined with a framing of technical-rational subjects as essentially masculine (Franzway et al, 2009, p. 102).

In 2002 Egan was commissioned to write a second report. This was titled *Accelerating Change*, and included an update on progress since *Rethinking Construction*. It also added 'sustainability' as a cross-cutting issue (p.35), relating it to multiple aspects of projects and industry including whole life performance, corporate social responsibility and the 'triple bottom line of sustainable development by maximizing economic and social value and minimizing environmental impacts' (Egan 2002, p.35). It repeated the importance of 'integrated teams' and added the need for 'sustainable products', including considerations of end of life impacts and potential for recycling and reuse. A case study of the Beddington Zero Energy development was offered as an example in which not just utility bills were reduced, but also car use, and for which 'low embodied energy products' were specified.

Sustainability in construction was increasingly on the agenda. Also in 2002, in his report to the Department for Transport, Local Government and the Regions (DTLR) on *Rethinking Construction Innovation and Research*, Sir John Fairclough concluded that, 'Construction …needs to be seen as central to a better quality of life for everyone, and concerned with a sustainable future.' In 2003 environmental economist David Pearce was commissioned to write a report on the specific role of construction in relation to sustainable development. *The Social and Economic Value of Construction: The Construction Industry's Contribution to Sustainable Development* (Pearce, 2003) became highly influential, and included recommendations both to industry and to Government. The report defines sustainable development as 'the over-arching goal of government policy in the

United Kingdom' (p.1). It considers the construction sector in respect to 'Man-made capital', 'Human capital', 'The natural and social environment' and 'Technology' (p. xi-xiii). In the last of these Pearce stated that 'the construction industry faces massive challenges in the next few decades. Failure to meet those challenges by embracing new technologies – new materials, IT, off-site manufacture etc.- will be at a considerable cost to the UK economy' (Pearce, 2003, xiii). Egan too had considered off-site manufacture, and the use of IT in the form of computer aided design (CAD), as important components of a more efficient industry. Shipworth in his paper on the implications for the construction sector of the *Stern Review on the Economics of Climate Change* (Stern, 2006) concluded that 'more and faster' innovation was needed in order to combat climate change, and that 'the built environment will be an increasingly likely target to deliver improved performance' (Shipworth, 2007, p.483).

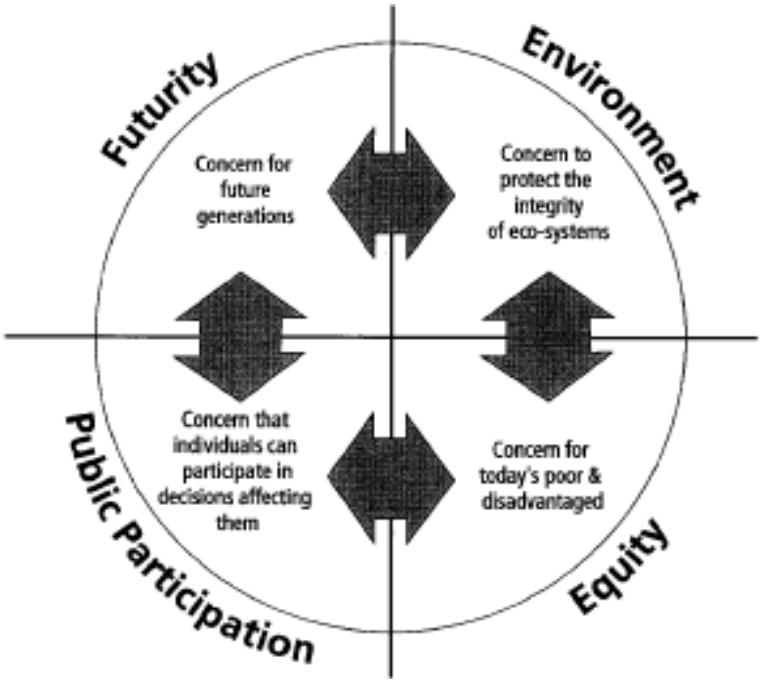

Fig 1.2 The principles underlying sustainable development (adapted from Cooper, 1995) (from Palmer et al, 1997, p.88)

Other evidence of how an interpretation of sustainability has developed within the construction industry during this period can be found from the research literature. Mitchell et al (1995), Cooper (1995), and Palmer et al (1997) developed a framework based on the UNCED summit in 1992 which identified four quadrants of sustainable development as 'equity', 'futurity',

'environment' and 'public participation'. The model allowed mapping for particular contexts and perspectives to include each quadrant to a different extent, and was used by a number of built environment research programmes (Brandon et al, 1997).

Ten years after Mitchell et al developed their four quadrant framework, the UK academic journal Building Research and Information published a special issue on *The future of sustainable construction*. The editorial for the issue states unequivocally that 'the dominant measuring stick for all aspects of sustainable construction will be energy'. While noting that 'there will still be a wide variety of issues, e.g. biodiversity and health, that do not readily lend themselves to an energy metric' (Kibert, 2007, p. 599), the editorial and most of the papers in the special issue were focused clearly on providing solely technical solutions. Sustainability, re-defined as reduced energy use, was to be assessed by technical tools (Zimmerman and Kibert, 2007), and by technical design-teams considering energy (and material) resource impacts (Schultman and Sunge, 2007). Some evidence of Mitchell et al's 'Public participation' quadrant does appear, in the papers by Reed (2007), who advocates stakeholder engagement and local 'place-based' decisions, by Kibert (2007, p.600) who calls for 'integrated design that includes all stakeholders in the process', and by Leaman and Bordass (2007), who focus on the response of users to 'green buildings'. However, considerations of 'Futurity' are only implied, in the environmental concerns related to climate change, and 'Equity' is limited to the indoor environment and 'healthy' buildings, and the unspecific but wider social implications of climate change. The focus of 'sustainable construction' for this journal issue and, it might be inferred, for the built environment sector in 2007, is that of the imperative for reducing energy use in the operation of buildings. A suggestion that this technological future may also depend on social relationships is, however, proposed by the guest editor of the journal, who notes that superior outcomes will be produced through the inclusion of stakeholders in an integrated design process, and who further warns of the current 'tendency for these professions to function in 'silos', each optimizing the outcome for their own benefit' (Kibert, p. 600).

Papers which have since emerged out of the major Engineering and Physical Sciences Research Council (EPSRC) programme *Towards Sustainable Urban Environments* however suggest a more complex interpretation of sustainability. The EPSRC made concerted efforts in this programme to consider the wider aspects of sustainability through the formation of multi-disciplinary teams

including social scientists, and through the encouragement of meaningful participation in the research by the end-users. Although the predominant mode of dissemination was still peer-reviewed technical journal papers and academic conferences (Moncaster et al, 2010), the inclusion of wider participation had led to multiple interpretations of sustainability. However, rather than these having the effect of unifying teams, Catney and Learner saw them as having 'created the greatest differences' (2009). In spite of the claim of the chairman of the Commission on Architecture and the Built Environment (CABE) School Design Review Panel that 'we are pretty well on top of a lot of sustainability issues in terms of building' (Westminster Education Forum, 2008), the meaning and delivery of sustainability for the built environment appears, from this evidence at least, still to be unresolved.

The increased application of technology for sustainability in construction, encouraged by Pearce (2003), is further evident in the burgeoning use of assessment tools; the UK Building Regulations (DCLG, 2006) require the use of the Standard Assessment Procedure (SAP) for domestic buildings and Simplified Building Assessment Method (SBEM) for non-domestic buildings, both methods to demonstrate that design energy use is in compliance with the EU Energy Performance of Buildings Directive (EPBD). The use of the Building Research Establishment Environmental Assessment Method (BREEAM) became a planning requirement for all public school building projects over a certain size from 2005 (DfES, 2005). There has also been an explosion in the development of voluntary sustainability design and assessment tools; the EPSRC funded SUBRIM project reported over 600 such tools, although 'virtually none … have seen practical application or evaluation' (SUBR:IM, 2007); the EPSRC SUE-MoT project assessed 78 of the tools (SUE MoT, 2004). Meanwhile the use of CAD, as recommended by Egan (1998), has proliferated (Coley and Schukat, 2002). In 2010 the Government's Innovation and Growth Team final report recommended the development of CAD into a higher functioning integrated modeling tool Building Information Modeling (BIM), as a direct response to achieving sustainability in construction (HM Government, p.15). There has been a similar increase in the complexity of technologies applied inside buildings, including the development of complex and integrated mechanical heating and ventilation systems, of electronic Building Management control Systems (BMS) (Doukas et al, 2007, Mata et al, 2009), and of micro-renewable energy technologies (Polatidis and Haralambopoulos , 2007, Bergman et al, 2009).

Politically-encouraged structural changes have therefore combined with technical innovation (Winch, 2003, Adamson and Pollington, 2006, Barratt, 2007), and a picture can be painted of radical progress in the UK construction industry, moving rapidly into a modern, efficient and technologically advanced era – 'a period of momentous change' as Macmillan has said (2006 p.603). However, while changes are clearly occurring, in particular in response to the focus on sustainability, it is not clear that these are resulting in more equal distribution of power, or in considerations of futurity, or in meaningful public participation, or indeed in more sustainable building. The industry has changed, but the change appears to have been piecemeal. Its response to sustainability appears to have narrowed to a technical focus on operational energy, to be achieved through technical solutions and measurements – the stance of 'weak sustainability' as outlined by Palmer et al in 1997.

1.4. School buildings

In the UK, the Government's attempts to incorporate notions of sustainability into the fabric of public life were particularly conspicuous within the school building programmes. The Academies Programme launched in 2000, and the Building Schools for the Future programme (BSF) in 2003, were originally a commitment which emerged from the 'number one priority' of education in the UK Labour election manifestos (Labour Party, 1997, 2001). Over £60 billion of private and public money was earmarked for the two programmes. They were focused, at least initially, on areas of social and educational deprivation, and envisaged as programmes for improving social and economic equity between and within different regions of England. The building programmes aimed through the provision of school buildings to 'engage and inspire young people, their teachers and the wider community' (DCSF, 2008). The programmes also meshed with the aims of the Green Paper 'Every Child Matters' in 2003 (DCSF 2003), a plan to put children at the centre of care policies by focusing on five key rights: be healthy, stay safe, enjoy and achieve, make a positive contribution, and achieve economic wellbeing.

In 2004 Tony Blair gave a key presentation to business leaders at the 10th anniversary of Prince Charles' Business and the Environment Programme. In his speech Blair stated a new aspiration for 'sustainable schools':

> 'There is a huge school building programme underway. All new schools and City Academies should be models for sustainable development: showing every child in the classroom and the playground how smart building and energy use can help tackle global warming.
>
> The government is now developing a school specific method of environmental assessment that will apply to all new school buildings. Sustainable development will not just be a subject in the classroom: it will be in its bricks and mortar and the way the school uses and even generates its own power.
>
> Our students won't just be told about sustainable development, they will see and work within it: a living, learning, place in which to explore what a sustainable lifestyle means.
>
> (Blair: full text of speech reported in The Guardian online, 15 September 2004)

Throughout the speech the concept of 'sustainable development' is linked directly to 'global warming', and the route to achieve this is mapped out in technical solutions for 'smart building', building fabric, energy use and energy generation. Blair's definition therefore appears to be focused clearly on technical design solutions aimed at the mitigation of climate change, as assessed through a 'school specific method'; this was to be the Building Research Establishment Environmental Assessment Method adapted for school buildings (BREEAM Schools, 2005). The combining of sustainable development with technologies, and the parallel potential for socio-economic gains, are reflected further in the conclusions to the speech:

> '3. Recent experience teaches us that it is possible to combine reducing emissions with economic growth.
>
> 4. Further investment in science and technology and in the businesses associated with it (sic) has the potential to transform the possibilities of such a healthy combination of sustainability and development.'

The schools programmes therefore appear to have merged with the developing political focus on one specific aspect of sustainability, that of the mitigation of climate change, and its translation into a concern with energy in use. Three years after Blair's speech, the House of Commons

Education and Skills Committee report on *Sustainable Schools: Are we building schools for the future?* noted that:

> 'The issue of sustainability was not addressed when BSF was launched, yet now it is a central part of the project. We welcome this change, but it is not yet clear how the aspirations on sustainability will become reality.' (House of Commons Education and Skills Committee, July 2007)

Previous school building programmes have similarly responded to political and social influences, as shown by Maclure (1984), Saint (1987), Lowe (1997) and Dudek (2000), while at the same time reflecting regional and individual influences. In the 19th Century therefore the high windows of the London Board schools were designed to shield children from the harmful influence of their external social environment, while in Birmingham high chimneys were introduced for the purpose of natural ventilation (Seaborne and Lowe, 1977). After the turn of the century reports of the poor health of the soldiers returning from the Boer War led to a general concern with health (Heggie, 2001, 2011), and in Staffordshire the county medical officer George Reid was instrumental in the design of single-storey, cross-ventilated schools with distinct physical divisions between classes, based on the prevention of disease spread in hospitals (Seaborne and Lowe, 1977). Later, Henry Morris, the education officer for Cambridgeshire County Council in the 1930s, developed the concept of the Village Colleges, whose innovative design included libraries and community rooms, as an integral part of, and a strong catalyst for, the development of a whole way of community life (Jeffs, 1998). It is clear that a number of social and political concerns were combined with the impact of individuals in the design of school buildings.

After the Second World War, central government started to play a more formal role in school design, with the publication of the first Building Bulletin by the Ministry of Education; the bulletins are still an important document for the guidance of school design today. The introduction to the first bulletin, BB1, reads: 'A very large school building programme is under way. We need schools and we need them quickly, but they must be good ones: This is the challenge which faces architects and educators to-day.' (Ministry of Education, 1949, pg 2). The introduction closely reflected the communal spirit of post-war British society, with a call for 'the closest collaboration between all concerned' (Ministry of Education, 1949, pg 44). While BB1 describes its central aim

as to increase efficiency of material use and lower costs in the impoverished country, it also 'outlines recent trends in primary education and tries to describe their architectural implications' (Ministry of Education, 1949, p.1). Cooper suggests therefore that the publications also had a hidden (although on the whole, he says, failed) political intent to develop a new style of education; through their design interpretation of the 'recent trends' in education the Building Bulletins could be seen as 'at least in part, a bid to influence – if not actually determine – how teachers and children behave' (Cooper, 1981, pg 133).

Therefore school buildings have not just reflected socio-political change; they have themselves been a deliberate instrument of that change, if an imperfect one. Blair's speech introducing sustainable development to the schools programme in 2004 could be seen as a similar attempt to influence society through the design of school buildings, by educating children within these 'models for sustainable development' and thus installing within them a notion of 'a sustainable lifestyle', albeit one defined by the Government.

1.5. Summary, structure and approach

Sustainable development is a concept born out of a desire to reconcile on the one hand the economic and social drivers for development, and on the other the environmental implications of that development. The term suggests that the two can be achieved simultaneously. However sustainability in practice is fraught with tension and conflict; it is frequently therefore proposed that the concept should be re-defined for each new context and at a local level, and should include the perspectives of the multiple stakeholders.

Meanwhile, political, social and technical influences are changing the structures within which the construction industry operates, and the relationships between the different disciplines and with clients and stakeholders. At a project level the changes claim to encourage teamworking rather than confrontation, and to lead to greater public and stakeholder participation in decision-making. However other analyses suggest that the industry continues to be hierarchical in nature and has changed little at a cultural level, remaining focused on technological solutions. The political interpretation of sustainable construction has also led to an increasingly technical focus chiefly on the reduction of operational energy, suggesting that concerns with the socio-economic aspects of sustainability may be sidelined.

These political influences on the interpretation of sustainability for construction are particularly intentional and clearly expressed in the construction of school buildings. Key Government programmes for educational reform have combined with the developing focus on sustainable construction to merge into a construction programme for 'sustainable schools' (Blair, 2004). Blair's speech to the business community appears to hand responsibility for delivery to the construction industry, while the interpretation of sustainability for this context seemed to have been already set by central Government as a technological response to climate change.

The question stated in section 1.1 was:

'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?'

Martello and Jasanoff suggest that:

> 'How we understand and represent environmental problems is inescapably linked to the ways in which we choose to ameliorate or solve them (Jasanoff, 2004). And which issues are defined as meriting the world's attention has everything to do with who has power and resources, including scientific ones, to press for them.' (Martello and Jasanoff, 2004, p.5)

The interpretation, they are saying, is 'inescapably linked' to the translation into practice. This suggests something more than a uni-directional cause and effect, *from* understanding and representation *to* amelioration or solution. Instead it seems that the relationship might act in the opposite sense too, that the solutions might also affect the understanding. Furthermore, they suggest, it will depend on who has the power and resources, and it is to be assumed the interest, to push for that particular interpretation or solution. This suggests a complex inter-relationship between the diverse groups who have interest and power in interpreting sustainability for construction, and between these groups and the material translations.

The first research question is asking for a description of what is happening, but the issues raised in this chapter suggest that an explanation of why it is happening is equally important. As DeVaus says, description provokes explanation (DeVaus, 2001, p.1). The question is therefore extended by a second:

'How have political, social, professional and technical decisions and concerns led to these particular interpretations and translations of sustainability for construction?'

This thesis suggests that the answers to these two questions lies in understanding the interests of the different actors involved and the resources and power at their disposal, the systems within which they operate and the freedom and restrictions afforded them by these systems, and the actions and interactions between these systems and actors and the resultant technological and material solutions.

The next chapter sets up a framework through which to understand and interpret both relationships between different social actors and relationships between actors and technologies. It first discusses the theories of social power and the analysis of its different forms, focusing in particular on the theories presented by Lukes (2005), Scott (2001) and Foucault (1979, 1988). It then looks at particular applications or sites in which power is exercised, including the formation of policy, the power effects of expertise, the use of numbers, and the implications of power in the relationships between social actors and the technical tools and artefacts they design and use. These particular aspects were chosen in an iterative process before, during and after development of the case studies.

Specific details of the case study research design, method and data collection and interpretation, follow in chapter 3.

An over-arching policy-level study considers the political priorities for sustainable construction in Chapter 4 and how these have developed. The UK strategies and policies for sustainable construction are reviewed, considering the processes that have formed them and how they have been expressly translated for schools. This leads to an examination of the role that the construction sector plays in the formation of those policies and priorities, through a study of the lobbies and policy networks involved.

The following chapters 5 and 6 develop four case studies of secondary state school building projects embedded within this political context, to consider the role that construction professionals, clients and stakeholders play in the translation of these priorities into practice at the project level. In particular the effects of procurement structures, tools and technologies are

considered in the cases presented in chapter 5, and the role of professional expertise in the formation of technical solutions in chapter 6.

Chapter 7 reviews three particular technical translations of sustainability which have resulted from the policies and practices revealed in the previous three chapters; these are energy efficiency measures, renewable energy technologies, and embodied carbon. The chapter assesses both the claims and the most likely impacts of each, considering also what effect they have had on the emerging definition of sustainable construction. The conclusions, limitations of the study and recommendations for further research and for practice are presented in the final chapter.

This examination of the policies, professions, power and technologies involved in interpreting and translating sustainability suggest an interdisciplinary perspective. The Sustainable Development Research Network (SDRN) indeed specifically advises us to address 'the challenges of sustainable development at the engineering and physical sciences interface with the social sciences' (Eames 2006, p.23). However, such an approach has been shown to be complex and problematic (see for example Brandon et al, 1997, Petts et al, 2006, Barry et al, 2008, Lowe and Phillipson, 2009), and its attempt by an individual researcher further suffers from the problems of mastering knowledge from two or more disciplines, and having to resolve conflicts between research paradigms and methods (Golde and Gallagher, 1999, p. 284). Even so it is considered extremely valuable (Evans and Marvin, 2006, Owens et al, 2006). This research is therefore conducted across the boundaries between the disciplines of the built environment and the social sciences, and between academic research and practical decision-making on live projects, drawing insights from each.

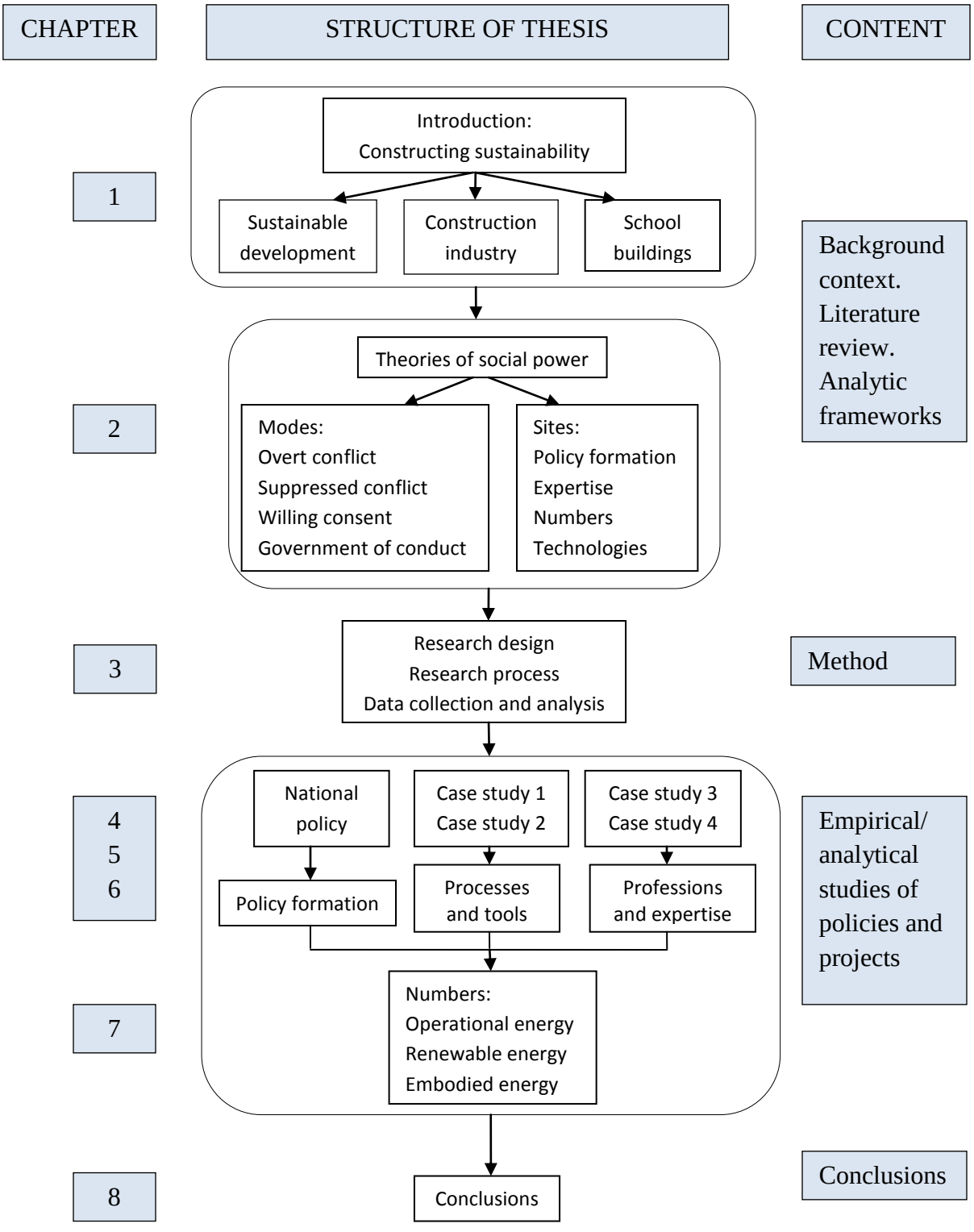

Fig 1.3 Structure of thesis

Chapter 2: Relationships of power

'This is the real significance of Wordsworth's phrase, "Shades of the prison house begin to close upon the growing child." His wishes and activities begin to be inhibited, and gradually, by definitions within the family, by playmates, in the school, in the Sunday school, in the community, through reading, by formal instruction, by informal signs of approval and disapproval, the growing member learns the code of his society.'

WI Thomas, 'The Unadjusted Girl', 1923

2.1 Introduction

Chapter 1 has suggested that sustainable construction is a complex and value-laden concept. It depends therefore on context, not only at a broad, national or political level, but also at a local and individual level. It is about policies, but also about their interpretations; and it is about technologies and how they are developed and used. It is also therefore about actors and their relationships, with each other, and with the policies and technologies at their disposal.

The questions posed at the end of the chapter were:

'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?', and
'How have political, social, professional and technical decisions and concerns led to this particular interpretation and translation?'
Chapter 2 develops an analytical framework through which to interpret what is happening, in order to answer these questions. Martello and Jasanoff suggest that 'which issues are defined as meriting the world's attention has everything to do with who has power and resources, including scientific ones, to press for them.' (Martello and Jasanoff, 2004, p.5) Taking this as a cue section 2.2 discusses theories of social power, focusing in particular on the work of Stephen Lukes (2005), John Scott (2001) and Michel Foucault (1977, 2011). Section 2.3 then considers the application of the theories within policy formation, in professional disciplines and the creation of expertise, in the use of numbers, and, incorporating concepts from science and technology studies, in the relationships between social actors and the technical artefacts they design and use. The final section summarises the key points which will be used in the analysis of the case studies.

2.2 Theories of power

2.2.1 Introduction

'In its most general sense, power is the production of causal effects…Social power is a form of causation that has its effects in and through social relations.' (Scott, 2001, p.1)

Scott's starting definition for power is deceptively simple. As with sustainability, however, theories and analyses of power are far more diverse and complex than this suggests; Lukes described it as an 'essentially contested concept' after Gallie, who says such concepts 'inevitably involve endless disputes about their proper uses on the part of their users' (quoted in Lukes, 1974, p. 26). Therefore power is a concept which is 'ineradicably value-dependent' (Lukes, 2005, p. 26).

Diverse theories of social power have been developed throughout the Twentieth Century, and are founded further back still; Foucault (1977), Clegg (1989) and Hindess (1996) for example include analyses of Machiavelli's political treatise *The Prince* (around 1532), and Hobbes' social contract in *Leviathan* (1651), as well as the influential analysis of capitalist power by Karl Marx (for example, 1867). Many writers have tried to unify these theories of power, chiefly through the clarification of disunities and divisions. The main clarifications and divisions are briefly reviewed in this section.

Dowding (1996) describes the chief theoretical division as a distinction between 'power to' and 'power over'. He defines the first as 'outcome power=the ability of an actor to bring about or help to bring about outcomes' and the second as 'social power = the ability of an actor deliberately to change the incentive structure of another actor or actors to bring about or help to bring about outcomes.' (Dowding, 1996, p5). Lukes acknowledges this debate, but chooses to focus on 'power over' and to exclude from his own concept aspects of 'power to'. He therefore dismisses, for example, Hannah Arendt's construction of power as an idealised democracy, in which 'When we say of somebody that he is 'in power' we actually refer to his being empowered by a certain number of people to act in their name.' (Arendt , 1970, p. 44, quoted in Lukes, 2005, p.32). He further extends this objection to Talcott Parsons' view of power as 'generalized capacity to secure the performance of binding obligations by units in a system of collective organization' (Parsons, 1967 p. 308, quoted in Lukes 2005 p.31). Lukes considers these benign views as indicating a 'capacity', rather than a conflictual relationship, which is the essence of his own definition of power, and therefore suggests that they do not belong to the same debate (Lukes, 2005). Instead Lukes divides theories of power into three

dimensions, implying that each assimilates the former and extends it. This analysis of the different theories and forms of power in particular is discussed in the following two sections.

Clegg (1989), rather than distinguishing between types of power, instead makes a distinction between the two main groups of writers, one which considers power as demonstrated through its effect with little consideration of intention, and the second which considers it through its intention. The second category, he says, is particularly exemplified in Weber's 'will to power' – 'the probability that an actor within a social relationship will be in a position to carry out his own will despite resistance, regardless of the basis on which this probability rests' (Weber, 1947, p. 152, quoted in Clegg, 1989, p. 73). However Clegg starts to demonstrate the limitations of these two views in his consideration of Wrong's work, as both categories assume 'the exclusion of pre-existing structures of meaning' (Clegg,1989, p. 75). For Clegg therefore the link 'between agency and structure… is central to conceptualization of power' (p. 75). Giddens also makes the essential distinction in the 'two-fold nature' of power, the first being the capacity of individual agents 'to make a difference' and the second being a structural property of society (Giddens, 1984, p14).

Scott also distinguishes between two groups, which he calls the mainstream and the second stream. In the first view, power is both intentional and exercised. The second stream, for Scott, is typified by its different concerns rather than its different definitions; while the mainstream is concerned with 'specific organisations of power', the second is instead about 'strategies and techniques of power… the collective property of whole systems of co-operating actors, of the fields of social relations within which particular actors are located' (Scott, 2001, p.9). Therefore it is that in which 'the power of a principal can be manifest in the ability to make a subaltern believe that their interest lies in doing something that is, in fact, harmful to them or contrary to their deeper interests' (Scott, 2001, p.8). Within this second stream Scott includes Lukes' third dimension of power, as well as Gramsci's concept of hegemony (Gramsci, 1957), and also Foucault's analysis of the disciplining effects of social structures.

Scott also sets up a 'map of power relations' (p.16) which defines the two principle elementary forms of social power as 'corrective influence', and 'persuasive influence', each of which is further subdivided and also related to more 'developed' forms of power. Important for the following analysis is his idea, shared by many other theorists, that each form 'depends on the use of resources, [although] the type of resource and the ways in which they are used differ.' (Scott, 2001, p.12).

This introduction has suggested then that power is a function of social relations which produces effects. Power can be seen as a capacity to change outcomes in the interests of one social agent and against the interest of another ('power over'). An alternative form of power may produce a positive outcome through collective organisation ('power to'). Demonstration of power can be identified through its effect or through its intention, or both. A separate form of power may be exercised through strategies and results from structures and systems of society. Scott saw all forms of power as using resources.

The following sections discuss these ideas in more detail concentrating first (section 2.2.2) on the theories included by Lukes' in his first and second dimensions, which also accord with the 'mainstream' theories proposed by Scott. Secondly in section 2.2.3 on the 'third dimension' view which was added by Lukes, and other related theories and applications of this form of power; and thirdly (2.2.4) on a discussion of Foucualt's theories of power. The latter two sections are therefore both examples of Scott's second stream theories.

2.2.2 The first and second dimensions of power

Scott ascribes the mainstream view of power to Weber's 'rule of man over man', of which a particular example, says Scott, is 'the sovereign power of a state' or of other organisations (Scott, 2001, p.6). Within this view are included both the first and second dimensions of power identified by Lukes. The first dimension Lukes assigns to the 'pluralists', who include in particular Robert Dahl (1957, 1958, 1961) and Nelson Polsby (1963, 1968). Dahl expresses power as 'A has power over B to the extent that he can get B to do something that B would not otherwise do' (Dahl, 1957, quoted in Lukes 1974 p.11-12). Pluralists observe empirical actions and behaviour, assessing power by its impact. Inherent in their analysis is an assumption that 'issues' involve conflict and are controversial, contested, and that the exercise of power is demonstrated by actual outcomes. Polsby describes the powerful as those who 'initiate, modify or in some visible manner act so as to change outcomes'. Dahl and Polsby are therefore 'behaviourists' – what is important to them is the behaviour, the action and the outcome, not the intent. For Lukes, the important limitation of the pluralists' theory of power is that they don't accept 'that interests might actually be unarticulated or unobservable', or 'that people might actually be mistaken about, or unaware of, their own interests' (Lukes 1974 p. 14). However the pluralists' theories are still a useful tool in particular in understanding the impact of pressure groups on policy formation, as discussed further in section 2.3.2.

Lukes' 'second dimension' of power is drawn from the particular criticism of the pluralists by Bachrach and Baratz (1970), who pointed out that power is also exercised through practices

which rule *in* some issues and rule *out* others – they call this the 'mobilisation of bias', after Schattschneider (1960) . Power is therefore not just exercised in free decision-making. It is also found in the constraints upon what issues are open for discussion – the making of 'non-decisions'. This form of power is exercised through a process in which 'an A devotes his energies to creating or reinforcing social and political values and institutional practices that limit the scope of the political process to public consideration of only those issues which are comparatively innocuous to A' (Bachrach and Baratz 1962, p. 948). Non-decision making is therefore a 'means by which demands for change in the existing allocation of benefits and privileges in the community can be suffocated before they are even voiced' (Bachrach and Baratz, 1970, p. 44, quoted in Lukes, 1974, p. 19). Bachrach and Baratz called this the 'second face' of power.

For Dahl and the pluralists therefore, power is about *actual* political issues. For Bachrach and Baratz it also includes *potential* political issues. However, says Lukes, both views still assume that there must be *conflict*, either overt or covert ('outside the system'), and both assume that the decisions and the non-decisions are 'observable' and therefore empirically verifiable.

2.2.3 The third dimension: Lukes and others

Lukes then adds a third dimension in order to explain what he terms 'willing consent' to domination: 'the domination of defenders of the status quo may be so secure and pervasive that they are unaware of any potential challenges to their position and thus of any alternatives to the existing political process, whose bias they work to maintain.' (Lukes, 1974, p. 21). Lukes claims three points of departure from the forms of power discussed previously. First, power can be collective rather than individual, both stemming from collective action or policy, and from the 'form' of the collective organisation. Second, power does not necessarily stem from conflict: 'A may exercise power over B by getting him to do what he does not want to do, but he also exercises power over him by influencing, shaping or determining his very wants.' (p. 23). Indeed Lukes finds evidence of this happening in Dahl's book *Who Governs?* (Dahl, 1961) in 'the sense [of the dominant group], shared not only by themselves but by the populace, that their claim to govern was legitimate' (p. 17, quoted Lukes p. 23). Dahl also says that leaders 'do not merely respond to the preferences of constituents; leaders also shape preferences' (p. 164, quoted in Lukes p. 23).

The third point of departure then is in the assumption implicit in the first two that, where no grievance is consciously *realised,* then there is genuine consensus. But, says Lukes, 'is it not the supreme and most insidious exercise of power to prevent people, to whatever degree,

from having grievances by shaping their perceptions, cognitions and preferences in such a way that they accept their role in the existing order of things, either because they see it as natural and unchangeable, or because they value it as divinely ordained and beneficial?' (p. 24). The most effective use of power is in preventing conflict in the first place, and this is the essence of Lukes' third dimension of power.

Lukes' third dimension is therefore concerned with the underlying ordering effects of power on society – in other words, aspects of social structure, or 'norms' of social relationships which have inherent and accepted imbalances of power. Gramsci is another key figure in this theory of power, relating it in particular to the concept of hegemony – 'a mechanism of power through which a dominant class can secure the consent of subaltern classes without the need for any direct use of coercion or repression' (Scott, p.9). He suggests the formation of schools, churches, factories and other 'agencies of socialisation' allow a stable position for a dominant class. In *The Modern Prince* he writes that 'the whole liberal ideology, with its strengths and weaknesses, can be summed up in the principle of the division of powers, and the source of liberalism's weakness becomes apparent: it is the bureaucracy, i. e. the crystallisation of the leading personnel, which exercise coercive power and which at a certain point become a caste.' (Gramsci, 1957, p.186).

A further question is introduced by Lukes: is 'rational persuasion' then a form of power? Lukes answers both yes and no; yes, because A causes B to do or think something he otherwise wouldn't, but no, because 'B autonomously accepts A's reasons, so that one is inclined to say that it is not A but A's reasons…' (Lukes 2005 p. 33). Both answers presuppose that the rationality on which A's persuasion is based is *truly* rational, and that therefore it is as much in B's interests as in A's; in other words, Lukes accepts that 'rationality' itself is impartial and true.

Lukes also addresses a question implied by his critics, who ask whether power 'can be exercised by A over B in B's real interests?' (Lukes, 2005, p.31) He believes that it can but acknowledges that the identification of 'real interests' is not always straightforward. His response is only partially helpful – 'The identification of these is not up to A, *but to B*, exercising choice under conditions of relative autonomy and, in particular, independently of A's power – eg through democratic participation.' (Lukes, 2005, p. 31) The question that remains is, how will B, brought up in a system which has shaped his interests, as Lukes suggests in p.23, then be able to recognise that those interests are false.

2.2.4 Foucault

Foucault's view of power is quite distinct from that of Lukes. The latter is concerned primarily with power as a form of commodity, and with an implied (social) owner of that commodity. Power in this case is therefore the result of a relationship between, as Foucault puts it, the 'obedient subject' and the 'master'. Although Lukes' second and third dimension make it harder to identify the relationship, they are still based on the implicit assumption that an unequal relationship between two social agents exists, even if it is not visible. Foucault instead saw 'no master plan of indoctrination at work' (Scott, p.11). Instead for him power is a function of the necessary conditions for the production of 'systems', both of knowledge and of social relations (McHoul and Grace, 1993, p.65), and therefore an inherent property of society, 'an ubiquitous feature of human interaction' (Hindess, 1996 p103).

Foucault also identified three particular alternative forms of power. Firstly he sees power *in general* as being dependent on the freedom of agents to act, and therefore as 'strategic games between liberties' (Foucault, 1988a, p19, in Hindess, p99). This form of power is unstable and reversible, as in any situation the outcome may differ. Further it is not due to a single act but to 'the total structure of actions' (Foucault 1980, p220, in Hindess, 1996, p99), including the 'instruments, techniques and procedures that may be brought to bear on the actions of others' (Hindess, p100).

Foucault's two other forms of power are more stable and hierarchical – these are 'domination', and 'government' (Hindess, 1996 p99). The first is the case in which the individual has little freedom of choice, and this perhaps relates most closely to Lukes', and others', identification of power as implying a greater capacity in one individual or group to impose their will on an individual or group with a lesser capacity. But rather than an inevitable part of social relationships, Foucault considers this as a negative and undesirable form of power, and one which should be minimized in order to allow the first form, the strategic games, to be played (Focuault 1988a, in Hindess, 1996, p.104).

'Government' lies somewhere between domination and the 'strategic games'. Foucault uses the term to include in particular the government of the self, as well as of the household and community, and of the state. He discusses this concept in a lecture on the history of state governance from Machiavelli to the present (Foucault, 1979); during this period the use of the term has changed from the governance of a territory 'sovereign power' to governance of the subjects within that territory, and through the structures of society or 'mechanisms of power' in the 18th and 19th centuries to the self-governance of subjects. In a later lecture on

'governmentality' the term 'is particularly associated with notions of 'conducting' (in the sense of leading or controlling a series of action), of 'rationality' and of 'technology'' (Hindess, 1996, p106). Foucault's concern here is with deliberate and calculated intervention in order to regulate conduct, and importantly he links this closely to 'the use and invention of technologies' (Hindess, 1996, p.106). As governance is also a form of power, this shifting concept of governance also illustrates Foucault's view that changing context can affect the actual concept of power.

Foucault described five particular aspects of his focus on power in a lecture in 1980 (related by McHoul and Grace 1993, p.88-90). Firstly, he explains that he is interested in the local sites in which the impacts of power are demonstrated. Secondly, rather than concerning himself with the *cause* of such power relationships, he is instead (at any rate at this point) more interested in the *effects* of the exercise of power. In his view it is also important to understand that individuals are 'always in the position of simultaneously undergoing and exercising this power. In other words, individuals are the vehicles of power, not its point of application.' (Foucault 1980a:98, in McHoul and Grace, p.89). His fourth point is that it is more instructive to consider power from a study of the 'infinitesimal practices' of the small-scale institutions and sectors of society. Finally he explains that he is concerned not with the production of ideologies, but with 'the instruments and procedures which produce them, and what may be called the historical 'conditions' of this knowledge' (McHoul and Grace, p.90).

The changing nature of power, and his intentional near-sighted focus on local sites and 'infinitesimal practices', lead to Foucault documenting 'an ontology of the present' (Foucault, 1986b:96, in McHoul and Grace, 1993, p60). His question is about 'the nature of the world we find ourselves in' (McHoul and Grace, p.60).

Knowledge and 'truth' are therefore constructed by and through the forms of hegemony within which they operate: ' "Truth" is linked in a circular relation with systems of power that produce and sustain it, and to effects of power which it induces and which extend it – a "regime" of truth.' (Foucault 1976, p.170) Both the power within a regime, and the accepted knowledge, is reflected in *and produced by* the objects or technologies which are used.

2.3 Applications of power

2.3.1 Introduction

After setting up his concept of the two streams of theory, Scott then applies these within the different 'patterns' or sites in which it is practiced. Two of his 'patterns' which are of particular relevance to the definition and implementation of sustainable construction are policy formation, and the role of 'expertise', as identified in the previous chapter. These are the subject of the following two sections. Closely related to the systems of expertise and discipline are the ideas of truth, knowledge and trust. Numbers and measurement as a means of demonstrating expert knowledge and of invoking trust are discussed in section 2.3.3. Foucault's suggestion of the relationship not just between social and social, but also between the social and the technical, relates also to theories developed in science and technology studies, and these are discussed further in section 2.3.4.

2.3.2 Policy formation

Political power, its imperfections and its inevitability, were a principle concern of Weber's work *Economy and Society* (see Roth and Wittich (eds), 1978, first published as separate texts from 1907). In Weber's view

> 'Anyone engaged in politics is striving for power, either power as a means to attain other goals (which may be ideal or selfish), or power 'for its own sake', which is to say, in order to enjoy the feeling of prestige given by power.' (quoted in Lassman, in Turner (ed), 2000, p.85)

Weber also believes that 'it is the fate of modern man to live with a 'polytheism' of conflicting values' (Lassman, in Turner (ed), 2000, p.98).

Scott refers to a number of theories in his review of policy formation. He starts with pluralism (see Polsby (1960) and Dahl (1957)), which originally emerged as a critical response to the elite theories of political power structures proposed by Weber and others. One of the main aspects of the pluralists work was their consideration of the mechanisms of political decision-making, acting through and on behalf of the interests of the particular lobby groups involved. According to Polsby therefore policy formation is 'fractured into a congress of hundreds of small 'special interest groups', with incompletely overlapping memberships, widely differing power bases, and a multitude of techniques for exercising influence on decisions salient to them.' (Polsby, 1960, p. 66, quoted in Scott, 2001, p. 54). Therefore the political leaders

merely respond to the collective interests of the population without imposing their own interests and concerns. However Dahl in particular has been criticised for his tendency to minimise the political interests and power of the state (Scott 2001), with the suspected deliberate political intention to 'license and legitimate post-war American democracy' (Clegg, 1989, p.9).

The 'second, hidden face of power' suggested by Bachrach and Baratz further illuminates the application of power theory to politics, in its suggestion that there are also hidden backroom negotiations . Their non-decision-making 'involves creating or reinforcing barriers to the airing of issues about which there is concern or disagreement' and therefore 'political leaders are able to shape public opinion as well as to respond to it' (Scott p59). Habermas emphasises this further:

> 'Public opinion is not simply the result of free and frank deliberation by an autonomous public: the 'demands' to which party politicians respond are *partly produced by political activists themselves*' (Habermas 1962)' (quoted in Scott, 2001, p.59, emphasis added).

Scott suggests that a study of the impacts of pressure on policy formation should therefore include identifying both who is included and who excluded from the policy arenas, as well as 'whose wishes ultimately prevail' (Scott p. 61).

Domhoff (1979) suggests that there are two separate routes to inform political decision making, which he terms 'special interest groups' and 'policy formation'. While Dahl started from the viewpoint that the political pressure groups acted *rather* than a hierarchical elite in the formation of policy, Domhoff identified the hidden links between the two, in particular in a short study on the recruitment of economic experts to the Council to Economic Advisors in the US. He demonstrated that the majority of appointments had direct links to the power elite through membership of a policy discussion group, and demonstrates how this mechanism allows the elite group to involve itself in 'the making and shaping of general governmental policies' (Domhoff, 1979. P. 192).

Laumann and Knoke (1989) suggest that 'policy arenas' are a combination of political and private actors, and suggest that such groups range along a continuum from 'issue networks' - composed of many, shifting groups with relatively open membership, equivalent to Domhoff's 'special interest groups' and to Dahl's pluralist idea of policy making - to 'policy communities', which have a more closed and controlled membership. The latter therefore may have a

disproportionate and elite form of influence in the formation of policy (Scott, 2001, p.65). An example is given by Smith (1990), who has described the close relationship between the UK Ministry of Farming and Fisheries (at the time) and the National Farmers Union (NFU) as one such example of a policy community. Although the farming lobby were seen to have considerable power in the making of policies to support their interests, Smith demonstrated that the issues raised, and the officers elected to the NFU, were non-contentious to policy-makers. Crucially the NFU itself emanated from a Government initiative. Smith compares the UK case with that in the US where the multiple interests and loose organisation of different groups is closer to an issue network, and has limited alliance with the Government. The difference between issue networks and policy communities is not that the power of the second is much greater than that of the first; rather, either may have power, but the power of the second is more closely aligned with the power of the political agents with which it operates.

In a recent critique of Private Finance Initiative as a 'meta-policy' Greenaway et al draw on these analyses to describe the inter-relationships, too, between policies and policy networks:

> 'For, it is not just policy networks that shape outcomes: the reverse process may happen as well. Changing government policy and policy outcomes may fundamentally alter the membership of a policy network, impact upon the social structure (and hence the relative powers of interest groups) or modify the behaviour of the various agents as they struggle to adapt new strategies to cope with the altered policy.' (Greenaway et al, 2004, p. 509).

Therefore it seems that policy networks and individual members have a reciprocal relationship with government policy. Membership may be deliberately chosen or encouraged to support the outcomes already promoted by the state. In this case the power of the professional 'experts' within the policy groups is perhaps being used by the greater power of the state to create policy.

All such policy forums are also to a greater or lesser extent

> 'important sites of meaning-making...[which] create and embody particular cultures with their own languages, practice and standards…[and] offer ready entry to some actors while consciously or unconsciously erecting barriers against others' (Jasanoff and Martello, 2007, p.342).

So three points can be made about policy groups. Firstly they both create and embody particular cultures. Secondly, however, these cultures may in some cases be determined by Government, through their power over choice of the subjects for discussion and even over membership. Thirdly the power of the policy groups is closely linked to that of their expert members. In Scott's view 'Professional claims are particularly strong when they are underwritten by state power' (Scott, 2001, p. 102), but also, and reciprocally, he sees that, 'expert knowledge plays an ever-greater role in policy making as decisions come to be seen as technical matters rather than issues for contentious discussion.' (p.108)

2.3.3 Expertise

In his discussion of professional expertise Scott refers in particular to the work of Foucault and of Talcott Parsons. Parsons' concept of the professional was essentially linked not just to the occupation but also to a distinct body of knowledge, which as a key resource is controlled by the profession; 'Their knowledge-claims are organised through discursively formed symbolic monopolies that organise the systems…that professionals employ to buttress their position' (Scott, p.101). The thus created 'institutionalised expertise' confers power on the profession, through its own monopoly. In this view, Scott says, 'the experts themselves are the producers and transformers of this knowledge'.

Gouldner sees 'subalterns' as recognising 'the technical character of expert knowledge and see its use as something that will benefit them'. Therefore the power of expertise may act in a benign way for the general advantage of society. In Lukes' terms, it could be said that A is exercising power over B in B's interests. According to Giddens,

> 'People acquiesce in the exercise of expert power when they place their trust in the body of knowledge and the competence of the practitioner to define the risks that they face and the actions necessary to treat them (Giddens 1989: 84)' (quoted in Scott, 2001, p. 104)

The power of experts is based partly on the 'knowledge-gap' between experts and lay people, and 'involves an exercise of persuasion' (Scott, p.102). This clearly falls into the second of Scott's principle elementary forms of social power, persuasion rather than correction. However, in situations where a number of different professions are operating, work 'involves power relations with other professions… as well as with clients', and experts compete 'for rights over a particular sphere of activity'. This dependence on experts may also make citizens more critical of expert (and expert institutional) failure, and prone to ambivalence or mistrust.

In 1923 WI Thomas described a similar effect of society in training, and by so doing also inhibiting, its new members. Foucault's view focuses on the disciplinary effects on the individual through 'systems of rules that are not simply imposed on them but are instilled in them.' (Scott, 2001, p.94-95) Foucault was particularly interested in the disciplining effects on society of specific interlinked institutions including prisons, psychiatric hospitals, and orphanages – 'a network of expert power through which disciplinary controls reached throughout the entire society' (Scott, p.97) Externally imposed disciplines in Foucault's view then become internalised in the subjects to become modes of self-discipline. Scott sees Foucault's ideas as an account of how 'discipline arose as an aspect of the building of systems of expertise.' (Scott, p.95).

According to Gramsci, 'Discipline is a language, an element of a necessary 'uniformity' (in Forgacs (ed), p. 401). Latour too considers the forming of expertise through specific 'languages, practice and meaning' (Latour, 1991); thus created these can act to exclude others from entry, in a very similar method to Jasanoff and Martello's policy forums (Jasanoff and Martello, 2007, p.342). Only individuals who have been brought up within the correct disciplinary training and identity will be able to interpret and use the language and thus in turn assert their own expertise. The restriction of knowledge to experts therefore becomes a method through which power over related decisions is retained. Furthermore,

> 'Modern professions, rather than simply existing as the sum of the professional interests of their individual members, instead are complex social constructs that structure their autonomous identities in relation to the specific configuration of the economy and society in which they operate. Successful professional identities depend as much upon devising convincing ideological representations of professional practices as on the actual practices themselves.' (Crawford, 1991, p.27).

Therefore Crawford too sees the importance of the trust, or conviction, of lay people in professional knowledge.

In *The Structure of Scientific Revolutions* Kuhn, originally a physicist, had also detailed the relationship between scientific knowledge and the social conditions which produced it, and used this to explain the 'paradigm shifts' which happened periodically in the history of the development of scientific theories as opposed to the gradual progression of 'scientific truth' (Kuhn, 1962). He explained this through demonstrating the dependence of progressive scientific discovery on the social context which allows it to be created. Foucault went further

in questioning 'the political status of science and the ideological functions it could serve', and 'the interweaving of effects of power and knowledge', seeing this as particularly relevant to the more empirical sciences which are 'profoundly enmeshed in social structures' (Foucault, 1976). Unlike Kuhn Foucault did not see the 'scientific revolutions' as necessarily progressive; instead there may be complete rupture between one ideology and the next.

Scott also says that state authorities may 'subordinate expertise to their own priorities and interests' (p.108). Therefore

> 'The apparent neutrality of expertise obscures its character as power and can help to legitimate contentious policies and decisions.' (Scott, 2001, p.108)

An analysis of the relationship between expert knowledge and power must therefore consider not only who is the expert, but also *who governs* what is acceptable knowledge and therefore who does it serve, and through what mechanisms does it operate?

2.3.4 Numbers

Gramsci and Latour spoke of a specific language being an essential defining element of disciplinary expertise, and Giddens, Crawford and Foucault described trust as a necessary condition for expertise to hold power. The main unifying language of technical expertise is mathematics, and in his influential book *Trust in Numbers*, Porter considers the use of standardised measurements by professions in different social settings, using historical case studies to analyse successes and failures. A particular aspect of Porter's analysis is the demonstration that measurement and standardisation stems from a *lack* of trust in particular groups and emerging professions:

> 'the rules of right reasoning have generally been most explicitly defined and most rigorously enforced in weaker disciplines' (p.228).

Secondly, they also stem from a desire by the State to impose control, which happens to the greatest extent in areas of applied science, and technology :

> 'Applied fields, at least those that bear on matters of policy, are almost always exposed to scrutiny and criticism by the interests they affect…Public responsibility, if it is even mildly enforced, breaks down the boundaries around the research community and makes it necessary to satisfy a larger audience…Such a situation encourages the

> greatest extremes of standardization and objectivity, a preoccupation with explicit, public forms of knowledge.' (p. 229).

G H Hardy, an eminent Cambridge mathematician, perhaps not surprisingly, sees numbers as related to truth, something which does indeed inspire trust: 'the mass of mathematical truth [is] obvious and imposing…its practical applications, the bridges and steam-engines and dynamos, obtrude themselves on the dullest imagination. The public does not need to be convinced that there is something in mathematics.' (Hardy, 1967, p. 64-65). However, the way in which numbers are used can be at the least misleading, and sometimes intentionally misinforming, as pointed out by David MacKay, the Chief Scientific Advisor for DECC and himself a professor of physics at Cambridge University:

> 'Here's an example from the Conservative Party's otherwise straight-talking Blueprint for a Green Economy:
> "The mobile phone charger averages around . . . 1W consumption, but if every one of the country's 25 million mobile phones chargers were left plugged in and switched on they would consume enough electricity (219GWh) to power 66 000 homes for one year."
> 66 000? Wow, what a lot of homes! Switch off the chargers! 66 000 sounds a lot, but the sensible thing to compare it with is the total number of homes that we're imagining would participate in this feat of conservation, namely 25 million homes. 66 000 is just one quarter of one percent of 25 million. So while the statement quoted above is true, I think a calmer way to put it is:
> If you leave your mobile phone charger plugged in, it uses one quarter of one percent of your home's electricity.
> And if everyone does it?
> If everyone leaves their mobile phone charger plugged in, those chargers will use one quarter of one percent of their homes' electricity.'
> (Mackay, 2008, p.114)

On the one hand of course Hardy is right; mathematics does have an internal truth, and this is the reason that the public, as suggested by Porter, implicitly trusts numbers. Numbers are therefore a very powerful way of persuading others of the 'truth' of an argument. On the other hand numbers are frequently used accurately but selectively, and can thereby create a false impression such as that suggested by the Conservative Party in MacKay's quote. The impression here is that if everyone makes a tiny difference, a huge difference will be made. In

fact, if everyone makes a tiny difference, as Mackay points out, only a tiny difference is made. This is the rhetoric of numbers, where they are used not just to inform but to persuade. MacKay's account doesn't make it clear whether he believes that the Conservatives are deliberately trying to deceive the electorate over the importance of turning off phone chargers, perhaps to encourage general energy-awareness, or whether they are themselves deceived by the numbers.

Toke however demonstrates that MacKay's choice of numbers is as selective as those that he damns; for example (Toke says) he calculates the energy requirements of the UK by multiplying the 'average Western energy' consumption by the number of UK inhabitants. This gives an annual energy usage of 4270TWh (terra Watt hours), whereas the published consumption of the UK in 2008 (DECC 2010) was 2605TWh. MacKay's choice of numbers leads to a 64% increase in perceived energy usage. The reasons for this choice of figures is not made clear, but what is clear from the book is that MacKay, although clearly approving of renewable energy, believes that the UK also needs nuclear power stations. He uses his figure for the annual energy required, along with several other judgements about the potential for renewables also contested by Toke (p171-175), to demonstrate the case for nuclear. Shortly after his book was published MacKay was appointed Chief Scientific Advisor to the Department for Energy and Climate Change, a department which has advocated the need for nuclear power since it came into being. However although the felicitous concord of his beliefs may have encouraged his appointment, it is not because MacKay is CSA that nuclear power is the preferred option of DECC. Equally he genuinely believes that his book is avoiding the point-scoring emotional rhetoric that he accuses others of, and that it does indeed set out the 'real' numbers.

Jasanoff points out further how numbers, due to their (apparent) objectivity, can be used to overwhelm other arguments: 'The brute objectivity of numbers is often gained at the expense of subjective values that democratic societies also hold dear' (Jasanoff, p.86). Gramsci provides a straightforward expression of the issue in his discussion on the use of statistics:

> 'numbers are simply an instrumental value, which offers a measure and a relationship and nothing more. What then is measured?' (Gramsci, 1957, p.183)

This is of course the key question, although one which is surprisingly often left unanswered. But if MacKay's example seems to be describing merely a 'mistake' in the use of numbers, Galvin (2011) gives another more complicated example. In a section of his PhD titled 'The politics of mathematics' (p 203-209) Galvin describes the form of the numeric calculation

which is used to determine whether German householders' refurbishment projects are economically viable in terms of energy saved and payback times. He demonstrates that the calculation, which has been developed by (technical) building physicists, is in fact dependent on several (value-based) decisions. The result is to produce an answer which is almost always 'yes', thus having the effect of imposing the refurbishment on the householder. Clearly the aspect of numbers which implies trust is their claim to impartiality and to rationality. Unlike Porter, Galvin focuses not just on the sociology but also the mathematics behind the numbers, giving a very clear picture of the basis of the limitations and assumptions that have been made at each step of the calculation. He also shows that the answer is at odds with the views of the interviewed home-owners, who are now obliged to pay for work which they do not believe to be cost-effective.

Another example is given in Flyvbjerg's extended case study of the planning process for the new Aalborg bus terminal, throughout which Flyvbjerg demonstrates not only the interplay of different power effects but also their dependence throughout on what he calls 'rationalisation'. A review of his analysis reveals the case study to be full of decisions and 'non-decisions', in the manner of the first two 'dimensions' of power as identified by Lukes. Furthermore numbers are used by all parties to support their arguments. However it is noticeable that when used by the side with less pre-existing power, the numbers are dismissed from the arena. This is not due to the *falseness*, or irrationality, of these numbers, but rather the failure of the rationality, 'reason', which they are describing; this fails merely because the *version* of rationality, and the numbers, are both produced by the less powerful actors (Flyvbjerg, 1998, p.132). Flyvbjerg therefore proposes that reason or rationality becomes *redefined* by power:

> 'Defining reality by defining rationality is a principal means by which power exerts itself. This is not to imply that power seeks out rationality and knowledge because rationality and knowledge are power. Rather, power defines what counts as rationality and knowledge and thereby what counts as reality.' (Flyvbjerg, 1998, p.227)

In this case, numbers are not just a technical tool but also a political tool.

While Hardy suggested that numbers *are to be* trusted, Porter and Flyvjerg suggest something slightly different - that numbers are *used to invoke* trust. They suggest that they are particularly used where there is a specific need for trust, such as by weak professions, or because of a close link to public interests. Galvin's example suggests however that the method

failed, in the case that he studied, to invoke trust in the home-owners. Rather than Lukes' third dimension of power in which the subject believes the decision to be in their own interests, this is closer to the second dimension, in which the issue is contested, and the means by which that contest could be made is repressed.

Porter, MacKay and Galvin reveal therefore not only trust in numbers but also mis-trust, and the necessity to support the numbers through other forms of power – often that of State regulation. Where this power is also effective, the numbers will prevail. Numbers, in other words, can be used to give support to otherwise existent power. Numbers, and measurement, have been shown to be used by both political and professional groups to reinforce their existing power base and to validate a particular position.

2.3.5 Technologies

The fourth site of power to be discussed is that of technologies, and their relationship with the societies that develop them. An example is provided by Langdon Winner in a much-discussed article titled *Do artefacts have politics?* (Winner, 1980), in which he suggested that the bridges over the New York parkways were designed deliberately low by Robert Moses in order to prevent buses from passing under them and reaching the beaches. As buses were occupied mainly by the poorer, black, population, Winner hypothesised that this was a form of deliberate apartheid through the design of a technical artefact. Although the account itself has been retold so many times that it has fallen victim to the effect of Chinese whispers (Joerges, 1999) Winner's example does provide a simple example of the social effect of an apparently mundane and neutral artefact. In this example, the bridge determines who has access to the beaches and who does not. However in spite of the title of the article, the effect or power of the 'artefact' is shown to be a resource by which the designer, Moses, imposes his will on others – in other words, the artefact itself does not hold power, but is merely an instrument for the intentional practice of social power.

Winner's understanding of the deliberate social construction of technologies is developed further by Hughes: 'Technologies, we are saying, are shaped…They might have been otherwise.' (Hughes, 1988, p.3). But he also develops a more complex analysis of the causes and effects between technologies and societies, and the 'complicated contests and negotiations' which develop both new products and new processes (Hughes, 1988, pg 3). In an influential paper in 1986 Hughes described these interactions between technical objects and social actors as a 'seamless web' of 'disciplines, persons, and organizations…interacting entities in systems or networks' (Hughes, 1986, p. 282).

Latour's commentary on Winner's article gives an alternative view of the power effects of the technical over the social, expanded beyond Winner's perceived deliberate intentions of the designer. Latour relates Winner's original interpretation of New York bridges to the design of his own apartment block, in which a separate set of stairs leads to the upper floors, once to ensure the segregation of servants, but now having the same effect on students. Latour points out that uses change with time, and that this cannot be predicted by the original designers:

> 'if artifacts do more than 'objectifying' some earlier political scheme, if their design is full of unexpected consequences, if their durability means that all the original ideas their designers entertained about them will have drifted in a few decades, if, in addition, they do much more than carrying out power and domination and are also offering permissions, possibilities, affordances, it means that they are doing politics in a way not anticipated by Langdon Winner's seminal article.' (Latour, 2004,p.2)

Latour's argument suggests that, where the consequence of a material artefact is not one which was intended by the designer, and yet has an observable effect on social agents such as users of the artefact, the artefact itself is 'doing politics', exerting power over the social agent.

This is suggested, too, by Shove: 'If material artefacts configure (rather than simply meet) what consumers and users experience as needs and desires, those who give them shape and form are perhaps uniquely implicated in the transformation and persistence of social practice.' (Shove et al, 2007, p 180-181). Shove's suggestion is slightly different to Winner's; it can be assumed that Shove's designer set out merely to *meet* the needs and desires of the consumer, but that the artefact has had some other effect which was not the intention of its designer. Although the designer is perhaps ultimately responsible for this effect of the artefact on its users, the artefact again has a capacity of its own, in this case to shape the needs and desires of the users.

While Latour's discussion above seems to limit the power of an artefact or a building to those unintentional consequences which develop with its changing use over time, elsewhere he and others argue that both actors and technologies ('actants') are equally involved in enabling or disenabling different priorities and acts:

> 'in order to understand domination we have to turn away from an exclusive concern with social relations and weave them into a fabric that includes non-human actants, actants that offer the possibility of holding society together as a durable whole' (Law, 1991, p. 103).

Foucault takes this further, considering that it is the technologies of a society that determine 'what is considered as truth' (McHoul and Grace, p.90). The theories developed in science and technology studies investigate 'how scientific knowledge and technological artifacts are constructed' (Sismondo, 2010, p.11) and furthermore what the impact of the technologies is on the societies from which they stem.

Latour is further concerned with the related aspect of change, and how the social and the technical co-evolve: 'Contrary to the claims of those who want to hold either the state of technology or that of society constant, it is possible to consider a path of an innovation in which all the actors co-evolve.' (Latour, 1991, p.117)

This relationship between the evolution of technologies and society extends the concept of the social construction of scientific knowledge. Winner, Shove and Latour are specifically talking about things, objects, rather than knowledge.

This idea of the equivalence between social actors and non-human 'actants' forms the central premise of actor network theory (ANT). ANT therefore implies that all forms of power are capable of being exercised by both humans and technologies. Following Lukes' analysis, technologies would themselves be capable of overtly imposing some actions, and restricting the inclusion of others (in the first and second dimensions of power), and would also have the ability to affect accepted norms of behaviour (in the third dimension).

Law and Callon, at the start of their study of the TSR2 British military aircraft project, wrote that 'Any attempt to separate the social and the non-social ….is…., quite simply, impossible because the social runs throughout the technical' (Law and Callon, 1988, p.284). Making a case study of the specific interaction between the engineers and the aircraft, they described the 'relatively autonomous negotiation space' which the proponents of the project team had sought to create separate from outside influence. This negotiation space was never complete, and the project was eventually aborted. However Law and Callon propose that the elements of the negotiation space – in particular the possibility that privacy offers actors to make mistakes while developing new concepts and designs – allow the formation of 'relatively stable networks of sociotechnical objects', or innovations. Through demonstrating the impact that technical decisions had on the TSR2 project, and in turn on the actors involved, as well as the impact of the political climate, their analysis further showed that the technical and social were 'jointly created in a single process' (Law and Callon, 1988, p.296).

This further effect of projects, and of artefacts and technologies, in being able to shape and change the actors which are engaged with them at the same time as the actors are shaping the technologies, in a reciprocal evolution, was a key element of Actor Network Theory (ANT). In other words it considers not only how 'our technologies mirror our societies', but also 'how did the users *and their technologies* shape and influence future social, economic, and technical decisions?' (Bijker and Law, 1992, pp 3-4, emphasis added).

Pinch and Bijker (1984) introduce one more concept, that of 'interpretative flexibility', or the potential of an artefact to be re-interpreted by the actors who promote or use it. Lars Lerup also considers a similar aspect in the 'layer upon layer' of possible uses, and meanings, of a bridge (Lerup 1977, p.37). Pinch and Bijker state therefore that 'the good design of an artifact cannot be an independent cause of its success; what is considered good design is instead the result of its success.'

Technologies are both implements of their designer's power, and have power of their own. If equal status and potential are assigned to both human actors and non-human actants, this suggests that power can also potentially be possessed by these artefacts and technologies; they can have impacts and effects which are unintended by their makers. While Porter considered numbers as a tool, of the new professions and of the State, rather than as an agent of power in their own right, Actor Network Theory suggests something more. Just as the power of artefacts has been shown to be capable of separation from the power of their designers, the power of numbers is not merely that of their designers, but in and of themselves.

2.4 Summary and Conclusion

Scott stated that, in its simplest form, 'power is the production of causal effects' (Scott, 2001, p.1). The complexity and value-dependent nature of sustainability, the changing cultural and professional structures of the construction industry, the relationship between sustainability and policy and with construction and technology, have been discussed in chapter 1. The research questions examine how these complex relationships are affecting the interpretation of sustainable construction and its translation into material form. The theories of power discussed in this chapter are theories of how these relationships between political, social and technical agents may produce outcomes.

The first half of the chapter considered the different forms through which power acts. Lukes' first dimension of power is perhaps its simplest form, that of overt conflict, producing an

observable change of outcome. The second dimension acts through hidden conflict, where issues are restricted – the presence of conflict can nevertheless be demonstrated and is known. The third dimension produces willing consent to domination, which Lukes admits is difficult to demonstrate through empirical evidence. Lukes and others see power as a capacity of one or a group of actors to make another do what they would not otherwise do, in the interests of the first and against the interests of the second. Foucault instead sees power as an inherent property of society, acting through individuals as well as on them. Social power is dependent on the freedom of individuals to act, even if that freedom is not equal. The concept of 'governance' is used to explain the ordering of the actions of society and individuals, through the regulation of conduct. This ordering may, however, be unstable and reversible.

These aspects of power, it is suggested, may be observed through several sites of application, which are discussed in the second half of the chapter. Firstly the formation of policy is seen to be responding to multiple and conflicting values and interest. Dahl considers political lobbies and special interest groups to be autonomous and competing only amongst each other for the power to influence policy, with political leaders acting as neutral arbiters. Others demonstrate a much more integrated relationship, showing evidence of government having considerable control over the membership and demands of the policy groups.

The second application of power is that which is held by professional disciplines through their claims to expert knowledge. These may be acting within the policy groups discussed above or at the level of professional practice. As for the policy groups, the different professions working at the same site may also compete with each other for power and influence over the outcomes. Three specific aspects relate to expertise. Firstly professions create and protect their own identities through monopolies of specific languages and practices. Secondly the basis of their power is the gap between lay knowledge and their expertise. Thirdly this only succeeds through the trust put in their expert knowledge by the laity. However the apparent neutrality of expert knowledge may disguise its social construction by professions in their own interests, and its potential use in the service of political ideology.

The third application of power is that of numbers and measurement. Porter suggests that these are used to elicit trust in, and hence the power of, professions through the demonstration of objectivity. This happens, he argues, particularly in instances when the profession is weak, and when the subject is of public and political importance. However numbers may also be used subjectively, to support ('rationalise' in Flyvbjerg's terms) a political

stance. Numbers can be used selectively for this purpose, as MacKay has shown, and Galvin extends this to expose the selective and value-based decisions which are made not just about the numbers but also about the calculations of the numbers. Finally, numbers are not always successful in invoking trust, but may by repressing conflicting views, contribute to the semblance of consensus and consent.

The final application of power that is considered is that of technologies. These may be either a method or resource through which their designers can gain power, or they may in themselves possess the capacity to change outcomes. Furthermore they may have the ability to 'configure' users' assumptions about their own needs and desires. In Foucault's view technologies may also regulate conduct, influence future decisions, and produce 'knowledge'. Not only are technologies socially constructed, but societies are also technologically constructed.

These theories will be applied to the empirical studies which follow, in order to unpick and explain the complex network of interactions which together have interpreted broad notions of sustainability, and translated them into particular processes and material realities.

Before proceeding to that analysis the next chapter describes the research design used to examine this complex network, firstly at the national policy level and then within four individual construction projects.

Chapter 3: Research design and method

'…if one wants to see where society is heading, it is as useful to consult those holding it back as those pushing it forward. This should be remembered by those involved in current building programmes and they should think more precisely about who they need to consult. … and to avoid implying that the aspirations of a few are the current practice of many.'

Pamela Woolner et al, 'School building programmes: motivations, consequences and implications', *2006*

3.1 Introduction: case study research

Chapter 3 describes the design, methods, and processes followed in undertaking the research for this thesis. The research subject clearly falls within Robson's *Real world research* (Robson, 2002). As noted by DeVaus (2001), the research design will depend on the type of evidence needed to answer the questions convincingly. The research questions were stated at the end of chapter 1 as:

'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?', and

'How have political, social, professional and technical decisions and concerns led to these particular interpretations and translations?'

The first of these is looking for a descriptive answer – this could also be re-expressed as a 'what' question : 'What is the interpretation of sustainability?'. The second is looking for explanation –it is interested in exploring 'why is this so?' An appropriate strategy for answering 'how' and 'why' questions is the use of theoretical propositions, 'to focus attention on certain data and to ignore other data' (Yin, 2009, p. 130). One method for answering descriptive questions, and for organising a large quantity of data, is developing a chronological order of events (Miles and Huberman, 1994). This is particularly useful as a method for developing an understanding of complex situations such as construction projects; furthermore it is often the time delays and their causes which have unintended and negative consequences on the outcomes (Short et al, 2007). Both of these strategies were utilized, and are explained further through this chapter.

The questions are focused on the multiple perspectives and practices in the development of policies for, and the procurement, design and construction of, sustainability in school buildings,

and on the objects which are produced, both the school buildings, and specific technologies chosen as a response to the translation of sustainability. Donaldson et al (2010, p. 1535) note, 'whereas it is too easy to iron out mess when words are all that is involved ... a focus on objects and practice places us right in the middle of the mess.' Fiss points out that using case studies for such problems then is ideal as it 'reduces complexity to manageable proportions and turns the potentially limitless possibilities into concrete 'cases'' (Fiss, 2009, p. 426). Ragin notes that casing is 'an essential part of the process of producing theoretically structured descriptions of social life and of using empirical evidence to articulate theories.' (Ragin, 1992, p.225). Indeed Flyvbjerg believes that 'the most advanced form of understanding is achieved when researchers place themselves within the context being studied in the manner of case study research' (Flyvbjerg, 2006, p. 236). Campbell is slightly less enthusiastic: '…it is all that we have. It is the only route to knowledge— noisy, fallible, and biased though it be.' (Campbell, 1975, p. 191). Yin simply suggests that case study research is the most relevant approach to answering 'why' and 'how' questions (Yin, 2009, p.4).

3.2 Research design

3.2.1 Introduction

The research questions are looking for both descriptive and explanatory answers. The latter in particular, DeVaus (2001) suggests, can be addressed in two ways; through theory development (inductive) or through theory testing (deductive). However these are not necessarily exclusive; Hammersley (2010) suggests that while Grounded Theory (see for example Glaser and Strauss, 1967) is only concerned with theory developing, the method of Analytic Induction (see also Bryman, *Social Research Methods*, 2004) can consider both development and testing. In fact, many researchers using case study methodology in particular combine the two methods in an iterative process, which starts with tentative propositions and develops these further as the case studies progress.

Yin suggests that the research questions themselves are just one of the five levels of 'case study questions' (2009, p.86-87). The level 1 questions he suggests are the questions that are asked of the respondents in the interview process. The second level are the questions which are asked 'of the case', reflecting the actual inquiry, and are developed not for the respondent but for the researcher. These level 2 questions form the focus for the development of level 1 questions for the research interviews and also provide evidence for the level 3 questions 'of the pattern of

findings across multiple cases'. These lead to level 4 questions 'of an entire study', which are the main 'research questions' as copied above. Level 5 questions are then 'about policy recommendations and conclusions', and will be addressed in the final chapter.

3.2.2 Hypotheses of power

The starting point for a deductive, or an iterative deductive/inductive, research design is the development of initial propositions or hypotheses. These form Yin's level 3 questions (Yin, 2009, p.86-87). Yin also writes (p. 34) that 'specifying important rival explanations is part of a case study's research design work'. This is one method through which to address the acknowledged limitations of case studies, which is the presence of multiple, uncontrolled physical and social variables. In a laboratory experiment these variables can be artificially kept constant or varied in a specific way in order to understand the effects of the variation while holding other factors constant; in empirical, real world case studies very little control is possible. Campbell (1989) equates the control of physical properties to the development of rival hypotheses in order to improve the validity of the findings. Thus he suggests that if a hypothesis based on one variable is proposed and tested in a case study, a plausible rival hypothesis based on the same variable should also be tested. If both can be demonstrated then the variable is not that which is affecting the results. DeVaus also stressed the importance of developing 'many possibly incompatible hunches', and then to collect information which will demonstrate which of these best fits the data (DeVaus, 2001, p.2). Campbell and DeVaus therefore both build on the concept of falsification originally developed by Popper: 'The point is that, whenever we propose a solution to a problem, we ought to try as hard as we can to overthrow our solution, rather than defend it.' (Popper, 1959, p 16).

3.2.3 Units of analysis

There are diverse examples of what a case study, or multiple case studies, can be, as given in the collection of papers answering the title question *What is a case?* (Ragin and Becker, 1992), and therefore there are also diverse examples of the unit of analysis. Ragin himself suggests that a 'case' is 'an analysis of social phenomena specific to time and place' (Ragin, 1992, p. 2). The questions are considered through looking at 'cases as objects' of individual projects (see Ragin's typology of approaches to casing, 1992), defined by industry-recognised project boundaries of space, finance and time. Therefore each case is concerned with the physical construction of school buildings within the boundaries of the school site, within the specific contract price for

those buildings and no others, and between the first decision of the client to procure the buildings until the contractor has finished construction.

However the school buildings are not themselves the object of interest, but rather what they demonstrate of the interpretation and translation of an idea of sustainability for construction. Each project is set within and limited by the political and regulatory context. Chapter 1 identified the impact that policy and political goals can have on the development of sustainable construction. There is also an inter-relationship between political intent and the professional interests and influence of the construction sector, and chapter 2 developed this aspect in more detail to consider the formation of policy groups, and the power and impact of these groups on policy development. Therefore rather than the political framework merely forming an external context and acting on the project cases, policy formation is viewed as part of a complex system in which this action may in fact be interaction, and dynamic rather than static; furthermore the relationship may vary from project to project. First therefore a case study at the policy level is necessary to consider both the policy documents and the effect of stakeholders and special interest groups on policy formation. The policy context for sustainable schools is therefore considered as an over-arching case study, also forming part of the contextual landscape within which the individual building project cases are embedded.

A key concern for the design of case study research is its practical achievability. The researcher must ask how many project case studies are feasible within the time available? How many will produce enough data to address the questions? What skills will be needed to conduct specific types of case studies? And how do practical and personal considerations limit the choice of case studies?

An analysis of some previous case studies in the built environment was therefore carried out at the start of the research process in order to understand better what might be achievable within the time scale; these are shown in table 3.1. As can be seen, there appears to be two extremes, with the most inductive studies being longitudinal and current (that is, studied as they were unfolding) ethnographic studies of a single case, while at the opposite end of the spectrum there are hypothetico-deductive analyses of historical accounts of multiple case studies (although Sutrisna and Barrett warn that multiple case studies ‘can seem overwhelming’ (Sutrisna and Barrett, 2007, p. 165)).

Flyvbjerg provides a strategy for selecting samples and cases, depending on whether the purpose of the study is suited to random selection or information-oriented selection - 'cases are selected on the basis of expectations about their information content.' Within this category Flyvbjerg further recommends 'To obtain information about the significance of various circumstances for case process and outcome (e.g., three to four cases that are very different on one dimension: size, form of organization, location, budget).' (Flyvbjerg, 2006, p. 230).

By studying a small number of individual case studies of school building projects, it is not, of course, possible to reveal everything about all school building projects. The research aim is instead to study some of the issues that are faced in practice – those which are documented, and those which make up the knowledge of these specific people working on the procurement, design and construction of these specific school building projects – in order to develop a deeper understanding of how a focus on sustainable construction effects decisions and relationships, and how relationships and technologies affect sustainable construction.

The other question which arises from this review is whether to study a case which is happening currently, or to study a case which happened in the past. Historical case studies, particularly those which have been published, may seem readily available. It is reasonably easy to choose cases which provide general or extreme versions of the hypothesis. Further, in initial discussions with colleagues in the construction industry many took the view that the fundamental assessment of sustainability of a building is how it performs in use, both in terms of energy use and occupant satisfaction. This was supported by a number of papers (for example, Lieper, 2007, Leamann and Bordass, 2007). However in order to understand *the process* of how sustainability was interpreted and translated through the every day actions and interactions of the construction project, rather than to assess *the result* of that process post-occupancy, data were needed on the decision making processes during the design and construction stage. Interviews about decision-processes within a project which has finished will be limited both by memory and by a tendency to post-rationalise explanations for particular decisions once they have been shown to be right or wrong.

Reference	No. of cases	Case	Methods	Timing of research	No. of researchers	Main discipline of initiating researcher	Length of time	Research strategy
Bartlett (2005)	4	Educational building projects	Semi-structured Interviews, document analysis	1 current, 3 historic	1	Engineering	3 years	Deductive, hypothesis testing
Flyvbjerg (1998)	1	Planning process for a bus terminal in Aalborg	Observation, document analysis, Semi-structured interviews	longitudinal	1	Social Science	>3 years	Inductive, theory development
Hubermann and Miles, (1984)	12	School improvement programmes	Ethnographic studies, observation	current	4 +	Social Science	3 years	Inductive, theory development
Pinnegar (2000)	1	Construction of the Earth Centre, Durham	Ethnographic observation, interviews, document analysis	longitudinal	1	Social Science	3 years	Inductive, theory development
Samad (2008)	10 (+10)	Primary school building projects	Structured interviews + surveys, qualitative analysis	historic	1	Architecture	3 years	Deductive, hypothesis testing
Short et al (2007)	8	Arts building projects	Semi-structured interviews, document analysis, graphical analysis	historic	3	Architecture/Social Science	3 years	Inductive theory development

Table 3.1 Review of similar case study research projects

The study of a building project while it is occurring will mean that the actors will have a detailed (if possibly unreflective) view of what is happening at that moment. A further practical consideration is that they will also be more likely to agree to spend time giving the interview, as their time can reasonably be assigned to the project. Documents too will be easier to access, as they will not yet have been archived, and site visits while the project is under construction can provide a third data source.

The conclusion was that, following the previous single researcher from an engineering background, and following Flyvbjerg's 'maximum variation' advice, four case studies of school building projects were chosen as likely to be practically possible, provide a breadth of data to develop an understanding of different circumstances, and be few enough to develop a deep and rich level of data through which to consider the aspects of power outlined in chapter 2. The cases were also chosen to be studied during their design and construction stages, for the reasons outlined above.

3.3 Development of case studies

3.3.1 Policy case study

The policy study was in two parts. The first considered policy for sustainable construction which was likely to have had an impact on the project case studies. This was explored through policy documents and Government publications. The second stage was a study of the impact of special interest groups and policy communities on policy formation. The groups which were considered to be closest to policy formation were initially identified as those which had an official role in the Government school building programmes, or those which were openly created by Government and reporting to them. The groups which were seen as likely to be lobbying from the point of view of their stakeholders and most removed from political pressure were those which were developed by the professional institutions (for the construction sector stakeholders) and individual education charities and trusts (for the education sector stakeholders). Their roles were examined through interviews with members and through their publications. Further information about the specific groups and data collected is given in chapter 4.

3.3.2 Preparatory and exploratory studies

Exploratory studies (see for example Yin, 2009, p.92-95) were carried out during the first year of study in order to refine the interview questions, identify any obvious problems with the

methodology, scope areas of potential interest and impact, and identify initial project case studies. These studies also provided a training exercise in interview techniques. While a whole pilot case study of a school building project was not considered feasible in the timeframe, individual data sources (documents and interviews) from specific projects were used to frame the following research design, identify areas of interest and assess any logistical problems with the proposed data collection methods.

Other sources of information included attendance at relevant industry events during the first and second year, which also helped to identify individuals involved in policy networks and helped to identify some interpretations of sustainability within the actor groups which were to be interviewed later. These studies are shown in the table below, and a brief summary of their influence on the following research design is shown in the final column.

	Date	**Source**	**Method**	**School**	**Impact on research design**
1		Structural Engineer	Formal Interview	Bradford BSF phases 1 & 2	Refinement of research questions. Practiced interview technique. Developed interest in following successive projects with same contractor. However logistical problems associated with interviewing led to decision to locate all schools in East of England.
2		Structural Engineer	Informal interview	St Augustine School	Identified St Augustine as potential case. The vision of sustainability as low embodied carbon informed the consideration of the role of professional expertise.
3		Project Manager	Formal interview	County X BSF Schools	Developed clearer understanding of BSF process and suggested the procurement process for multiple projects might have a different effect to that for just one project.
4		Local Authority Client	Formal interview	County X BSF Schools	Developed better understanding of client's role and responsibility, and of their potential interest in sustainability. Refined research questions to clients as a result.
5		Head teacher	Informal interview	Backhouse School	Identified Backhouse as potential case study school. Developed understanding of relationship between school and LA client.
6		Head teacher	Formal interview site visit	X High School	Revealed alternative view of sustainability, and the unsustainability of a school with decreasing numbers of pupils and untenable finances.

7		Sustainability Manager		Contractor	Informal interview about the different major construction companies and their interest in sustainability
		Event/Workshop			
8		Sustainable Built Environment East			Identification of individuals involved in policy networks.
9	28/03/08	Reviving Buildings the Sustainable Way, Cambridge			The different sustainability issues for refurbishment and new build projects.
10	13/06/08	IT-Centric Design: Virtual Schools or Intelligent Architecture? Nightingale Associates (invited participant) at Arcadia Fashion Academy			The future of IT in schools. Also clarified need to draw specific boundaries around type of schools for comparability, and to identify projects majority new build not refurbishment.
11	26/10/08	Scientists for Global Responsibility AGM			Presentations on architect's and LA client's views of sustainability.
12	26/03/09	Westminster Education Forum			The effect of IT–educational opportunities, social sustainability through the Every Child Matters policy, and high use of electricity to power and cool the computers. Helped to identify policy networks and groups.
13	24/06/09	Two day course on 'Eco refurbishment', The Green Register, Bristol			Detailed information and workshops on the environmental impacts of different building materials, and on natural and 'assisted-natural' ventilation designs.
14	22/10/09	Wates BSF National Skills Academy			Improved knowledge of contractors' interests in and interpretations of sustainability and understanding of BSF from contractor's point of view.
15	01/12/09	RIBA School Clients Forum			Identification of individuals involved in policy networks. Clearer identity of some alternative interpretations of sustainability.
16	25/02/10	BSEC 2010 (Building Schools Exhibition and Conference)			Identity of some individuals involved in policy networks. Clearer view of the multiple issues, and interested parties, involved in the construction of schools

Table 3.2: Exploratory Studies

3.3.3 Identification of school projects for case studies

Following the findings of the exploratory studies and the literature review, the projects were also chosen to meet the initial criteria and boundary conditions (the aspects or dimensions to be kept constant), determined as follows:

1. Spatial: All case studies should be in cities in the Eastern part of England
2. Social: All to be existing secondary state schools, 11-18 years
3. Financial: Value of construction works for each school to be comparable – chosen to be between £10m and £20m
4. New build/retrofit: All projects are to be between 50 - 100% new build
5. Time: All projects are to be under construction during the research period from 2007-2010. In addition all schools are to be designed since 2004, when the Government first emphasised the need for new schools to be sustainably built.
6. Procurement: All projects to be procured through 'Design and Construct' type agreements.
7. Contractor: Contractors to be comparable large, national, reputable contractors.

The similar timing of the projects is particularly key because of the rapid change of both policies and construction practices in this area. For comparison with each other and with the policy study, the context in which the projects are built must be the same.

Two of the projects to be studied were identified from the exploratory studies, Backhouse School and St Augustine School. Both were 'typical' school building projects; that is to say they were not externally considered to be path-finders or exemplars (see Chapter 4), nor had they received any particular extra funding for sustainability. The difference between these two projects revealed at this early stage of investigation was the relative impact of the design team on the interpretation of sustainability for the projects. The design team for St Augustine had a particular interpretation of sustainability as low embodied carbon and had successfully translated this into practice by introducing a timber construction system. The buildings at Backhouse School on the other hand were of the same steel frame and brick panel construction as the existing buildings from the 1990s. This appeared to give a comparative view of the use and impact of professional expert knowledge within projects. This distinction was followed for the next two projects, such that two of the four cases selected showed clear evidence of professional innovation, and two did not.

A further area of interest which had developed from the review of the changes in the construction industry in chapter 1 was the claimed effects of partnering and multiple-project procurement systems on reducing the traditional hierarchies in the construction industry. The impact of the different procurement methods had also emerged from some of the pilot study interviews, and this appeared to be an example of Foucault's governing effect of the structures of society. As both

of the first two projects identified were singly procured, the remaining two were chosen to be part of a multiple procurement structure.

The role of the contractor in design and build contracts was also considered to be instrumental to their progress. The two remaining cases were therefore chosen from the two contractors providing the first two cases. In fact the engineers and contractors for St Augustine won a subsequent contract based on their innovative solution, and so this became the second case study with that contractor. The matrix of case studies is shown in Table 3.3.

CS1: Backhouse School	**CS3: St Augustine School**	Single project procurement
CS2: Eastwick Field School	**CS4: Lane Academy**	Multiple project procurement
Contractor: Willmott Dixon	Contractor: Kier Eastern	
No apparent particular influence of project team on translation of sustainability	Specific interpretation of sustainability from project design team with particular outcome in form of construction	

Table 3.3: Matrix of case studies

3.4 Data

3.4.1 Linking data to hypotheses

The first question is looking for a descriptive answer, and is addressed through the policy case study and all four embedded case studies, through chronological accounts as noted at the start of the chapter. The second question was exploratory and Chapter 2 discussed four applications of power which were relevant to the exploration: these were policy formation, expertise, numbers and technology. The policy formation is considered through the case study at the policy level. St Augustine and Lane Academy had been particularly chosen for the impact of professional expertise and its influence on the sustainability outcomes, and therefore this was the focus of the analysis for these two case studies. The role and impact of tools and the different procurement formed the focus of the analysis for the other two cases. Numbers as discussed in chapter 2 may be a tool of professional expertise but may also be used by political actors to support their decisions. Therefore a cross-case analysis will consider the power effects of numbers through the

study of policy and across the four embedded project case studies. The links are shown in table 3.4 below.

			RQ1 'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?'	RQ2'How have political, social, professional and technical decisions and concerns led to these particular interpretations and translations?'			
Case study/Application of power				Policy formation	Expertise	Tools and processes	Numbers
Policy level case study			X	X			X
Embedded case studies	Willmott Dixon	Backhouse School	X			X	X
		Eastwick Field School	X			X	X
	Kier	St Augustine School	X		X		X
		Lane Academy	X		X		X

Table 3.4: Linking data to theory

3.4.2 Sources and methods

Yin recommends the use of multiple sources of data within individual case studies, and describes this as one of the advantages of the case study methodology (Yin, 2009). Many researchers also use multiple methods in other (non-case study) research designs (for example Kelle, 2001, Hoffman, 2009). The use of more than one source, method, investigator or theory to increase the validity of a finding has been described as 'triangulation' by Denzin (1978), following the numerical surveying method that uses several measurements to find the accurate location of a point. Just as the surveying method is designed to reduce errors in a single measurement, triangulation in social science can be seen to reduce errors in the findings from a particular methodology or data source, thereby increasing the 'validity and credibility of findings' (Patton, 1990). Yin similarly proposes that multiple methods and data sources are used to provide 'converging lines of enquiry' (Yin,

2009, p.116). The terms 'mixed-methods' or 'multi-strategy' are also used by Bryman (2006) to specifically describe the use of both quantitative and qualitative methods in the same research design.

For this research different sources and types of data were used firstly to corroborate specific issues through different sources, and secondly to understand the multiple and potentially varied perspectives at policy and at project level. In addition, multiple cases were used to examine the same issues, as has been described in the previous section.

Yin suggests that there are six potential sources of evidence in case studies: documentation, archival records, interviews, direct observations, participant-observation and physical artifacts (Yin, 2009, p.102). Detailed and formal participant-observation was considered too time-consuming to use for multiple cases.

The specific sources used for each case study are given in table 3.5. The main sources of data for the policy and the project case studies are considered to be the interviews. Yin suggests that there are three types: the 'in-depth' interview, in which a respondent may develop into a key informant through assistance over a length of time; the 'focused interview', in which a single interview is held with the respondent; and the 'structured' interview, which is similar to a face-to-face survey. For the project case studies, a list of key personnel involved with the decision making for each project was put together with assistance from the initial contact, and through a 'snowballing' from the early interviewees. These key people were contacted to arrange a recorded interview from a list of pre-determined questions (adapted in each case to the specific field of knowledge of the interviewee and to the case study where relevant) and a 'focused' or semi-structured interview was conducted.

The second main source of evidence for both the policy and project case studies is from the documentation. Documentary data for the policy case study, to inform the view of the context in which the schools were being designed and built, was gathered from the Government documents, including reports and policy documents. These were used to understand the development of the interpretation of sustainability which was being promoted by central Government for schools. Independent and commissioned public reports and reviews of the school building programme and of individual schools, including exemplar schemes, were also used to draw a wider view. Further details of both are given in section 3.4 below.

For the project case studies, data was gathered from several sources including:

Project documents

- the client brief and procurement stage documents
- subsequent design stage reports
- meetings of minutes
- cost reports
- contractors project programmes
- other specific reports on stakeholder consultation
- specific reports on sustainability aspects
- evidence of tools used to support or form decisions

Public documents

- OfSted reports
- Press reports on building projects

Interviews with (at least)

- Client, usually local authority
- Key school participant, usually bursar or business manager
- Project or Lead Architect
- Project or Lead Engineer (Structural or Services)
- Contractor, usually site or project manager

Project documentation was requested from the design and construction group of respondents. The extent to which they were willing to share these with the researcher varied. Further information about the building projects were gathered from these documents in order to support data from interviews in identifying key sustainability components and track them through the process, and to provide supporting evidence to the interviews. Publically available documents, including OfSted reports and press articles, were also used as sources of information primarily on the school itself rather than the building project.

For the project case studies only, data sources also include physical artifacts, in which Yin includes ‘a technological device, a tool or instrument, a work of art, or some other physical evidence.’ (Yin

2009, p.113). A particular example of such an artifact examined in the case studies is the government-endorsed environmental assessment tool BREEAM.

Data source	**I) Members of policy groups & Govt. advisors**	**II)Govnt. Docs incl policies and regs**	**III)Published reports, and public events**	**IV)Exemplars**	**V) Project actors**	**VI)Site visits**	**VII)Project documents**	**VIII) Public documents**	**IX)Tools**
	Policy				**Projects**				
Power in policy formation	Y	Y	Y	Y					
Power through expertise	Y				Y	Y	Y		Y
Power of numbers	Y	Y			Y		Y		Y
Power of technologies	Y		Y		Y				Y
Data type (after Yin, 2009, p.102)	Interviews	Documentation	Documentation + direct observation	Documentation	Interviews	Direct observation	Documentation	Documentation	Physical artifact

Table 3.5 Research questions and relevant sources of data

Direct observation was a further method used both for the projects and the policy case studies. This can be either 'formal' or 'casual' according to Yin; while formal observation is time consuming for four case studies, site visits to the projects were used as casual data gathering exercises for further understanding the context of the project. At least two site visits were made to each project under construction, during which notes were made and photographs taken. A third site visit was made after construction was complete, where possible. Direct observation was carried out through the site visits, included a guided tour, informal contact with the contractors on the site and taking photographs. The visits were conducted at different stages of the construction project, in order to gain a perspective of the project as it developed. For the policy case study, direct observations included attendance at workshops and meetings of the identified policy networks and special interest groups and visits to displays. Details of interview dates, documents

consulted and site visits are given in Appendix A and B, and further specific information about data sources for the policy study is given in chapter 4.

3.4.3 Development of questions and interview process

Yin's first and second levels of case study questions (Yin, 2009, p.86-87) focus the research questions into something more tangible. Level 2 are those which reflect the inquiry of the researcher; these are developed with a view to finding out details which will answer the propositions as best as possible. These questions will be termed the 'case study questions':

- CQ1: What happened in the project in general ?
- CQ2: What impact did the procurement process have on relationships within the client-design-construction team?
- CQ3: What were the power relationships between the client-design-construction team? Who was respected, who was dominant, etc?
- CQ3:What decisions were made about sustainability for the project?
- CQ4: Who or what made or determined these decisions (individual, policy, exemplar, tool), and what were the overt reasons?
- CQ5: Who was excluded from decision making? What evidence of suppressed conflict was there?

The informants were chosen so as to best represent the views of the four stakeholder groups identified in chapter 1: the client, the school, the designers and the contractors. The focus of the research on the power effects of professional expertise and potentially competing perspectives led to the inclusion of a wider group from the third of these, including the project architect and at least one other key member of the design team, for each project. The client and school respondents were chosen to be the key people involved in that particular project, as identified by the design and construction teams. In two of the four cases, the key person involved from the school was identified as the bursar (or equivalent) rather than the head teacher, and in the other two cases the head teacher who had been involved had left the school part way through the project, and so the school representative was the member of the senior management team who had continuity of involvement with the building project. As the projects were under construction during the research period, not all interviewees were easily available for interviewing. In some cases it took considerable effort and time to arrange an interview with a key player, which is

reflected in the interview dates in Appendix A. The process of recruiting informants necessarily varied depending on method and routes of contact.

Where possible, introductory informal discussions with interviewees were held, usually by telephone, to discuss the construction project and to explain what the research was looking at. These informal discussions helped to frame the initial questions, and also helped the interviews to flow more openly as a relationship had been set up between the interviewer and interviewee. The informal discussions, and the off-tape discussions either side of the more formal taped interviews and from initial phone calls and emails, were also useful in finding out more about the viewpoint and experience of the individual in their particular role. This data was not used directly in the analysis, but was used to identify potential areas of interest for following up in subsequent interviews and documents.

The interviews were designed to gather the information required to answer the case study questions above, but the design of the questions also took into account some potential problems with the interview process, and the prompt questions were configured so as to reduce these problems as far as possible. The problems and the techniques used to reduce them are given in table 3.6, which includes both the problems anticipated before the start of interviewing (numbers 1-6) and other problems encountered during the course of interviewing (numbers 7-9).

A general list of interview questions was designed, and then tailored for individual respondents. The questions were used as prompts during the interview, rather than as a strict list of questions to be asked. As successive interviews were conducted, the questions were developed in more detail in order to respond to new understandings of what had happened during a particular project and to improve the rapport and therefore the communication between the researcher and respondent. The initial list of questions is given in Appendix A.

The interviewees were sent a brief outline of the research study and details of the proforma for the interview process in advance. At the start of each interview they were given a form to sign stating their informed consent to the interview, and their right to withdraw any part or all of the interview data at any time. Copies of all three documents are attached, also in Appendix A.

	Problem	Reduced by:
1.	The respondent may be unwilling to answer questions for commercial or other confidentiality reasons	Provide details of the project and the researcher in advance for credibility and courtesy. Reassure the respondent that records of any comments can be withdrawn at any time, and that all responses will be kept confidential if requested.
2.	The respondent may be timid or awkward answering questions	Start with easy, factual questions, and try to set respondent at their ease through manners and body language
3.	The respondent may not understand the language and concepts used in the questions	Use language and concepts which the respondent can easily understand, and introduce more difficult concepts where necessary after a warm-up period.
4.	The respondent may have only understood their own part in the project and not have a wide overview.	Ask multiple respondents the same questions, and correlate with documents where possible
5.	The respondent may not realise the relevance of particular instances and so omit them.	Encourage the respondent to talk freely and openly about the project, so that the researcher has more data than the respondent may think is relevant
6.	The respondent may have forgotten, or remembered inaccurately what happened in the past	Take respondent through the project in chronological stages to help. If necessary, prompt with facts that the researcher already knows.
7.	The respondent may be overly talkative, making it difficult to put the important questions to them.	Ensure that a few key questions are identified, and are asked either at the start or at the end of the interview (depending on complexity of concept), as these are easier places to interject.
8.	The respondent may be overly terse in responses.	Ensure that a list of detailed questions are prepared, in order to gather as much information as possible from less talkative respondents.
9.	The respondents may ask to be interviewed in a group with others, making their responses more guarded	Understand the limitations of their answers based on hierarchical constraints

Table 3.6 Interviewing: potential problems and proposed solutions

For each interviewee a specific list of questions was formulated. These were not offered to the interviewees when the initial contact was made, but two asked to see the question list before the interview and it was sent to these. While the initial lists were similar, they covered different aspects and different stages of the building project, depending on the involvement of the interviewee; for example, fewer questions on the design process were asked of the contractors as they had had little involvement at this stage except in the case of the Lane Academy.

During the interview the questions were put to the participant, after a short greeting/friendly warm-up. Nearly all participants started off with shorter answers to the initial questions and, as they relaxed in front of the researcher and got used to the presence of the digital recorder, gave longer answers to subsequent questions. However the extent to which the list was followed varied a great deal. Some participants were able to talk at length about their views on sustainability and what they saw as the key sustainable aspects of the project with little input, while some answered each question briefly. Where participants were particularly talkative and difficult to direct in the interview, the prompt list was used to ensure that they had answered at some point the key questions.

After each interview, notes on the key points were written, and used in some cases to develop further interview questions for subsequent participants, both within that particular case study and within others. The interview was then transcribed in full either by the researcher or by a commercial transcription service under a confidentiality agreement.

3.4.4 Data analysis

At the start of this chapter it was stated that the two research questions were looking for, respectively, a descriptive and an explanatory answer. It was suggested that the development of a chronological order of events would be a suitable approach to answering the descriptive question, both for the policy study and for the individual case studies. This would reveal not only what solutions were chosen, but their genesis and the context and reasoning behind their choice. To answer explanatory questions Yin suggested the development of theoretical propositions, 'to focus attention on certain data and to ignore other data' (Yin, 2009, p. 130). This chapter has suggested rather than the development of formal propositions, that the 'applications' of power identified in chapter 2 be used to focus attention in the analysis of the case studies. The 'forms' of power discussed in the first half of chapter 2 were explored for all of these applications. The analysis of the data from each pair of case studies, and from the policy case, focused on different applications of power as has been shown in Table 3.4.

A large amount of data was collected, in particular for the project case studies, both of interviews which needed transcribing and analysing, and multiple project and other documents. Developing a chronological account of the project was quite complex, as no documents set out the progress of the project in this form until construction started. Developing an understanding of how decisions

were made and who was involved was even more complex, as this is often information which is not overtly included in minutes of meetings or other documents, and it was difficult to understand what some of the relevant decisions were until after all the data had been collected and analysed.

A number of Computer assisted qualitative data analysis software(CAQDAS) packages have been developed to support the coding of texts in order to help their understanding, and to discover areas of similarity and disagreement, and reveal analytical issues of interest from the wealth of textual data. Welsh (2002, p.5) reassures that 'it is not necessary to follow the grounded theory guidelines when using this software', allowing therefore the focus on pre-conceived notions of interest. She also goes on to suggest that, although appealing in its technological focus, in fact it is mainly useful for data management, and less appropriate (except for very experienced practitioners) in developing thematic ideas from the grouped sections of text 'due to the fluid and creative way in which these themes emerge.' (Welsh, 2002, p.7)

Therefore once data from the interviews and site visit notes had been gathered and transcribed they were 'fed' into NVIVO, and coded loosely in order to identify commonly grouped sections of text. First all data about the chronological sequence of events were coded. The data was then re-coded for the second research question concentrating on evidence of power relations and focusing in particular on the areas which had been identified of interest. However, following permission from Welsh, the development of the analysis from there was done by hand, referring to the individual transcripts as well as to print outs of the node 'reports'. NVIVO was not appropriate for analysing the documents, as in some cases these were very large word files, and in others were drawings, Excel programmes or photographs, or other non-textual data. Therefore the analysis of the project and public documents, and of the tools used in the projects, was carried out separately.

Schiellerup comments that qualitative data analysis 'has received little reflexive attention' (Schiellerup, 2007. P. 163). Barrett and Sutrisna agree, acknowledging that the analysis of case studies 'has been considered one of the least developed areas, and therefore the most difficult aspect of adopting the case study approach' (Barrett and Sutrisna, 2009, p. 946), and Welsh notes that 'in most published research it is unusual to find accounts of exactly how researchers analysed their data'. In this research the analysis took place over more than a year, with iterations between writing and re-analysing.

An important point which changed sometime through the analysis is that of confidentiality. Throughout the data collection stage, all respondents and projects were asked to allow the data in its entirety to be published as this PhD. All were told at the start, and again at the end, of the interview that they could ask for any specific parts to be anonymised or removed altogether. Very few instances of this happened. All organisations who allowed copies of their documents to be used were aware of this, and the only data which was asked to be omitted, or which was deliberately deleted from the documents provided, was details of costs and profits. Informants were also told that publication outside the thesis which included names of projects and individuals would be referred back to the individual for specific permission.

At a late point in the analysis of the data the author decided that the account and analysis of the case studies had developed beyond that which the informants could have predicted from what they had been told about the project at the time, and that therefore their consent was not fully informed. Therefore the names of all schools and individuals and councils have been changed. The policy forum informants, in their role as 'expert' interviewees, were selected on the basis of their position of authority held by that informant, and were on the whole opinions that they had published elsewhere. They too were happy to accept the publication of their interview. Therefore these individual names were retained.

3.5 The language of schools procurement

Language used in the procurement of buildings, and in particular that introduced by the BSF programme to the procurement of school buildings, is very specific to the area. Therefore a glossary is included below as Table 3.7 in order for the easier access to the following three chapters. This is an extract from the glossary in *An Introduction to Building Schools for the Future* (DCSF et al, 2008, pp 45-48), with some additions by the author, and applies to the terms used in the following policy and project case study chapters.

Academies	Academies are all ability independent schools established by sponsors from business, faith or voluntary groups working in partnership with central government and local education partners.
BSFI Building Schools for the Future Investments LLP	The vehicle set up by DCSF to work with PfS to invest in the BSF programme
BREEAM (Building Research Establishment Environmental Assessment Method)	BREEAM assesses the performance of buildings in the following areas – management, energy use, health and well-being, pollution, transport, land use, materials, and water
Building Bulletin 77 (BB 77) Designing for Pupils with Special Educational Needs and Disabilities in Schools	Publication by DCSF that contains information on designing for pupils with special educational needs in mainstream and special schools.
Building Bulletin 98 (BB 98) Briefing Framework for Secondary School Projects	Publication by DCSF that sets out area guidelines for secondary school buildings.
Client Design Advisor (CDA)	A consultant employed by the client to advise on specific or general aspects of design
Competitive Dialogue	The procurement process used by the public sector for the award of complex contracts such as those for the Private Finance Initiative (PFI). This procedure was introduced by the EU and became part of English law in January 2006.
Department for Children, Schools and Families (DCSF)	DCSF is the government department responsible for … overall schools capital strategy. The DCSF has responsibility for strategy, overall funding and policy within BSF, and reporting on programme and project progress to Ministers
Design and Build (D&B)	A form of contract in which a single contractor is responsible for both the design and construction of a building project. In BSF this will usually be the LEP.
Design Quality Indicator (DQI)	The DQI is a tool to assist with the briefing, development and evaluation stages of a project.
Financial Close	Point at which, if PFI is being utilised, the interest rate is fixed on the bank debt taken out by the bidder to finance the project. This is also the point at which all contractual details between the LEP and the Client are finalised and signed.
Funding Allocation Model (FAM)	PfS provides the local authority with a funding “envelope” for

	a group of schools in a project. The envelope is calculated using the FAM, based on the recommended gross floor areas and the agreed projected number of pupils.
Key Performance Indicator (KPI)	The KPIs will measure the ongoing performance of a contract. They are extensively used in the Strategic Partnering Agreement.
Local Education Partnership (LEP)	The joint venture company for local delivery of the BSF programme, formed by a local authority, BSFI and a Private Sector Partner (PSP) which is usually a consortium. The standard model anticipates the PSP owning 80% of the shares, BSFI 10% and the local authority 10%.
Official Journal of the European Union (OJEU)	The publication in which contract notices appear, to which interested suppliers respond – previously the Official Journal of the European Community (OJEC). OJEU is commonly used as an abbreviation of the official notice which appears in the Supplement to the Official Journal of the EU.
Outline Business Case (OBC)	Business Case which sets out in detail the scope, costs, affordability, risks, procurement route and timetable of the project such that it can be approved by the local authority to the satisfaction of DCSF and the Project Review Group (if PFI included), and for advancing to the procurement stages of the project. The OBC is written using guidance provided by PfS.
Partnerships for Schools (PfS)	The non-departmental public body (NDPB) set up to deliver BSF, working at both a national and local level. It is separate to BSFI, the investment vehicle. PfS has also been tasked with delivering the government's Academies programme. [since 2007]
Private Sector Partner (PSP)	The private sector organisation with which a local authority enters into a PPP or PFI contract. In BSF, the PSP will have the majority stake within the LEP, and may also be in direct contract with the local authority through PFI contracts. The PSP is usually a consortium made up of a range of private sector companies working collaboratively. These might include Construction Companies, ICT Providers, Legal Advisors and Education Consultants.
Procurement	The whole process of acquiring goods, works and services from third party providers.
Public Private Partnerships	4ps is local government's project delivery specialist. 4ps works in partnership with all local authorities to secure

Programme (4ps)	funding and accelerate the development, procurement and implementation of PFI schemes, public private partnerships, complex projects and programmes. 4ps' multidisciplinary team provides hands-on project support, gateway reviews, skills development and best-practice know-how. 4ps is providing support to local authorities for the BSF programme, through its Expert Client programme.
Reference Schemes, in 2008 renamed Sample Schools	A small number of schools chosen by the local authority as a cross-section of the type of schools the LEP will be likely to deliver. Designs developed during the procurement process and form a significant part of the evaluation process to select the private sector partner.
Transfer of Undertakings (Protection of Employment) regulations (TUPE)	TUPE is intended to safeguard the interests of an employee if the organisation they are working for transfers to another employer. Existing terms and conditions are automatically transferred to the new employer.
Wave	A group of BSF projects in a number of authorities with funding starting in a particular financial year.

Table 3.7 Glossary of schools procurement terminology

Chapter 4 Policy: pressure, advice and assessment

'Yet despite the historical pattern and the BAU [Business As Usual] projections, the world does not need to choose between averting climate change and promoting growth and development. Changes in energy technologies and the structure of economies have reduced the responsiveness of emissions to income growth, particularly in some of the richest countries. With strong, deliberate policy choices, it is possible to 'decarbonise' both developed and developing economies on the scale required for climate stabilisation, while maintaining economic growth in both.'

Nicholas Stern: 'The Economics of Climate Change', 2006

4.1 Introduction

This chapter examines the Government focus on sustainable construction and sustainable schools in the first years of this century, and how this has been influenced by the construction sector. A case study of the development of a specific discourse of sustainability from central Government is used to consider the research questions. These are refocused for this chapter as 'How is sustainability being interpreted and translated into policies and policy instruments for school buildings?', and 'What were the processes that led to these particular interpretations and translations, and who was involved in and had influence over these processes?'

The following section 4.2 describes the dominant political concerns between 2000 and 2010 through a review of key Government strategies and primary and secondary legislation. Two particular Government departments, identified as having strong influence on the development of policy for sustainability in the construction of school buildings, form the focus of the next two sections 4.3 and 4.4. These were: the Office of the Deputy Prime Minister (ODPM), whose responsibilities passed in 2006 to the Department for Communities and Local Government (DCLG); and the Department for Education and Skills (DfES), which in 2006 became the Department for Children, Schools and Families (DCSF). A review of publications from these two departments in turn considers the developing interpretations of sustainability and how these were translated into specific policy instruments. The involvement of construction industry experts in those developing interpretations is also considered, focusing on how membership of the different groups was chosen, how subjects for discussion were included and excluded, and what the impact was on the

resultant policy. In assessing the influence of the construction industry on policy formation this goes some way towards answering the second question.

In Chapter 2 it was suggested that policy networks and lobbying groups follow a continuum, with at one extreme the 'special interest groups' of Dahl and Polsby on whose autonomous behalf policies are made, while at the other are the 'policy communities' (Domhoff, 1979) whose formation, membership and discussions are closely linked to and even controlled by Government interests. In this case a right to autonomy is swapped for membership of this elite group, and for the prestige and influence over their peers that membership awards the individuals. Sections 4.3 and 4.4 identify some of these groups and individuals who had clear relationships with the Government departments, and examine the relationships and the resultant effects on policies. While according to Laumann and Knoke (1989) both 'policy communities' and 'special interest groups' may define which issues are discussed and negotiated over and which are kept out of the discussions, in the latter the definition stems from the political factions who control the membership of the group. At the extreme, power is therefore retained by Government, acting through the *perceived* expert influence of the industry groups, rather than belonging either to industry as a whole or to the individual members.

Other groups were also identified in the research who had no clear relationship with any political department or group, but who had tried, whether successfully or not, to influence the emerging focus for sustainability in school buildings. Section 4.5 identifies some of these other groups and discusses their methods for influencing policy and practice; however their resultant influence on both was difficult to determine.

The final section first summarises the (overt) policy and regulatory context within which the following case study school projects are conducted. It then discusses the policies in terms of who was involved in and excluded from their creation, and the implications for the resultant definition of sustainability. Data is drawn from a number of sources including policy documents and reviews, individual interviews carried out with some key members of the policy groups, and direct observation at industry events.

4.2 UK policy: sustainability, energy and carbon

The links between sustainability, energy and carbon were set up within the WCED report, *Our Common Future* (WCED, 1987). The report quoted the earlier discussion at Villach in 1985 on the impact of greenhouse gas emissions, including carbon, on climate change, and the conclusion drawn that 'climate change must be considered a 'plausible and serious probability'' (p.175, WCED, 1987). The major cause of anthropogenic carbon emissions is the burning of fossil fuel for energy; however energy is considered fundamental to development. Therefore this issue is at the heart of the dichotomy of sustainable development. The section on Energy in the WCED report suggested two parallel approaches to address this issue: first, 'that energy efficiency should be the cutting edge of national energy policies for sustainable development' (p.196, WCED, 1987), and second, that renewable energy should 'form the foundation of the global energy structure during the 21st century' (p195, WCED, 1987). This section reviews which of these three issues, sustainability in its broad sense, carbon, or energy, has taken precedence since then, and considers the links between the three.

Of the three, 'Sustainable development' was described by David Pearce as 'the over-arching goal of government policy' in *The social and economic value of construction: The Construction Industry's Contribution to Sustainable Development* (Pearce, 2003). Sustainability has indeed been the subject of numerous strategies and reports from various Government departments, since the Brundtland Report of 1987 and the Rio Summit in 1992. Chief amongst these was the UK strategy for sustainable development in 1994 (DoE, 1994), with the UK being the first nation to develop its own sustainable development strategy. The UK strategy was updated in 1999 (Defra, 1999) and again in 2005 (Defra, 2005). This identified four priorities for sustainable development: Sustainable Consumption and Production; Climate Change and Energy; Natural Resource Protection and Environmental Enhancement; and Sustainable Communities (Defra 2005, pg 18). 68 indicators were also introduced under these four priority headings, some of which apply to more than one area. By the 2005 Strategy, of these four priority areas climate change was described as 'the biggest threat'. Of the fourteen indicators in this particular area, four had deteriorated between 1999 and 2005, four showed no change and six had improved. One of those that had deteriorated was the supply of energy within the UK relative to its use; in 1999 the UK was a net exporter of energy, producing 22% more than it consumed, but by 2005 this had changed to producing 13% *less* than it consumed. Fossil fuels used in electricity provision had also

risen. Carbon emissions, other than from transport, were shown as having improved from industry, and remained constant since 1999 from domestic emissions, but as having increased from electricity generation due to an increase in use of fossil fuels. One indicator which had improved, however, was the production of renewable electricity.

In 2006 Defra published *Procuring the Future: Sustainable Procurement National Action Plan*. This was the final report of a task force on sustainable procurement chaired by Sir Neville Sims, a chartered civil engineer and chairman of construction company Carillion. It particularly identified the role of Government and the public sector to set standards and lead by example:

> 'The Task Force … believes the public sector should reduce the footprint of its procurement in three key environmental areas: carbon, water and waste, in areas of big spend as part of a move towards a carbon neutral, low water use, zero waste public sector.' (Defra, 2006, p.17)

The report identified construction as the top priority for the public sector (Defra, 2006, p. 17) and states that:

> 'If Government is to make progress on its carbon targets, for example, *it should focus much more attention on the carbon emissions from the production and transport of construction materials*. Materials production and transport make up 44% of all construction related emissions, while 72% of a building's life cycle carbon is embedded into the physical asset.' (Defra, 2006, p.18, emphasis added)

In 2006 the Government Cabinet Office and Treasury commissioned Sir Nicholas Stern, Head of the Government Economic Service, to write a review on *The Economics of Climate Change* (Stern, 2007). The review made it quite clear that the impacts of climate change would not be restricted to the natural environment but would include widespread and serious social and economic impacts, estimating the cost of climate change if no action was taken to be between 5 and 20% of GDP. Action to mitigate climate change, the report estimated, would cost around 1% GDP. In 2007 the Intergovernmental Panel on Climate Change fourth assessment report (IPCC 2007) further emphasised the increasing certainty that climate change was happening, that it was a result at least in part of human activity, and that it was likely to have serious impacts on the earth's ecosystems. Both reports had a strong impact on Government policy, and in 2008 the UK Government passed the Climate Change Act, which set legally binding targets for reducing

emissions of carbon dioxide and other greenhouse gases by 34% on 1996 levels by 2020 and 80% by 2050.

Meanwhile the first specific strategy for sustainable construction was published as *Building a better quality of life: a strategy for more sustainable construction* by the DETR in 2000. This states that the industry can contribute to the aims of the Sustainable Development Strategy through four main actions:

> '• being more profitable and more competitive
> • delivering buildings and structures that provide greater satisfaction, well-being and value to customers and users
> • respecting and treating its stakeholders more fairly
> • enhancing and better protecting the natural environment
> • minimising its impact on the consumption of energy (especially carbon-based energy) and natural resources.' (DETR, 2000, p.8)

In 2006 the Department for Trade and Industry reviewed progress since the 2000 *Sustainable Construction Strategy* (DTI, 2006), and fed into the publication of a much-revised *Strategy for Sustainable Construction* in June 2008. This was a joint publication between the Department for Business, Enterprise and Regulatory Reform (DBERR) and the Strategic Forum for Construction (SFfC), an over-arching Construction Industry body which collated feedback from several industry groups. The strategy includes a wide view of the effects of construction on the environmental aspects of sustainability, divided the strategy into chapters on 'the means', including 'Procurement',' Design', 'Innovation', 'People' and 'Better Regulation', and 'the ends', comprising 'Climate Change Mitigation', 'Climate Change Adaptation', 'Water', 'Biodiversity', 'Waste' and 'Materials' (HM Govt. 2008, pg 7). It also considers the responsibility of the construction sector to reducing carbon emissions, and sets a target for their reduction by 15% compared to 2008 levels by 2012.

In 2009 a report by the SFfC, the Carbon Trust and Arup set out a response to the Strategy's specific challenge to reduce carbon emissions. This report defines the carbon emission responsibilities of the construction sector as those which are incurred by the construction process itself. It excludes the carbon impacts of the manufacture of building materials and components, because of 'the lack of complete and consistent data' (page 15), but includes their transport to site.

A further picture of developing political concerns can be obtained from a brief analysis of the subjects covered by primary and secondary UK legislation. Fig 4.1 shows primary legislation since 1976 including the words 'Energy', 'Sustainable' and 'Climate Change' in the title ('Carbon' was not included in any titles). The chart shows that an earlier focus on atomic energy was followed by the 'conservation' of energy, with the first Energy Conservation Act in 1981 followed by others in 1995, 1996 and 2000. This appears to be replaced with the broader notion of 'sustainability', first in 2003 (the Sustainable Energy Act), then again in 2004 (Sustainable and Secure Buildings Act), 2006 (the Climate Change and Sustainable Energy Act) and 2007 (Sustainable Communities Act).

Fig 4.2 shows the effect on the secondary legislation. All UK Statutory Instruments passed since 2000 including 'sustainable' or 'carbon' in the title are plotted. The former was included in the titles of 7 Instruments between 2003 and 2008, and carbon appears in the titles of 13 Statutory Instruments since 2007. Between 2008 and 2011 (the date of the analysis) sustainability and sustainable development no longer featured either in the titles of secondary legislation (see Fig. 4.2), or primary legislation (see Fig 4.1). Further Energy Acts were passed in 2008, 2009, 2010 and 2011.

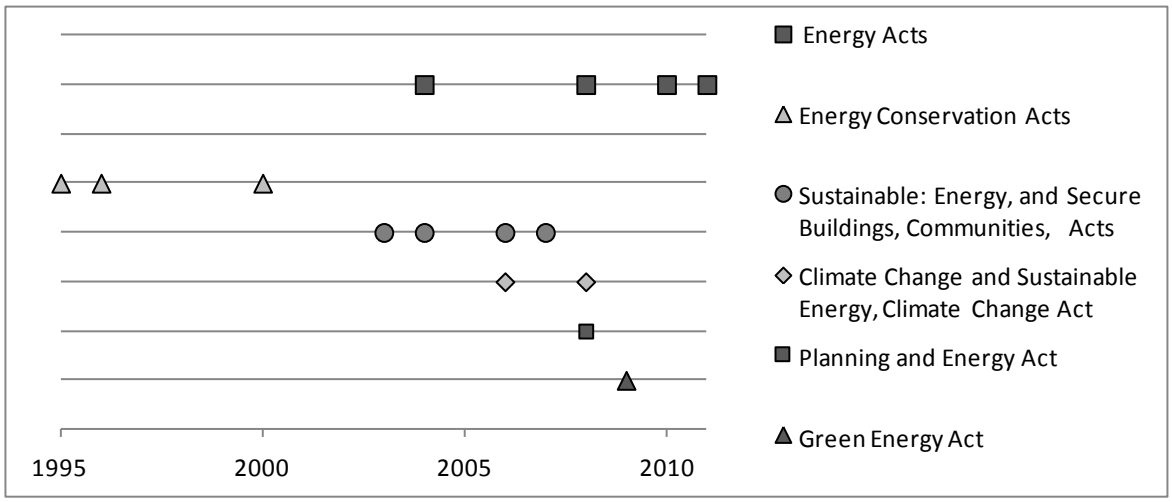

Fig 4.1 All UK Public General Acts (primary legislation) with Energy, Sustainable and Climate Change in titles

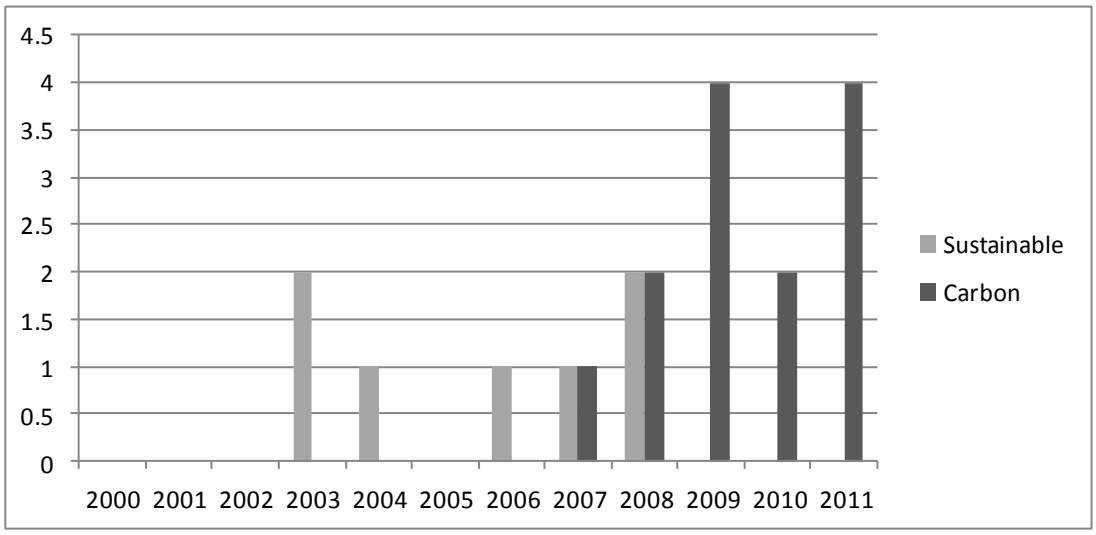

Fig 4.2 All UK Statutory Instruments (secondary legislation) with Sustainable and Carbon in titles

A mixed picture therefore appears from this overview. The pre-existing focus on energy appears to have strengthened since 2000, and in particular since 2005. Sustainable development has incorporated concerns over both energy use and carbon emissions since before the Brundtland Report of 1987; legislation and Government reports suggest that it became an increasingly important concern between 2003 and 2008. However since then a growing concern about climate change seems to have replaced the discourse of 'sustainability' with a more narrow one of 'carbon'. A clear focus on construction has also emerged, and on the Government's role to ensure that public sector construction leads the way in reducing carbon from procurement. Therefore the Government's 'over-arching goal' on sustainable development appears to be increasingly focusing on one specific aspect of sustainability, that of climate change and carbon emissions, which has conbined with a continuing focus on energy production and security. The review therefore concurs with the conclusions of Lovell at al, that within UK political goals 'climate change and energy have converged' (Lovell et al, 2009), possibly at the expense of the wider considerations of sustainability.

4.3 ODPM and DCLG: from sustainable communities to zero carbon buildings

An important influence on UK policy for sustainable buildings was the EU directive on Energy Performance of Buildings (EPBD) in December 2002. This directive required member states to measure and certify the energy performance of buildings, including that used in the heating, cooling and ventilation, and fixed lighting; it gave member states until January 2006 to include the requirements in national regulations (Szalay, 2005). The EPBD is implemented in the UK through the Building Regulations, which are statutory design requirements for all buildings in England and Wales including new buildings and major refurbishments. The Building Regulations are published by the Office of the Deputy Prime Minister (ODPM), and from 2006 the Department for Communities and Local Government (DCLG 2006).

The ODPM/DCLG also published a great number of separate policy statements and reports on sustainable construction and sustainable buildings. Some were focused specifically on housing, but these had a vital impact too on later strategies for non-domestic buildings. The role of the Department was therefore critical in the development of a political interpretation of sustainable buildings

Although the focus on energy was clearly a concern from the start, in understanding the development of future regulations for sustainable buildings it is important to acknowledge the influence of one of the first reports the ODPM published following the EPBD. This was *Sustainable Communities: Building for the Future* (ODPM 2003) published in February 2003. Written in consultation with the Local Government Association (LGA), who have a particular emit for local planning issues, the report defines a 'sustainable community' on page 5 widely, with social, economic and environmental elements. The first of twelve 'key requirements of sustainable communities' on page 5 of the report is 'A flourishing local economy to provide jobs and wealth'. Others include 'effective engagement and participation by local people, groups and businesses', and several general statements on diverse issues such as leadership, public transport, green spaces, housing mix, public spaces and community. The list of requirements also includes (twice) the need to 'minimise use of resources' both specifically for buildings and generally for the community. While requirements for 'energy efficiency' are mentioned in several places in this report, the main thrust is, however, on the need for a better supply of new and affordable housing in England.

Two months after the publication of the *Sustainable Communities* report, in April 2003 the ODPM appointed Kate Barker to review housing supply. The terms of reference were to:

> '• Conduct a review of issues underlying the lack of supply and responsiveness of housing in the UK.
>
> • In particular to consider: the role of competition, capacity, technology and finance of the housebuilding industry; and the interaction of these factors with the planning system and the Government's sustainable development objectives.' (ODPM, 2004)

The Barker Review was published a year later in March 2004. Kate Barker was an economist, and the first bullet point of the report's Foreword states: 'A weak supply of housing contributes to macroeconomic instability and hinders labour market flexibility, constraining economic growth.' In total 'economy' and 'economic' are mentioned 12 times through the report, while neither 'energy' nor 'carbon' are mentioned once. The conclusion was the need for a major programme of house-building to support the continued growth of the economy particularly in areas of high economic activity, through the provision of between 70 and 120,000 private and 17-26,000 social new homes per year. There was no discussion of the effects of further development on the degradation of the environment, local or global. Sustainable communities became part of the UK Sustainable Development Strategy, *Securing the Future* (Defra 2005, p.18) and developed into a local government planning policy statement *PPS1 Creating Sustainable Communities*.

While the Barker review was still ongoing, in December 2003 the Deputy Prime Minister (again), with the Secretary of State for the Environment and the Secretary of State for Trade and Industry, established the Sustainable Buildings Task Group. The 14 Task Group members, by invitation of Government, are given in box 4.1. The members of the group included three private property developers, three trade associations, the World Wildlife Fund, Energy Saving Trust and WRAP as public-facing third sector bodies, a representative body for the water industry, the regulatory body for social housing, and a representative for the LGA. One architecture and engineering design practice was included, and one professional institution was represented, that of the building services engineers, CIBSE.

Michael Ankers, Chief Executive, The Construction Products Association
Julian Barwick, Joint Managing Director, Development Securities
Sheila Button, Board Member, The Housing Corporation
John Callcutt, Chief Executive, Crest Nicholson (Convenor of the timber and other materials working group)
Ian Coull, Chief Executive, Slough Estates (Convenor of the waste working group)
Paul King, Campaign Director, WWF-UK
Paul Noon, Co-Chairman, Trade Union Sustainable Development Advisory Committee
Jennie Price, Chief Executive, The Waste and Resources Action Programme (WRAP)
Philip Sellwood, Chief Executive, The Energy Saving Trust (Convenor of the energy working group)
Peter Studdart, Head of Environment and Planning, Cambridge City Council
Lynne Sullivan, Sustainability Director, Broadway Malyan
Pamela Taylor, Chief Executive, Water UK (Convenor of the water working group)
Bryan Woodley, UK Timber Frame Association
Terry Wyatt, Chartered Institution of Building Services Engineers (CIBSE)

Table 4.1 Membership of the Sustainable Buildings Task Group (ODPM, 2004, p.27)

The Task Group was asked to identify 'specific, cost-effective, improvements in the quality and *environmental performance of* buildings which industry can deliver in both the short and long term' (ODPM, 2004, p.27, emphasis added). In particular they were asked to look at four areas – water, energy, timber and other construction materials, and waste reduction. Their wide-ranging recommendations were published in May 2004 in the report *Better buildings better lives* (ODPM, 2004). Four main recommendations were made by this report. The first was to rationalise the diverse construction sector bodies working on sustainable building, and in eventual response to this recommendation an industry membership organisation, the UK Green Building Council, was set up in February 2007. The Chief Executive of the UKGBC was Paul King, a member of the Sustainable Buildings Task Group.

The second recommendation was the development of a unified 'Code of Sustainable Building' (CSB), to be based on the existing Building Research Establishment's Environmental Assessment Method for non domestic (BREEAM) and 'EcoHomes' for domestic buildings, but adapted 'to

ensure progress in the areas prioritised by Government, notably energy and water efficiency and waste minimisation' (ODPM, 2004, p.6).

Regulation by 2005 for a 25% saving on water consumption and 25% energy efficiency were also recommended. The final recommendation of the report was to develop a best practice guide for delivering sustainable buildings, which included specific considerations of energy efficiency, renewable energy generation, water efficiency, reduction of materials use and improved recycling, and design for sustainable transport.

The Sustainable Building Task Group has a considerable impact on what followed. In December 2006 the ODPM/DCLG introduced the first stage of the recommended code, focused on domestic buildings, the Code for Sustainable Homes (CSH). CSH grades schemes for domestic buildings on a six point scale; it was introduced as a voluntary standard, but by 2010 Code Level 3 was to be introduced as the minimum regulatory standard in the Building Regulations. The Code covers nine design categories, and an indication of their perceived relative importance can be inferred from how minimum standards for each have been set. Therefore the categories given most importance by the code have a minimum standard set at each level of the code – this is the case for Energy/CO2, and Water. The second group of categories, of medium importance, have a minimum standard at the level of entry to the code only – these are Materials, Surface Water Run-off, and Waste. There are no minimum standards for the final four, Pollution, Health and Well-being, Management, and Ecology (DCLG, 2006, p.6). The 'Energy/CO2' category is based on improving carbon emissions compared with design to the 2006 Building Regulations, with a differential point system of 1.2 for 10% and 16.4 for 100% reduction of emissions, or 17.6 for a 'zero carbon home'. These reductions are demonstrated through the 'Target Emission Rate' (TER) calculation from the Building Regulations, based on the SAP 2005 method. An additional 1.2 points is awarded where 10%, or 2.4 points where 15%, of energy demand is 'supplied from local renewable or low carbon energy sources' (DCLG, 2006, p.14). A 'zero carbon home' in this document is defined as 'zero net emissions of carbon dioxide (CO2) from all energy use in the home' (DCLG 2006, p.27).

Earlier in the same year, and as a direct response to the requirements of the EPBD, the ODPM had also revised the 2002 UK Building Regulations, with particular changes to the *Approved Document Part L: Conservation of fuel and power*. This covers required design for thermal efficiency and standards for air-tightness for domestic and non-domestic buildings. The regulations require new

buildings to be designed to include 'a general improvement in the performance standards' for provision or renovation of thermal elements and heating, ventilation and lighting systems producing buildings that are designed to use less 25% less operational energy than those designed to the earlier 2002 standards (ODPM, 2006). A more detailed review of the calculations required by this Approved Document is given in chapter 7.

In December 2006, in the same month as the Code for Sustainable Homes was introduced, the DCLG continued its focus on building new houses with the commissioning of the *Callcutt Review of Housebuilding Delivery*. This was chaired by John Callcutt, who had also been a member of the Sustainable Buildings Task Group, and who by 2006 was the Chief Executive of the Government's regeneration agency, English Partnerships. The terms of reference for the review included a consideration of 'the nature and structure of the housebuilding industry', and how these factors influence 'the delivery of new homes to achieve the Government's target' while 'achieving high standards of energy efficiency and sustainability as set out in the Code for Sustainable Homes, and progressing to a *zero carbon standard*' (DCLG, 2007, p.3, emphasis added). During the review period the Housing Green Paper, published in July 2007, had doubled the target suggested by Barker for new homes to 240,000 per year by 2016. The *Callcutt Review* was asked to focus on how this huge increase in housing supply could be delivered by industry, as well as to respond to the emerging discourse on 'zero carbon' buildings. The penultimate chapter specifically considers the latter, stating that:

> 'We have focused mainly on the zero carbon standard in view of the scale and importance of the challenge, and we have also given some consideration to water efficiency and other aspects of sustainability which are discussed in Chapter 10.' (DCLG, 2007, p. 88)

Within the stated definition of zero carbon as set out in the CfSH, the *Callcutt Review* was able to conclude that:

> 'our Review shows clearly that the housebuilding industry and its supply chain have the potential to deliver 240,000 new good quality homes a year by 2016 and to achieve the zero carbon targets.' (DCLG, 2007, p.9)

However the review also made a recommendation for the establishment of an independent body to specifically consider the interpretation of 'zero carbon' and to follow through the delivery of zero carbon homes. The Zero Carbon Hub was subsequently set up in Summer 2008 to 'support

the delivery of zero carbon homes from 2016...[as] a public/private partnership drawing support from both government and the industry' (Zero Carbon Hub, November 2009, p. 86). The appointed chair of the Zero Carbon Hub was Paul King, the Chief Executive of the UK Green Building Council and another former member of the Sustainable Buildings Task Group. The Hub reported directly to the Government's '2016 Taskforce', also set up to ensure delivery of zero carbon buildings by 2016, and at that time co-chaired by Housing Minister, Margaret Beckett MP, and Stewart Baseley, the Executive Chairman of the Home Builders Federation.

The discourse around low and zero carbon was therefore developing as the dominant response to sustainability, and the DCLG was a principle actor in that development. At all stages the definition of 'zero carbon' was clearly tied to the parallel focus on increasing construction of new homes.

Defining zero

In the same month as the *Callcutt Review* was commissioned, December 2006, the DCLG also published their consultation on *Building a greener future: Towards zero carbon development*. The consultation asked four 'fundamental' questions:

> Q1 Are we right about the need for new housing to lead the way in delivering low-carbon and zero-carbon housing, and is it achievable in the timescale we have set out?
>
> Q2 Have we got the assessment of costs and benefits right?
>
> Q3 Have we got the balance right between the contribution of the planning system and that of building regulations? Are there other policy instruments we should consider? Are there ways in which we can design our policy instruments to achieve the same goals more cost-effectively?
>
> Q4 Are there significant solutions to climate change that our policy framework does not encourage and are there other things we should be doing to address this?
>
> (DCLG, 2006b, p.4)

The responses to the consultation (DCLG, 2007a) were mainly positive. To a specific question on the encouragement of renewable energy, 'Do you agree that, for the reasons set out, there should be a national strategy for regulating the emissions for buildings supported by local promotion of renewable and low carbon energy supply?' (p.54), 50% of respondents agreed (108 responses), while only 9% disagreed.

However one particular omission from the consultation was any mention of 'embodied' carbon or energy. This omission was highlighted as such in the analysis of the responses to the consultation, published in June 2007(DCLG, 2007a), which reported a considerable number of comments on the need to consider the 'embodied energy of materials and methods of construction', and to *include this in the definition* of zero carbon. In fact this was the principle concern of the consultation, as the comments reported throughout the text of the summary document, in response to various questions, show:

> 'The whole life cycle of buildings should be considered, not just the occupancy period. Hence embodied energy of materials and methods of construction should be assessed' (p.13, in response to Q2)
>
> 'The embodied energy of materials and the construction process should be considered.' (p.22, in response to Q4)
>
> 'The whole life cycle of buildings should be considered, not just the occupancy period. Hence embodied energy of materials and methods of construction should be assessed.' (p.40, in response to Q9)
>
> 'The definition should also take into account:
>
> – Transport emissions,
> – Carbon emissions related to the embodied energy of construction materials,
> – The use of recycled construction materials, and
> – Water consumption, including the impact of waste water treatment.' (DCLG, 2007a, p.45, in response to Q10)

The issue was also reiterated three separate times in the Conclusions section of the response to the consultation:

> 'The embodied energy of materials should be made part of Building Regulations' (p.56)
>
> 'In particular, it was suggested that transport, embodied energy of materials and water consumption should be included in the definition of zero carbon development.' (p.64)
>
> 'The whole life cycle of buildings should be considered, not just the occupancy period. Hence embodied energy of materials and methods of construction should be assessed.' (DCLG, 2007a, p.66)

Just a month after this response from the consultation was published the *Building a greener future: policy statement* was published. Only *one* reference was made to embodied carbon in the policy statement, relating it to 'technologies' rather than to the everyday building materials and construction methods to which the responses to the consultation had referred:

> '3.11 Several issues were raised by respondents. Some argued for a wider definition of zero carbon. It was suggested that we should seek to cover such issues as lifetime carbon impact of technologies (ie any carbon emissions associated with manufacture as well as use), transport emissions, and behaviour of households.
>
> 3.12 We do not believe a full consideration of embodied carbon is practical or realistic in the short-to-medium term. Evidence on the lifetime carbon costs of particular technologies is weak, and varies considerably depending on where and how they are manufactured.' (DCLG, 2007b, p 14)

The embodied carbon clearly identified in the consultation responses as that of building materials, and construction processes, was therefore re-assigned in this response to 'the lifetime carbon costs of particular technologies'. There was indeed only limited data for the embodied carbon of manufactured appliances, but the *Bath University Inventory of Carbon and Energy* for building materials giving generic values of embodied energy and carbon for standard construction materials had first been published in 2006 (Hammond and Jones, 2006). Furthermore, European standards were already in preparation which would encourage the production of data on carbon emissions for manufactured appliances and technologies through Environmental Product Declarations (BS EN 15804:2012).

A further forceful statement on what was included and what excluded from the Government's consideration of zero carbon was published a few months later by the DCLG with the UK Green Building Council, in a report on carbon reductions in new non-domestic buildings (DCLG and UKGBC, 2007c). 'The definition of zero carbon building' was the subject of the third section. This started by describing the provenance of the DCLG definition as coming from *Building a Greener Future* and the *Code for Sustainable Homes*:

> 'Communities and Local Government stated that zero carbon means that a home should be zero carbon (net over the year) for all energy use in the home. This would include energy use from cooking, washing and electronic entertainment appliances as well as space heating, cooling, ventilation, lighting and hot water. This means that any energy

> (and hence carbon emissions) drawn from the grid (electricity or gas) would have to be 'replaced' by energy generated from low and zero carbon technologies, and exported to the grid to offset those carbon emissions.' (DCLG and UKGBC, 2007c, p.21)

A list of items which are specifically excluded from the definition are also given, including:

> '• Actual behaviour of people occupying the buildings
>
> • A full consideration of embodied carbon' (DCLG and UKGBC, 2007c, p.21)

The continued, and now explicit, omission of embodied carbon effectively removes any objection to new development on the grounds of the extra embodied carbon emissions which would be the inevitable result of any new building. It also removed any responsibility from designers to use low carbon materials. However there were other clear environmental reasons to contest the proposed housing programme, which were also not being discussed in these policy documents. One of these hidden conflicts is the impact of the substantial part of the proposed house-building programme planned for the East of England on water in the region. In 2007 the Environment Agency classified the whole of the East of England as seriously water stressed (Environment Agency, 2007). A response to the subsequent East of England Implementation Plan (EEDA and EERA, 2009) by the Institution of Civil Engineers, representing the profession responsible for engineering solutions for water supply, treatment, and drainage, focused in particular on the implications of water shortage and concluded that:

'This regional policy masks the fact that in some locations *it is not sustainable to develop further*…. To truly respect environmental limits any development in such water stressed areas should be required to be water neutral through use of on site water efficiency and grey /green water re-use and recycling, rainwater harvesting etc.' (ICE, June 2009, emphasis added)

4.4 DfE and DCSF: Sustainable Schools

The focus of the recent UK Labour Government (1997-2010) on education had led to the introduction of three separate school building programmes. The Academies programme started in 2000, followed by Building Schools for the Future (BSF) in 2003 and the smaller Primary Capital Programme, for primary schools, in 2007. Both BSF and the Academies had a focus from the start on transforming learning in areas of educational and social deprivation. A focus on sustainability followed later, following a speech by Prime Minister Tony Blair in 2004 (see chapter 1). All programmes were managed initially by the Department for Education and Skills (DfES), later the

Department for Children, Schools and Families (DCSF). A non-departmental Government body, Partnerships for Schools (PfS) was created to manage the procurement process of the BSF programme. From 2006 PfS also took over procurement for the Academies, and from 2009 for all other schools procurement. Other capital funding routes for procuring new school buildings remained active. Fig 4.3 shows the procurement routes and the case study schools.

There has been an intentional and specific influence from Government over school buildings through the publication of the Building Bulletins since 1949 (see section 1.4). With the concerted focus on the new school building programmes, an additional method used by the DfES/DCSF either to share design knowledge, or promote their concerns, was the publication of exemplar designs (both those commissioned as such and those chosen post facto to demonstrate 'exemplar' qualities), and further specific design advice for schools.

In 2002, *Classrooms of the future: innovative designs for schools* was published by the School Building Design Unit (SBDU) of the DfES, reporting on an initiative which had been set up with twelve local authorities to design and build innovative new classrooms. The Foreword by 'DfES Ministerial Design Champion' David Milliband describes the purpose of the programme to produce designs which include better use of ICT, that are flexible for future changes of use, and that provide a high quality environment: 'If we are really serious about raising standards, we need to design buildings that both children and teachers find stimulating as well as functional.' (DfES, 2002, p.1). The 'major drivers of change' for school design included changing pedagogy, ICT, inclusion of pupils with special educational needs, more community use, flexibility, 'developments in building technology' and finally 'sustainability of building development and construction'.

Tony Blair's speech announcing 'sustainable schools' in 2004 mentioned a specific tool being developed to assess sustainability in school buildings. This was an adapted form of the existing Building Research Establishment Environmental Assessment tool, BREEAM. The tool assessed nine different aspects of design and construction issues which were considered to have an impact on the environment, and gave scores for procedures which reduced the impact. The nine areas were:

Management: Commissioning, site management and procedural issues
Health and well being: Factors affecting health and well being of the occupants
Energy: Operational energy and CO2 emissions
Transport: Transport related CO2 emissions and location related factors

Water: Consumption of mains water

Land use: Greenfield and brownfield sites

Ecology: Ecological value of the site and the impactsof siting

Materials: Environmental implications of building material choices

Pollution: Minimising air and water pollution

The aggregate scores gave BREEAM ratings of Good, Very Good or Excellent. Partnerships for Schools required a rating of 'Very Good' for all BSF schools from 2005.

Two years after *Classrooms for the Future* a further publication on *Exemplar designs: concepts and ideas* (DfES 2004a) set out details of designs for eleven new schools, commissioned by the DfES. These designs were intended to influence designers working on the new school buildings; however as only the architecture practices were included in the report, it may be assumed that the aim was mainly at architects. Again sustainability was not the main focus of the report, but the brief did require specific aspects identified as such to be addressed. These included 'performance requirements' for lighting, heating, thermal insulation, ventilation, hot and cold water supplies, and energy conservation. The report focused on particular issues to do with 'comfort', which included the prevention of summer overheating through 'Solar shading and the use of thermal mass and night cooling' (DfES, 2004, p.20). Provision of good ventilation was also considered important, with a variety of solutions proposed, many using the 'stack effect' to avoid the need for energy-using mechanical systems. For heating, a specific conclusion from most of the designs was that underfloor heating was to be avoided, as 'it responds too slowly to react to the fast changes of utilisation in a school and therefore requires a supplementary form of heating.'(DfES, 2004, p.21). 'Environmental performance' was assessed using BREEAM, with all designs required to achieve BREEAM Very Good. A number of renewable energy options were proposed, with the report stating that 'By the inclusion of renewable energy sources such as wind, photovoltaics and wood-fired boilers burning locally coppiced wood, the zero carbon school is achievable.' (p.21) This is the only mention of 'zero carbon' in the report, and indeed predates most of the political interest and use of the term. 'Sustainable materials' were mentioned by some of the exemplar designs, including timber frame construction and sedum roofs.

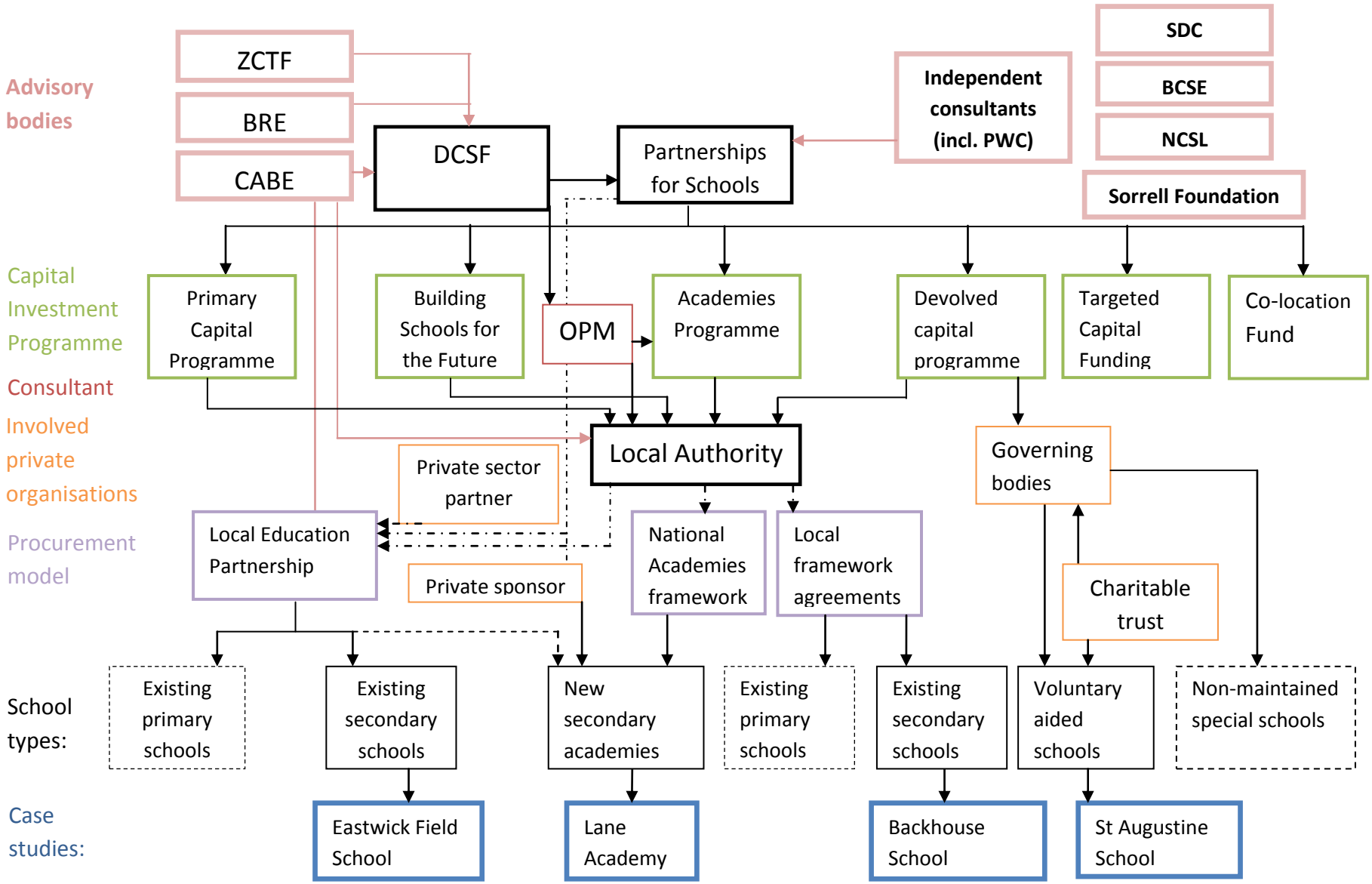

Fig 4.3 Schools procurement routes and case studies

The report was closely followed by a second, which focused this time on real case studies of refurbishment projects in seven existing school buildings. *Schools for the Future: transforming schools: an inspirational guide to remodelling secondary schools* is a lengthy report, but stated that it had been produced quickly, and as it was based on projects which had already been commissioned by local authorities rather than specially commissioned designs it seems to have been an afterthought rather than the main focus of the DfES. In addition the case studies were each written by the architects involved rather than by the SBDU editors, although the latter did add short specific introductory sections on 'Identity and Consistency', 'Conservation and Regeneration', 'Involvement and Sustainability' and 'Space and Time'. The section on 'involvement' stated that:

> 'It is widely recognised that the involvement of all stakeholders in the briefing process is vital to creating the best design solutions. … the use of the Design Quality Indicator (DQI) tool … can help to ensure that stakeholders are involved at key stages in the brief and design.' (DfES, 2004b, p.18)

The DQI tool had been developed by the Construction Industry Council (CIC) in 2002 as a tool designed to facilitate the inclusion of stakeholders in the design decision process In 2005 a specific version was developed by CIC for the DCSF for use in schools.

The section on sustainability in Schools for the Future focused on benefits of refurbishment to reducing energy use and improved thermal performance, and includes the statement that 'Reusing existing buildings uses smaller quantities of new materials, and expends less energy in manufacture and transport' (DfES, 2004b, p.19).

In 2006 the specific focus on sustainability introduced by Blair in 2004 for the new school buildings was starting to become evident. In 2006 the DfES held a specific consultation on Sustainable Schools, publishing its response in the same year (DfES 2006, 2006b). These documents defined a National Framework for Sustainable Schools, which set out eight 'doorways to sustainability'. These are given in table 4.2 below as reproduced for Teachernet (DfES, 2006c, p. 3).

Doorway	By 2020 we recommend that…
Food and drink	all schools are model suppliers of healthy, local and sustainable food and drink
Energy and water	all schools are models of energy efficiency, renewable energy use and water management
Travel and traffic	all schools are models of sustainable travel
Purchasing and waste	all schools are models of waste minimisation and sustainable procurement
Buildings and grounds	all school buildings make visible use of sustainable design features and develop their grounds in ways that help pupils learn about the natural world and sustainable living
Inclusion and participation	all schools are models of social inclusion, enabling all pupils to participate fully in school life
Local well-being	all schools are models of good corporate citizenship within their local areas
Global dimension	all schools are models of good global citizenship

Table 4.2 DfES eight doorways to sustainability (DfES, 2006c)

A new report, *Sustainable Schools: Case studies*, was also commissioned by the DfES from independent researchers, and published in December 2006. The report was based again on real examples of new school buildings, and a summary of their sustainability aspects. The foreword by Parmjit Dhanda MP includes a specific definition of 'sustainable school buildings' as:

> 'buildings that use less energy and water; that minimise waste and avoid the use of pollutants; that protect and enhance habitats for plants and wildlife; and that meet local needs.'(DfES, 2006d, p.1)

Also included was a commitment to the inclusion of stakeholders in the design of their schools, the 'formal environmental assessment' of projects through BREEAM, and the impact of the new Building Regulations on reducing operational carbon emissions. The beginning of the section on

emerging themes from the case studies explained the focus of the report on the environmental aspects of sustainability including:

- 'Reducing our dependency on fossil fuels for heating and lighting
- Encouraging methods of transport to and from school other than travel by car
- Improving school grounds in ways that encourage bio-diversity
- Reducing water demand and identifying sustainable drainage systems which reduce flood risk
- Responsibly sourcing materials, and recycling and re-using materials wherever possible.' (DfES, 2006d, p.6)

The report then mentions the social aspect of sustainability and explains that:

> 'a school that does not meet the needs of its community will not be sustainable. The best examples we have found started by finding out what people really wanted and needed.' (DfES, 2006d, p.6)

It also talks of the importance of post occupancy evaluation in order to understand how schools perform in practice, and the need for whole life costing. 'Themes' of sustainable schools which emerged from the case studies were given as:

- 'Stakeholder engagement
- Getting the basics right
- The building as learning tool
- Low energy design
- Renewable energy systems
- Managing energy and ICT' (DfES, 2006d, pp.7-11)

The final section of the report considered 'tools promoting sustainable design'. These included a number of independent tools which could be used by individual schools, and encouraged the use of feedback tools to demonstrate how the design had worked in practice. Two specific tools discussed which were required by the BSF and Academies programmes were BREEAM Schools, which concentrates on the environmental implications of design, and again the DQI for Schools.

The DfE also commissioned construction consultancy Faithful and Gould to write two reports on the cost of achieving BREEAM ratings (Lockie et al, 2006). This report was written by Lockie,

Butterss and Adams from Faithful and Gould with the collaboration of Thorne, on secondment from the BRE to the Schools Capital Design Team of DfES.

On the 10th April 2007 the Secretary of State for Education Ed Balls announced an extra £110million funding to reduce carbon emissions from schools by 60% compared with the 2002 Building Regulations (DCSF, 2007a). The funding would be made available for school designs which could demonstrate the carbon saving through the use of a spreadsheet-based tool produced by Ian Butterss of Faithful and Gould and Andrew Thorne from the DSCF called the 'schools' carbon calculator'. The announcement stated that the funding would provide for investment in heating, lighting and small power (mainly ICT), and 'low or zero carbon energy generation'. The impact of this tool is considered in chapter 7.

In the same year the DCSF with Partnerships for Schools (PfS) looked specifically at renewable energy systems, and published a guide on *The use of renewable energy in school buildings* (PfS and DCSF, 2007), as well as a spreadsheet and accompanying guide specifically on evaluating biomass heating for schools (DCSF, 2007). The reports, and increasingly the view of the Department, was that the small scale on-site renewables were more effective as a teaching tool and encouragement of behaviour change than as actual routes to carbon reduction:

Thorne '…*we produced some guidance on renewable energy systems about two years ago, two or three years ago and that was one of the things that came out, that its benefit is perhaps more educational.'*

The Children's Plan was published in December 2007 (DCSF 2007c), in which Ed Balls announced that all schools would be zero carbon by 2016. In June 2008 he followed this with the announcement of the formation of the Zero Carbon Task Force, to be chaired by Robin Nicholson.

The terms of reference for the Zero Carbon Task Force, as reported in the final report of the task group, were to look at routes to the achievement of zero carbon schools, including the development of 'a working definition of zero carbon' and 'available technologies and future potential for developing technologies to enable the target of 2016 to be met' (DCSF, 2010, p.68). The terms of reference also included the statement that:

> 'The Task Force will NOT:
>
> • consider carbon emissions beyond those attributable to the energy used within the building [ie embodied carbon]

> • address broader educational and sustainable schools issues which are not related to reducing carbon emissions from new building or refurbishment
> • consider carbon savings through offset or other measures to link with schools overseas.
> The Task Force will aim to ensure that carbon reductions are met in an efficient and socially responsible way – to discourage measures to achieve zero carbon school buildings which pass the burden elsewhere. (DCSF, 2010, p.69)'

Although Ed Balls personally appointed Robin Nicholson to chair the group, Nicholson in his own words:

> *'…was able to choose quite a lot of people that were on it…It includes Andrew Cripps from Buro Happold who has been involved in, they've been involved in quite a lot of research into their own academies and the academies they've worked on. Bill Bordass, … Bill I know very well, and Brian Ford from Nottingham, the Head of the School of Architecture there. So there were people who were used to working with really good architects and used to doing research into the poor performance of buildings'*
> (Interview with Robin Nicholson, 21/07/09).

In fact Bill Bordass had carried out post occupancy research on an educational building which Nicholson had designed (Cohen et al, 2002). The members of the group, shown in box 4.2 below, came from several different sectors of industry (architects, consultant engineers and one contractor), representatives from third sector groups (the Sustainable Development Commision (SDC), Commission for Architecture and the Built Environment (CABE), and the Building Research Establishment (BRE)), from central government (DCSF and PfS) and one member from regional government (Devon County Council).

The Task Force produced its final report in January 2010. It concluded that in fact it was not viable to demand that all new schools be zero carbon by 2016, but that path-finders should be indentified in each region of the country. The report identified four main challenges, made 30 recommendations to government, and identified a hierarchy of 'five steps to zero carbon'. These were

1. **'Engage with LAs, schools, young people and others -** The essential first step
2. **Reduce energy demand -** Low and zero carbon energy supplies are expensive and/or difficult to achieve, so it is essential to reduce energy demand as much as is practical
3. **Drive out waste through better design**

4. **Decarbonise school energy supplies** [Options are offered (again in a hierarchy) as:]
   - Optimising electricity use
   - Low carbon fossil fuels/biomass
   - On-site renewables and CHP
   - Community energy schemes
   - Local renewable energy supplies
5. **Neutralise energy supplies'**

(DCSF, 2010, pp28-29)

Robin Nicholson (Chairman) Senior Practice Director, Edward Cullinan Architects
Irena Bauman Bauman Lyons Architects
Bill Bordass William Bordass Associates and the Usable Buildings Trust
Sally Brooks Deputy Director, Schools Capital, Department for Children Schools and Families
Simon Burton Regional Director, AECOM (Faber Maunsell) Sustainable Development Group
Lizzie Chatterjee Senior Policy Adviser, Sustainable Development Commission
Peter Clegg Senior Partner, Feilden Clegg Bradley Studios
Andrew Cripps Regional Director, AECOM Limited
Vic Ebdon Head of Strategic Planning, CYPS, Devon County Council
Mike Entwisle Associate Director, Buro Happold Limited
Andy Ford Director, Fulcrum Consulting
Professor Brian Ford Head of the School of the Built Environment, University of Nottingham
Mairi Johnson Policy & Programme Director, Partnerships for Schools
Anthony Karabinas Policy Officer, Department for Communities and Local Government
Stephen Lucey Executive Director, Becta
Dame Ellen MacArthur
George Martin Head of Sustainable Development, Willmott Dixon Ltd
Peter Maxwell Head of Enabling – Public Buildings, CABE
Jon Mussett Head of Building Design Consultancy, Building Research Establishment
Deb Thoma Director, Arup Building Engineering
Liz Warren Policy Analyst, Sustainable Development Commission

Table 4.3 Membership of the Zero Carbon Task Group (DCSF, 2010, p.70)

However the report was edited by the DCSF before publication, as explained by George Martin, Head of Sustainable Development at Willmott Dixon and one of the members of the Task Force:

Interviewer: *And you said this in the Zero Carbon Schools Task Force?..Do you think it will get read and listened to…?*

Martin: *Sorry, sorry, that's two different things, you're jumping here. Have I said this, yes. …whether it's in what was published yesterday or not, I haven't yet checked.*

Interviewer: *Proofreading?*

Martin: *Oh no, it's not a proofreading, this is strategic, this is strategic government stuff in terms of what they're actually going to take out of the report. ….You know we make a whole lot of proposals, a whole load of recommendations, they decide which ones they want to include and what ones they don't.*

In 2010 the DCSF also published *Climate change and schools: a carbon management strategy for the school sector* (DSCF, 2010b), which followed a consultation and report by the Sustainable Development Commission on *Carbon Emissions from Schools: Where they arise and how to reduce them* (SDC, 2008). The DCSF report now acknowledged the crucial role of the operators of the school buildings in reducing the energy used and carbon emitted. This reflected the view of Andrew Thorne in interview in August 2009:

> *'….what I've come to realise is that every step you do just increases the probability of the zero carbon school. So if you design a school that can be zero carbon then it might be, but you need to do other things to make sure that it is, and that's why you need to make sure that the teachers are engaged and the occupants of the building understand the principles of the design, how it should work and that checks and balances are in place to make sure that that continues.'*

The number of initiatives proceeding from the DCSF, as well as the text of Blair's speech in 2004, suggested that the combined issue of sustainability and schools had indeed developed into a 'moral crusade', as it was described by the Sustainability Manager at Partnerships for Schools. The implication was, as she suggested, that educating children in sustainable buildings would teach them about sustainability. However the definition of sustainability, within the DCSF as in the

DCLG, was being increasingly narrowed to that of 'zero carbon'. The political intent for these buildings was not just to influence how pupils behaved, as suggested of the Building Bulletins by Cooper (1981), but also to influence what they thought and believed, through socialisation within a very specific discourse of sustainable development.

4.5 Policy networks and special interest groups: the continuum

The previous section has clearly identified examples of some public relationships between Government and industry, through the reviewed ODPM/DCLG and DfE/DCSF publications, formal reviews and task groups. As shown in these examples, the chairs and in many cases members of groups are appointed by Government and are required to respond to a specific brief.

There are a number of other organisations which also have close links to Government, shown through their commissioning for particular reports or tasks, and others which have more distant links but whose *intention* to influence either Government or industry is implied by their publications. While the former organisations may be similar to the policy communities identified in the previous section, but possibly with more autonomy, the latter group may be acting more in accordance with their own interests and less influenced by Government.

Of the first of these two types of organisation, one which appeared to be particularly close to Government was the Commission on Architecture and the Built Environment (CABE). CABE was formed of a small core team of (mainly) architects and administrators, and also appointed a wider group of practicing architects and engineers of high repute within industry as 'Commissioners' on a consultancy basis. The CABE Commissioners included for example Robin Nicholson, chair of the ZCTF, and Peter Maxwell, another member of the ZCTF. CABE was considerably expanded when appointed by the DCSF first as an 'enabler' for the procurement of the BSF schools, offering support to the local authority clients, and later as advisors to the design teams. CABE independently produced a number of design guides for schools, many of them aimed at clients, including *21st Century Schools* (Building Futures and CABE, 2004) and *Picturing School Design* in 2004 (CABE, 2004), and *Our School Building Matters* in 2010 (Broderick, 2010). CABE was also commissioned by the DfES and DCSF to write guides and case studies, including *Creating Excellent Secondary Schools: a design guide for clients* in 2007, updated to *Successful School Design* in 2009, *Enabling Design Quality in BSF* in 2009 and *New from Old: Transforming Secondary Schools through Refurbishment*, also in 2009 (CABE, all dates).

The BRE, formerly the Building Research Establishment, had been set up as a Government-funded research agency, before being privatised in 1997. It continued to have a close relationship with Government, as demonstrated through its monopoly of the design, development and administration of BREEAM. The requirement from 2004 for all new school buildings to be assessed against BREEAM gave the BRE a key role in the interpretation of 'sustainability' for schools.

Like CABE, the BRE also produced a considerable range of advisory publications, in this case mainly aimed at the construction industry. Two reports in 2008 were aimed specifically at the new schools programmes, and were co-authored with construction consultancy Faithful and Gould. *Costing sustainable schools* and *Putting a price on sustainable schools* identified the costs associated with achieving different scores for BREEAM Schools *and* 'low/zero carbon', and were written by Anna Surgenor of BRE Global and Ian Butterss of Faithful and Gould (Surgenor and Butterss, 2008a, 2008b). These reports clearly define 'sustainability' therefore as both measurable by BREEAM and by operational carbon emissions.

BRE also owns an 'innovation park' on its site in Watford, on which full-scale prototype buildings are open to visitors as demonstrations of specific innovations. From 2007 – 2009 one of the buildings on the site was a school building, built by Willmott Dixon, and demonstrating different built solutions for sustainability. With the exemplar design publications therefore this is another route through which designers can be influenced toward a particular interpretation of sustainability for schools.

The professional institutions representing the engineers and architects working in the construction sector institutions are further examples of groups who consider their role as being linked to policy formation; for example, the Institution of Civil Engineers aims to influence and inform policy directly through its *State of the Nation* report to Government (for example ICE, 2009), as well as through coordinated responses to Government consultations on national and regional policy (ICE East, 2009). Designers also use their professional bodies to identify knowledge about sustainability issues (see Moncaster et al, 2010), and therefore the institutions form a potentially influential link between industry and Government. Several of the institutions set up school-focused interest groups, including the Chartered Institute of Building Services Engineers (CIBSE) School Design Group, which held a conference and published a number of advice documents, and the Royal Institute of British Architects (RIBA) School Clients' Forum, which ran a number of

workshops on sustainable schools (RIBA School Client's Forum, 2008, 2009). Speakers at the RIBA SCF included Robin Nicholson and George Martin. The sector interest in building schools further led to a number of specialist workshops and conferences, including the annual Building Schools Exhibition and Conference held in February in London (BSEC, 2010). The Westminster Education Forum ran events with speakers and participants from industry and Government (for example, see Westminster Education Forum, Building Schools for the Future, 26th March 2009).

A policy group not connected to the construction industry was the Sustainable Development Commission (SDC), founded in October 2000 as 'the Government's independent advisor on sustainable development' (SDC,2010). In November 2007 the SDC published a report *Every Child's Future Matters* which emphasised the general environmental impacts of policies on children and concluded:

> 'For children's sake, all programmes, policies and initiatives brought forward by government and public service providers at all levels should be screened for their contribution to sustainable development, and challenged if they cannot be accomplished within environmental limits. Similarly, public services providers should take every opportunity to promote low-carbon ways of living to their stakeholders and exhibit this in their own buildings, operations and behaviours.' (SDC, 2007, pg 43)

This too therefore links sustainable development with environmental limits and 'low carbon ways of living'. Two members of the SDC were however members of the Zero Carbon Task Group.

There were also a number of independent education sector bodies who were engaged in trying to influence policy and practice, as shown through the publication of their own priorities for design and interpretations of sustainability for the new school buildings. These bodies included, for example, the British Council for School Environments (BCSE), a membership group including contractors as well as educators. BCSE published *Sustainable schools – getting it right* in 2006 (Bunn, 2006). The report interpreted sustainability as social, economic and environmental, but also states that

> 'A really important aspect of a school's environmental performance is the amount of greenhouse gases emitted and solid and liquid wastes generated - during the initial design and construction process, and more importantly after the building work is finished. This occurs both in normal use and in the course of maintenance and alteration.'

(Bunn, 2006, p.5)

This definition includes the impact of the construction phase – embodied carbon – as well as operational, and also maintenance and alteration. The report also emphasised the fundamental role of the client and stakeholder:

> 'Sustainability is more about the way in which a local authority or governing body sets out to procure a school building than renewable energy technology. The best chance of a school design being sustainable in practice comes when a school client and local education authority engages fully in the briefing process and are supported throughout by experts.' (Bunn, 2006, p.6)

The National College of School Leadership also published a document on *Leading sustainable schools building projects* (Alderson et al, 2008). Recommendations included training in sustainability for school leaders, more post occupancy evaluation in order to learn lessons from completed school building projects – negative as well as positive, the appointment of specific sustainability advisors for local authorities and to ensure better access to external experts for schools, and to allow more time for schools 'to research, consult on, develop and firm up their vision … for sustainability' (Alderson et al, 2008, p.39).

A further organisation, the Sorrell Foundation, set up a project called *joinedupdesignforschools*, which specifically includes children as participants in the design of their schools. Its two main objectives are described as:

> 'To explore the potential of partnership between schools and the design community and to demonstrate the potential of good design to improve the quality of life in schools, and to look at the educational value of the process of design and how it can help inspire creativity in young people.' (The Sorrell Foundation and Demos, 2001, p.10)

In 2000-2001 the foundation received support from the DfE to run pilot design schemes, and in 2008-2009 the scheme was run specifically for five academies, with support from Partnerships for Schools. The Foundation has published a number of reports and case studies demonstrating the positive effects both on design and on children of the approach.

All three of these independent bodies, with their origins in the education rather than the construction sector, therefore emphasised in particular the need for a close relationship between

the designers and the occupiers and users of the schools, and the importance of feedback on the effect of the design in the actual operation of the school.

4.6 Conclusion: power and sustainability in school building

This chapter first considered the question of how sustainability has been interpreted and translated in policies for school buildings. Energy use and carbon emissions have formed an integral part of the concerns of sustainable development since Brundtland (WCED, 1987); political discourses of sustainability and energy appeared to co-exist between 2003 and 2008, but from 2006 'sustainability' appeared to be gradually overshadowed by a discourse of carbon. This has been echoed in the development of a specific interpretation of sustainability for school buildings. However there has been a clear divide between the two government departments who have had the greatest influence.

The interpretation of sustainability which has developed within the ODPM/DCLG started from the holistic definition set out in the *Sustainable Communities Plan* in 2003, which included social, environmental and economic aspects, and had narrowed by 2006/2007 to a dominant focus on energy and carbon. Concern about water use was however still evident, as were other environmental impacts. Particular routes to reducing carbon were identified as a continued reduction of operational energy through energy efficiency measures, and a new focus on on-site renewable energy provision, both regulated through the Building Regulations of 2006. Meanwhile a parallel priority of the Department was to increase construction, both through the major school building programmes and through the building of new homes.

The interpretation of sustainability from the DfES/DCSF appears to have followed a similar track. While earlier publications focused on the broader aims of the schools programmes, and included social and economic aspects, more recent publications increasingly responded to the requirement for reducing carbon emissions. The inclusion of renewable energy sources has also applied to schools, but many of the individuals involved in developing policy have since questioned their effectiveness in reducing carbon emissions and see them instead as useful education tools. Ambitions for 'zero carbon' schools, a discourse which originated in the DCLG housing programme, overtook the latter with the 2008 statement from the DCSF that all schools would be zero carbon by 2016 (although this was later rejected by the Zero Carbon Task Force as unachievable (DCLG, 2010a)). The DCSF and the delivery body for BSF schools, Partnerships for Schools, also introduced

the 'schools carbon calculator' as a financial mechanism to measure and encourage the reduction of operational carbon emissions.

BREEAM assessments for new school buildings were also required, to give a numeric value for a much wider interpretation of environmental sustainability.

However one issue has been very different in the focus of the two departments. The inclusion of stakeholders, including clients and school end users, have been given an important –even fundamental – role in achieving sustainable schools by reports commissioned from the DCSF. A related tool required for BSF schools and Academies is the Design Quality Indicators (DQI), which were designed by the Construction Industry Council to facilitate stakeholder participation in the design.

In considering the second research question, *What were the processes that led to these particular interpretations and translations, and who was involved in and had influence over these processes?,* the chapter has described a closely woven relationship between central Government and the construction industry. A number of groups have been identified as acting to influence Government in the setting of the vision for sustainability in buildings in general and in particular in schools, in the manner of the policy forums identified and discussed in section 2.3.2 of this thesis. Several of these groups have been closely linked to Government, who have commissioned reviews, published consultations and statements, developed regulations, and have also commissioned exemplar designs, published advice and developed a number of tools to assess and measure 'sustainability' and other related aspects of the design.

However this too has revealed a difference between the two Government Departments in their preferred industry consultees. While DCLG had a close relationship with developers, the DCSF tended to choose to consult with architects and other designers.

Laumann and Knoke (1989) suggest that such groups range along a continuum from individual and independent 'special interest groups' to 'policy communities', which are close to Government. However the multiple links and relationships which have been revealed between many of the individual members and organisations involved have made it difficult to determine where on the 'continuum' each group sits. What appears to be happening instead is the operation of two separate networks, each connected to a different Department. One such network is formed of the architects and others from the design sector who are linked to each other and to the DCSF. This

network appears to be quite separate from the network of developers who are linked to the DCLG, perhaps because of a slightly derogatory view expressed by Nicholson that

> *'housebuilders have very, very few skills other than financial. I mean, that's what they do is make money and they're not interested in the hows and wheres of what it is that they are building very much.'*

These close relationships only involve a relatively few individuals, suggesting something akin to the elite groups identified by Smith (1993) discussed in chapter 2. Some industry firms are therefore well-represented; Willmott Dixon, the contractor who constructed the two case study schools discussed in the following chapter 5, is represented on several groups close to Government through the Head of Sustainable Development George Martin. In comparison, the sustainability manager of Kier, the contractor who provided the school projects discussed in chapter 6, had no presence on the Government-level policy groups, inspite of his company being a major player in the school building programmes. Membership of the elite is therefore limited, although not necessarily deliberately, to a relatively small number of individuals. However, as Schmitter (1979) has pointed out, central Government retains considerable control over the membership of the elite and over the issues which they consider.

While Special Interest Groups independent of these networks and relatively independent of Government influence do exist – the RIBA School Clients Forum and CIBSE School Design Group could be identified as such – there is little evidence of their impact on policy. Instead their impact may (conjecturally) be on individual projects. Similar groups emerging from the education sector on the whole did not appear to be included in the more formal processes of policy formation. However their clear focus on the involvement of clients and schools in the design of the buildings *is* reflected in the views of the construction sector groups close to the DCSF, showing perhaps that their influence is through a different route.

Inspite of the focus being clearly on the reduction of operational energy and carbon, the measures remained focused on the design stage, rather than assessing what happened once the schools were in use. New schools built under BSF were formally evaluated in order 'to measure the educational impact …and to identify best practice in the delivery of BSF' (PriceWaterhouseCoopers 2008, pg ii) – see reports from PricewaterhouseCoopers in 2007, 2008 and 2010. There are few evaluations of the environmental performance of the schools, and those that are published have

focused almost exclusively on the positive stories. The focus on design rather than outcomes is perhaps a reflection of the input by designers rather than by the education sector, who inspite of their clear interest in the matter were not part of any of the formal reviews or task groups identified.

Meanwhile one issue has been revealed as a clear example of an overt conflict. Embodied carbon has been expressly omitted from the definition of 'zero carbon' buildings by *both* Government Departments, as shown in the terms of reference both of the Zero Carbon Hub, set up following a recommended from a DCLG report, and the Zero Carbon Task Group, set up and reporting to DCSF. This is inspite of evidence that embodied carbon of construction materials and processes was of importance to the respondents to the *Consultation on Building a Greener Future* (DCLG, 2007a). It was also included by the authors of *Procuring the Future* (Defra, 2006), who added the carbon impacts of transport to site to those of materials and construction processes. The Strategic Forum for the Construction Industry, who co-authored the *Strategy for Sustainable Construction*, included the carbon emissions from transport to site and construction processes (SFfC, 2010).

The power of central Government over its industry advisors is illustrated by a workshop on embodied carbon in buildings in May 2010. The workshop was chaired by Paul King, Chief Executive of the Zero Carbon Hub, and attended to full capacity by over 200 industry members, including Robin Nicholson, chair of the Zero Carbon Task Group. It might be deduced then that both King and Nicholson were keenly interested in embodied carbon, but had had no power to include the issue within the policy groups which they had chaired.

Greenaway suggested that the political power over the industry groups can also be shown when changing policy affects the membership, social structure and behaviour of policy networks. The clearest example of this was seen in 2010 when the new Government disbanded the SDC and CABE. BSF was stopped and PfS dramatically restructured and reduced.

The next two chapters consider four case studies of school building projects which were designed and built within this political context, in order to examine the impact that these policy interpretations of sustainability had on its practice, and to investigate the power structures and influences acting at project level.

The choice and impacts of specific measures encouraged by policy to reduce carbon emissions, including energy efficiency and renewable energy options, as well as the impacts of that which has been discouraged, the reduction of embodied carbon, will be further discussed in chapter 7.

Chapter 5: Projects 1 and 2 - Processes and Tools

'Once we enter into what happens when a structure is actually assembled in any age, we find designing and making, architecture and engineering, art and science muddled up together so constantly and utterly that a once-and-for-all process of dissociation in an age of reason or enhanced technology appears implausible.'

Andrew Saint, in Architect and Engineer: A case of sibling rivalry, 2008

5.1 Introduction

The first two projects studied were constructed by one of the thirty leading contractors who form the UK Contractors Group, Willmott Dixon. The company has a strong environmental profile: it came third overall, and was the highest ranking construction company, in the Sunday Times Green Companies list in 2009. In 2007 Willmott Dixon worked with White Design and Max Fordham to design and build a prototype school building at the BRE (formerly Building Research Establishment) Innovation Park, demonstrating 'low carbon' and 'environmentally sustainable' building materials and technologies. Willmott Dixon's director of sustainable development, George Martin, was formerly employed at BRE as its Director of Sustainability, and was also a member of the Zero Carbon Task Force (see Chapter 4). In 2009 Willmott Dixon also appointed the former chairman of the Government's Sustainable Development Commission and founder director of NGO Forum for the Future, Jonathan Porritt, as a non-executive director; the appointment was intended to send a clear message about the company's environmental commitment.

Two schools constructed by Willmott Dixon form the case studies for this chapter. The first was procured by a Local Authority through a local framework agreement, and with 'devolved capital' funding (see Fig. 4.3 in chapter 4). The second was procured as part of wave 2 of the Building Schools for the Future programme. The procurement routes are shown in Fig 4.3 in chapter 4, and details of the two projects are given in Table 5.1 below. This chapter gives an account of what happened in each case study, looking particularly at how decisions were made about sustainability. The theoretical framework which was set up in chapter 2 is used to interpret decisions through an understanding of different forms of social power. Of particular interest in these two projects was the impact of tools and technologies on the decisions taken. A further aspect of comparison for all four case study projects was the ordering effects of the

different procurement routes, and how decisions were enabled or limited by the structure of relationships and interactions which these routes facilitated or hindered.

School/ Location	No. of pupils/ Age range	Procurement route	Cost (total incl fees)	Feasibility	Design team appointed	Contractor appointed	Construction started	Construction ended
Backhouse School, outskirts of East Anglian town	1350 11-19	Devolved capital funding from LA	£12 m	Spring 2005	Spring 2005/ Autumn 2007	Jan 2008	Summer 2008	Summer 2010
Eastwick School, Inner London Borough	1500 11-19	BSF Local Education Ptnrship	£21 m	Spring 2005	Autumn 2007 (Prf'd bidder)	Oct 2007	Spring 2008	Summer 2010

Table 5.1: Key details of Backhouse and Eastwick Field case studies

Individual documents and interviews are not referenced through the text, except where directly quoted. For details of all interviews, site visits and project documents which informed the case studies, please see Appendix A.

5.2 Backhouse School case study

5.2.1 Introduction to the Backhouse School and building project

The Backhouse School was created in 1974 by amalgamating three schools, one built on the current south site in 1959, and two schools which were built in 1957 on the north site. Both sites were large with extensive playing fields, and were divided by a busy local road. In the second half of the 1990s the south site buildings had been demolished and rebuilt, in several interlocking single storey brick buildings around courtyards. At the start of this period the south site housed the upper school (14-18 year olds), while the lower school was in the 1950s buildings on the north site; however pupils and teachers were required to cross between the sites throughout the day for different activities.

The legal responsibility of the Council to bring the buildings up to current standards for disability access, in order to cater for a wheelchair-using student, first prompted a scheme to refurbish the dilapidated north site buildings in 2002. A scheme was developed, and was costed at around £3.5m. In 2003 a new option was suggested of rebuilding the lower school

on the south site, while developing the north site for housing. There seemed to have been enthusiasm both from the school and the Council for the scheme. It would not only provide the school with new up to date buildings, but would also save the running costs of two separate sites and the current duplication of staff, and would save the educational time lost to the journey between the two sites by staff and students. The new scheme would also save the council the £3.5m cost of the refurbishment as the cost of the new buildings would be met from the sale of the north site, and would respond to the continuing pressure on housing provision in the city.

After a valuation of the north site in April 2004 the County Council formally agreed to the construction project. The council developed a scheme for new buildings on the south site, reducing the school from ten to eight form entry, and a period of public consultation followed.

In April 2005 the contract for engineering design for the feasibility stage was awarded to Mouchel, through a local framework agreement with the County Council. The architectural design was continued by the Council architects. The feasibility report was issued in June 2005. In October 2005 Mouchel were asked to carry out full project management, quantity surveying (QS) and engineering design services under a 'traditional' Joint Contracts Tribunal (JCT) contract.

5.2.2 Design development

The school appeared to be in a strong position; its agreement to surrender the large north site for housing released a capital sum of money to spend on new buildings, and directly benefited the Council through the saving of the estimated £3.5m essential capital investment needed by the old buildings. Although both sites were owned by the County Council, they were clear that they were unlikely to have carried out the project without the agreement of the school. The school was academically successful, having been identified as one of the most improved schools in 2000 by OfSted, and was judged 'Very Good' and grade 2 (out of a possible maximum of 1, minimum of 7) in 2005, although the report also mentioned the 'dispiriting conditions' of the north site buildings. The school also had an additional strength in its chair of governors at the time, a structural engineer and director of the large local office of a major design consultancy, who therefore had an advanced technical and managerial understanding of the proposed building project. The current head commented that from what she knew of the governing body, they would have been 'pretty sharp', and it was her view that both the

expert technical knowledge and the charisma of the chair of governors had given the school considerable power as a stakeholder.

However the influence that the head teacher assumed would have resulted from the Chair of Governors' expertise and charisma does not seem to have been realised in practice. Indeed the Chair saw his position very differently to the assumptions of the head teacher:

> '*I've got no authority under the contract, I've got no power to issue instructions, I'm very much hands off*.'

Asked about his 'real influence on the design of the schools' he answered '*minimal'*. Asked again, 'Only minimal?' he replied, '*Minimal, really, you know*.' His experience was based on his formal contractual position within the project, which afforded him little power over the outcome. It was possibly his better understanding of this contractual position which explained why he accepted his limited role without questioning.

In fact there was little evidence that the school had succeeded, or even tried, in persuading the council to change any particular aspects of the design. The school business manager in interview made several statements such as '*the local authority, it is their project, it's their money as it were, so it's their project*'. In answer to who was involved in the project from the school at this stage, he answered:

Business Manager: *'…there was a very clear set of parameters the county council laid down and said, " look, whatever money we get for the lower school is what you get to build the upper school." So the financial parameters were very, very tight.. the county council architects ... were brought on board to actually come up with a design and basically a lot of it had to fit in with the existing designs and style of buildings already in the upper school anyway…..*

Interviewer: *And the school was always happy with that?*

Business Manager: *Oh yes, yeah.'*

The project manager at the time from Mouchel, who was also involved in these early discussions, reiterated the view that it was the council officer who made the decisions at this stage:

> *The council were very active at that stage, mainly because of the personality of the client [the Council Officer managing the project at that stage] to be*

> *quite stringent in, "this is what we are providing... this is what you need" …..So he was quite strict with the brief here.*

Both the formal authority and the charisma of the council officer are evident in this response, with the result that his dominance appears to have been willingly accepted by the school stakeholders.

The formal mechanism for the stakeholders to have input to the design of their building was the consultation process. This appears, both from interviews and from project documents, to have been very limited. The county architect, questioned about consultation with the school, felt that '*The initial briefing went well, reasonably well*,' while noting that:

> *'We did try to formalise the staff briefing process – some were reluctant to give back the room data sheets, and we had to draw a line under it.'*

His definition of the briefing process, as well as the consultation process, appears to have been based on the right of the council and designers to determine the outcome. Consultation with the wider community also appears to have been limited, by the council and their architect, to the minimum that was required:

> *'I think we had consultations, as part of the planning process … We had a display of drawings in 4 or 5 display areas, and we stood by and answered any questions. All the questions had to be noted down and recorded as part of the planning process'.*

The structure of the planning process clearly ensured that stakeholders had a (limited) opportunity to comment, but the use of two particular physical tools, room data sheets and architectural drawings, may have constrained the feedback from actors who were not familiar with these forms of communication. Furthermore both the data sheets and the drawings already set out 'the solution', limiting options for response within carefully bounded parameters. The few comments that were made do not appear to have been taken any further.

The project manager mentioned the active role of the head teacher in managing, and in fact restricting, the input of the other members of staff:

> *'The design guidelines for the spaces are pretty well defined and letting the school dictate what they want needed to be managed and [the head] did that very well'*

Again, the 'design guidelines' for space, in the form of the Building Bulletin 98, appear to have been used to explain the limitations on the school's input to decisions. The resultant effect seems to have been an acceptance by the school that the Council, through their architects who understood and wielded the Building Bulletins and produced the room data sheets and the drawings, had the 'natural' right to dictate the design aspects of the new buildings. The Business Manager therefore stated that:

> '*I think right from day one we knew exactly what we were getting and the size of it.'*

The chair of governors, in spite of his own technical knowledge, revealed a surprisingly similar view:

Chair of Governors: '*The school was consulted'*

Interviewer: '*Consulted or told?*

Chair of Governors: *'Yeah, okay, the school was briefed as to what the plan was and had plenty of opportunity to react to what was being presented to us, but not really to get actively involved in the design and that's the way of the world.'*

Both the school business manager and the chair of the governors, despite being in a position of considerable potential power as a consequence of their own roles and expertise, therefore seem to have accepted the Council's decisions about the design of the new school as an unquestioned part of the natural order. This order was supported by the use of communication tools which were difficult to understand and interpret and therefore difficult to disagree with for the lay stakeholders. However the fact that the chair of governors, who had been fully involved and who *did* have the expert knowledge to be able to contest and query the decisions, also acquiesced, shows that the prevailing power was clearly held by the Council. Supported by the expert knowledge of the design team, they were able to impose their own definition of the situation uncontested by the school stakeholders, in spite of the latter's experience and expertise in using and managing the buildings being designed.

One aspect which supported the Council's power in this situation was their relationship with the design team. The architect was himself an employee of the Council at this time. Mouchel,

who were employed to carry out the feasibility study with the Council architect, knew that their framework agreement was coming up for renewal. They were also co-located in the council office, and all the work that this office of Mouchel carried out at the time was for the council, of which almost all was school buildings. Rather than the appointment of an external design team, who might have considered and explored the wishes of the school and the client more equally, this design team knew what the council wanted in its schools and appeared to accept their authority without question. Both the designers and the school accepted their limited role as 'the way of the world', as the chair of governors put it, and therefore as 'natural and unchangeable' in a form that suggests Lukes 'willing consent to domination'.

5.2.3 Sustainability in design choices

Another example of the power exercised by the County Council was given through the answers to the questions on how 'sustainability' had been incorporated into the design. The lack of input by the school on the choice of renewable technologies in particular was described by the chair of governors:

> *'I don't recall any serious debate at any stage about renewables. We never got involved in anything about photovoltaics or solar or ground source heat pumps [which were in fact installed] or anything like that…I'm just interrogating my* own *memory and I sort of think "well, why the hell not actually?" … I didn't really get involved in the "what are we not going to do".'*

The chair's reference to 'the what are we not going to do' here suggests that it was an issue which was deliberately kept off the agenda and that, rather than either an uncontested agreement or the ordering effects seen earlier, there was in fact some form of underlying, if unsurfaced, conflict between the school and the Council. This is further supported by evidence from the interview with the business manager, who mentioned that another governor had made a number of suggestions of different renewable technologies which the governors would have liked to have seen considered, in particular photovoltaic panels. From later comments this was clearly still a regret of his:

> *'You know, had we got solar panels, I mean you know the way energy prices are going in terms of, you know, costs the school a vast amount of money which could actually be spent on other things, so a more sustainable type of energy policy in the school would have been even better, but, you know…*

The form of language used here supports many parts of the interview in which he accepts that his view was not relevant, and that the council's right to have determined the options was unquestioningly accepted.

A question to the Mouchel project manager about sustainability made it clear that he understood sustainability to be about the provision of renewable energy technologies. In spite of this purely technical interpretation, he also stated that little expert advice had been sought other than that of their own services engineers:

Interviewer: *Was there anyone who is involved in sustainability or advising on sustainability?*

Project Manager: *[*The mechanical services engineer*] would be able to answer that better. I can't…nothing immediately springs to mind but we've got some advice about the ground source heat pumps I'm sure…, it's quite a sort of specialist area, sort of specialist subcontracting advice and how many boreholes do you need to heat this area and what sort of pump you want and that sort of thing, that's the only thing that immediately springs to mind.*

When the mechanical services engineer entered the room later, the same question was therefore put to her. Her answer tellingly revealed that it was again the Council who had determined the choice that was made:

Mechanical Engineer: *What we did, in the feasibility report we provide like a standard assessment, well we didn't really go with any external consultant at that time but we looked into the options of appraisals of different sustainable options which would be feasible for the project. And the following stage when we got the indication of the client might like to go ahead with ground source heat pump, then we went to the experts and had the proper feasibility with that option and then the client wanted to go ahead with it, didn't they?*

The mechanical engineer's position within the project appeared to be one of considerable power in this area, both as the member of the design team contractually obliged to give advice and support design decisions on energy technologies, and with the social power of her technical expertise. However she does not appear to have recognised her position as an expert - '*then we went to the experts'* - or her rights to make a choice - '*when we got the*

indication of the client might like to go ahead with ground source heat pump'. The project manager also appears to have accepted that the decision was the client's to make, and further explained that this had been made on an estimate of initial capital cost:

> *'we had a list of four or five, six options and basically went for, or the client went for,* ground *source heat pumps, primarily on cost I think it was…'*

Once again the council client appears to have redefined the situation so as to dominate all design decisions, and in this case based on very limited information. The table of options which had already been discussed at the feasibility stage, were repeated in the mechanical engineering services planning stage report, *after* the Council had made it clear which option they preferred – the table is copied as table 5.2 below.

Option	Energy per Annum	Peak Output	Approx Cost £	ROC Income*	Estimates Grant*	Comments
PV Panels	37 MWh	50 kW	£250,000	£600	£50,000	Expensive
Solar Hot Water	37 MWh	50 kW	£40,000		£400	No real demand for hot water.
Wind-Turbines	42 MWh	21 kW	£65,000	£680	£20,000	Planning issues
Biomass Boiler	45 MWh	20 kW	£35,000		£1500	Fuel delivery and storage required
Ground Source Heat Pump	40 MWh	20 kW	£35,000			Possibility of cooling and heating

Table 5.2 'Renewable energy technologies' from the mechanical engineering services stage D report, Section 8

The Council had chosen the GSHP on the basis of cost, as presented in this simple table. However the cost had been estimated at such an early stage in the design, and by services engineers who were by their own admission not experts in the system. In fact ground conditions on site later proved unsuitable for the cheaper horizontal 'slinky' option priced here. Instead deep boreholes were used, such as those used at the St Augustine project, who installed a similar system at a contract cost of a little over £200,000. Therefore the cost given in the report at this stage in the project was unlikely to have been reflected in the final price. A further impact of choosing GSHP was that underfloor heating was the most suitable mode of operation. However as later shown in chapter 7, both the carbon emissions and the cost of

the energy for the combined GSHP and underfloor heating system are likely to have been *higher* than the gas boiler and radiators that they supplemented.

Photo 5.1 Underfloor heating pipes being laid in new atrium, connected to ground source heat pump

This section of the planning stage report ends with a paragraph which seems to have been left over from the stage C report, before Mouchel had been told the Client's preferred solution:

> 'Note that *from both a cost and environmental perspective* electricity production is more attractive than heat production, due to greater savings in CO2 output and greater cost of electricity per unit kWh.' (emphasis added)

This seems to be clearly encouraging the Council to look at the electricity-generating options, PV panels and wind turbines. But the final sentence of the stage D report reiterates the decision already made by the council, without any further explanation:

> 'It is recommended that the ground source heat pump solution be investigated further.'

Detailed discussion of other options does not appear to have ocurred. In fact the most obvious physical attribute of the project at Backhouse School was the extensive space available, as shown in the photograph below which was taken from towards the back of the school grounds looking down to the new building under construction. Coupled with its position on the outskirts of town in a rural county, biomass would seem to have been a suitable option for consideration. However according to the project manager it was not considered because '*I don't think the county council like it'.* The choice of renewable energy

technologies therefore appears to have been a case similar to that presented in Flyvbjerg's (1998) analysis of the Aalborg bus terminal. Power, here framed in the form of the County Council's preferences and prejudices and supported by their contractual power over their designers, determined the choice of technology at the Backhouse School.

Photo 5.2 The new building being constructed on the large South site

While the County Council's power in determining which renewable option was chosen was evident, their knowledge of the technologies appears to have been very limited, and their provision of renewable energy at all was in response to an external influence, the planning regulations. The council officers were clearly unenthusiastic:

Council officer 2: *'Some stuff is a bit gizmo-ish really…. all this technology brings more complexities and before you know it the old days of the sort of the caretaker just flicking a switch to run the heating becomes like the Starship Enterprise.'*

Although the renewable energy options were given as the main interpretation of sustainability from the interviews with the designers and the council officers, there were others evident from the project documents. Section 6 of the supporting document to the planning application in 2006, written by the project architect, was headed 'Sustainability/ BREEAM assessment'. However almost all of the aspects in the section were either imposed by

regulation or by planning requirements, apart from two which were conventional 'good practice' within the sector.

The second half of the section was the 'pre-assessment checklist for BREEAM Schools 2005', which was required by the County Council at the time. It is evident from the introduction to the 'pre-assessment' for BREEAM that this was intended to have a follow on formal assessment of the project by a trained and independent assessor, but the County Council did not to have this as a requirement at the time. Therefore the checklist filled in by the project architect was never measured against. Furthermore neither re-assessment nor a review of potential design responses was introduced at any later stage of the design. This was particularly surprising given the long delay between the initial design and the detailed design and construction, during a period of rapidly changing knowledge and increasing regulation in this area. The architect's explanation of why the design had not been revisited was that '*if you don't do it at the initial stage it's too late to pick up*'. This section of the report was therefore repeated, with no changes, two years later in the 'Milestone 4 Report' in May 2008, just before work started on site. As with the commitment to the ground source heat pump, which was not reversed even after the ground conditions had been determined, this suggests that the situation had already been defined within such clear limits that there was no opportunity for review.

The scores for the different sections are given in table 5.3 below, showing particularly high scores for Transport and Landscape. For the former, most of the points were awarded because of the existing social and physical infrastructure. While the BREEAM scoring system awarded a maximum number of points for cycle racks being provided for 10% of the occupants, as the photograph below shows, the new construction works included 640 new racks, since this city has a very high percentage of pupils and adults who cycle to school or work. The school is also well connected by public transport. The Landscape points were awarded because the site was classified as 'brownfield', being built on the playing grounds of the existing South site. However an independent assessment would have been unlikely to have produced as high a score, since the commitment to consult does not appear to have taken place in any meaningful fashion.

The total score is marked as 655, equivalent to a 'Very Good' rating, and just 20 additional points would have gained an Excellent rating. However the County Council only required a rating of 'Very Good' to be achieved, giving no incentive to improve on this. Further than this,

although an independent assessor may have produced the same score for predicted improvements in CO2 emissions, in fact as Chapter 7 shows these are highly unlikely to have been realised in practice, with the most likely scenario being instead an increase in emissions. No comments on the BREEAM process other than the resultant score were made in the planning submission.

Photo 5.3 640 new bike racks, allowing parking for 1280 bikes, being installed – this is by far the most common mode of transport for pupils

The impact of this imposed process therefore appears to have been rather limited. This was a weak form of assessment, giving no encouragement for further action, and with no check in place to see what more could be carried out. As a tool it was an exercise in legitimating decisions which had already been made for other reasons.

Section	**Score**	**Max ***	***% of max****	**Notes and key omissions (added by the author)**
Management	108	164	*65%*	Whole life costing was omitted, losing 16 points
Health and well-being	112	160	*70%*	This related to the internal environmental quality – ventilation and lighting - of the finished building
Energy	108	180	*60%*	Most points in this section (120) were available for predicted CO2 emissions in kg/m2 based on the

				Building Bulletin 87 spreadsheet, for which PA scored the project at 84. No calculations shown.
Transport	60	60	*100%*	Includes 24 points for providing bike racks for at least 10% of the building occupants. The school already had far more racks than this, and the new works included 640 racks; this is the most common mode of transport by secondary school pupils in this town, and the racks are always full.
Water	21	49	*43%*	While a low priority of the BREEAM assessment in terms of points, this was also the lowest percentage score. Rainwater harvesting for flushing toilets, leak detection systems and 'proximity detection systems' were not incorporated.
Materials	72	102	*71%*	Most points achieved through the use of materials graded A in the BRE Green Guide. However has been commented on by several respondents during this research that the 'A' graded materials include most commonly used building materials.
Land Use	22	22	*100%*	Half the points were gained because the site is classed as 'brownfield', and half through a stated commitment to 'consult staff and pupils to determine their educational and social needs from the school grounds' and to inform them how their ideas were built into the design. There is no evidence of meaningful consultation on any aspect of design having been carried out.
Ecology	44	99	*44%*	Most points lost through no attempt to reverse a negative ecological impact of the building project. With considerable land available this would have been very possible.
Pollution	108	120	*90%*	Includes a high score for low NOx emission boilers.

*Maximum available points (and therefore percentage achieved) calculated by the author to exclude elements which were not obtainable by this project site.

Table 5.3 Derived from the pre-BREEAM assessment for Backhouse School, forming part of the County Council's Supporting Planning Statements, July 2006

5.2.4 Planning

Design development continued until the issue of the RIBA Stage D report in June 2006. This was followed by the OJEU publication of the tender notice for the JCT construction contract.

In August 2006 a formal application for planning permission was made to the Planning Authority, the City Council. There was a widely known and ongoing problem in the relationship between the two Councils, as noted by several respondents in (unprompted) comments, which they asked not to be attributed: 'a *disagreement between the City and County Councils'*, '*it was county council versus city council … the relationship was frayed*'. The project architect, who at the time worked for the County Council, had noted that the *City* Council were '*particularly … keen to be shown to be exemplar'* in terms of sustainability, and the suggestion that this was a specific object of conflict between the two councils was given by one reliable source close to both councils:

> *'There's a bit of a battle between.. City Council and the County Council about how important the environmental agenda is in relation to school builds, … the City Council would like the County Council to be more ambitious in terms of how they deliver public buildings generally and schools particularly, in a way that maximises their contribution to climate change reduction.'*

When the option for the new buildings was first agreed, the design team took care to complete all pre-planning requirements for public consultation. Section 5.2 of the feasibility report from the County Council, written a year before the planning application was submitted, noted:

> 'A pre-consultation strategy was recommended and this has already commenced with meetings held to seek the views of local residents and parents. Further meetings will need to be held as the proposals are developed *to show that their views have been fully considered*, and to hopefully ease the passage of the planning application.' (CCC, July 2005, p. 7, emphasis added)

The final phrase suggests further the uneasy relationship between the two councils, but also the impact again of the planning process on enforcing the need 'to show' that views have been taken into account. However throughout the case study there is no evidence that stakeholder views had been considered, or had any impact at all on the design of the buildings. Therefore the planning systems, as with the BREEAM process, appeared to have limited effect on actions taken.

In August 2006 a formal planning application was submitted to the City Council by the County Council. With the added incentive for the City Council that the move would release the land for housing, providing a relatively easy answer to the pressure which was coming from both

Central Government and from local residents, it seemed clear in summer 2006 that planning would be granted. It was not. Instead the City Council responded to the County Council's application with an additional requirement for a further period of consultation to demonstrate that no other educational use could be found for the land. The project was put on hold, pending further consultations.

This therefore seems to have been an example of overt conflict between the two councils, in which the City Council, as Planning Authority, had the formal power to impose a further consultation period.

Meanwhile the Mouchel framework agreement with the County Council was coming to an end. The Council decided to create new frameworks under a different contractual structure, and these were tendered in the OJEU in April 2005. Two design consultancies were appointed to the new framework from January 2006, including Mouchel. Mouchel then moved out of the co-located offices in the council buildings and into a nearby office block. The Project Management services were split off from the other design roles, and went to a third consultancy. Three major, and seven minor works, contractors were also appointed onto the framework. The Council also decided at this point to stop employing in-house design consultants, and the individuals were transferred under a TUPE (Transfer of Undertaking Protection of Employment) agreement to the design firms. The existing council projects were divided between the two design firms; in spite of the fact that it had previously been a Mouchel project, at this point Backhouse, the highest value project at the time, was given to the other firm. No consultation appears to have taken place with the two firms on choice of projects.

Planning was finally granted by the City Council in July 2007, almost a year after the application had been received. At this point the County Council decided to return the project to Mouchel.

5.2.5 The influence of the contractor

The original construction costs for the new buildings had been calculated as £8.2m, and the build programme had been set to be completed by the end of 2008. Interviews with the designers and the contractor suggested that both inflation and a high workload forecast for the Olympics had meant that construction costs had increased significantly during the extra year of consultation. Some items were value-engineered out of the contract at this point, including a planned move of the library, and the proposed temporary mobile classrooms to replace the science block when it was demolished - instead science lessons took place in the

North site buildings. The architect noted that this was probably 'more sustainable', as was re-using some of the old science fittings. Other changes were fairly minor, including some low timber retaining walls within the outdoor seating area; these were later re-instated, when it became apparent that the area was too steep for the pupils to comfortably use. A high concrete retaining wall to the tennis courts which was replaced by steel sheet piles, clad with brick. In spite of changes the construction cost was still over one million pounds higher than the original price at planning application.

The new contract for construction works was awarded to one of the three major contractors on the framework, Willmott Dixon, in January 2008. The form of contract was NEC option 3, and under this design and build form the contractor should have appointed a new design team. However the design for the Backhouse buildings was at such an advanced stage that the design team was retained by the client, and the resultant contract was therefore a 'hybrid'. Design development continued until the summer, and Willmott Dixon started on site in July 2008. The building work was conducted in phases, with the first phase, a music room, completed and handed over in February 2009. The second, and main, phase, a two storey teaching block and hall (see photograph below), was due to be completed by August 2009 for occupation at the start of the new school year in September 2009.

In the pre-contract meeting on the 27th June 2008 the Lendlease Project Manager stated and minuted that this was an important project for Willmott Dixon, their first and largest project in the new framework with the County Council, and was also important for the Council as their 'showpiece project'. The school felt that their relationship with Willmott Dixon was very good, and that both they and the local community had been kept informed about the construction works and their concerns responded to. The language used by the Business Manager and the Headteacher about their relationship with the contractor was very positive and contrasted with their passive acceptance of the Council's role shown earlier:

Business Manager: *They have made a very strong point to actually involve us in what they're doing….Our ongoing relationship with the contractor I think is very, very good.*

Headteacher: *Very good, yes*

Photo 5.4 The steel frame of the new teaching block being erected in 2008

Willmott Dixon had put an experienced accounts manager in charge of all the framework projects being run for the County Council. He took a particularly active role in the management of the Backhouse project, including basing his office there, and he and Willmott Dixon were highly rated by the design team and the County Council as well as the school. The project manager described him as a '*very nice bloke'* and also that '*the team they've got up there is fine, it's great!*'. The County Council officers also felt that '*the contractor has brought a lot to the project'* and that '*Willmott Dixon's are getting huge credibility from the school, they are on site every day.'*

There was now, for the first time in the project, a real sense that sustainability was an important issue. The flexibility in the form of contract allowed Willmott Dixon to make some changes to the materials and components. Two which the account manager highlighted as sustainability-related were a higher specification of window and the re-use of the excavated chalk as sub-soil. Although both of these were initiated as financial savings, the accounts manager was adamant that it was the sustainability aspects that were important to him. However he too suggested that it was not the priority of the client, the County Council: '*there's sort of no, extra money for, um, bells and whistles shall we say.'*

Willmott Dixon has developed two particular tools to encourage their own interpretation of sustainability on construction sites; these were the 'Ten Point Sustainable Project Criteria', and the 'Environmental playing cards for the future' game. The latter encouraged behaviour change through the collection of a set of playing cards which each represented certain activities. The types of activities were determined by the suit, as shown in table 5.4:

Suite	Type of activity	Number of cards collected by this site	Specific examples (added by author)
Clubs	Site practices and the use of assessment tools	7 out of 13	Including measures to reduce the energy use on site, which had been achieved
Diamonds	'Climate Change and Energy'	8 out of 13	Including several measures to monitor and reduce the operational energy of the building, some of which had already been achieved
Spades	'Natural Resources'	9 out of 13	Including the calculation (although not necessarily the reduction) of the embodied carbon of the major building materials – however this had not been achieved
Hearts	'Community'	11 out of 13	Including the achievement of particularly high scores for client and end user satisfaction and consultation during construction

Table 5.4 Willmott Dixon 'Playing Cards for the Future'

The playing cards also responded directly to several of the issues which had emerged in chapter 4 as being discussed in the network of construction industry professionals connected to the DCSF. The reduction of energy used in construction, and the carbon emissions of the construction materials, are both part of the embodied impacts of the building, which are currently specifically omitted from regulation. The focus on consultation and involvement of the school end user had also been an area highlighted as particularly important by a number of the Government reports commissioned by the DCSF, as discussed in chapter 4. The existence of these two issues, and proof that they were being acted on in this project, is open to several interpretations. Firstly although these issues were not part of the regulations, they were in fact happening at project level. Secondly it is possible that they were happening as a response by George Martin, Head of Sustainable Development at Willmott Dixon, to discussion he had

been involved in as part of the policy network also discussed in chapter 4. Thirdly, the mechanisms through which they were being implemented was a form of qualitative tool which through monitoring and evaluation delivered a final score and contributed to a ranking of projects and their teams. The cards themselves were on a poster in a prominent position in the site offices of the project, as shown in photo 5.1 below. The scheme was clearly structured to motivate behaviour change, and to reinforce patterns of such change through the reward of 'winning' as a site; it appears to have been an effective route to encouraging behaviour change on site. It therefore worked by introducing a system which encouraged the self-regulation, or governance, of the contractors which resulted in modification of their behaviour, echoing Foucault's work on governmentality (1977).

Photo 5.5 Willmott Dixon Playing Cards for the Future, with the ten sustainability criteria in the yellow box bellow, on wall of site office

One major setback occurred during construction, due to an error on the part of the structural engineer who had omitted windposts for lateral stability from the design. These had to be retrofitted, meaning that rather than sitting within the external wall envelope they jutted out into the rooms. The impact of the structural problems was not just the loss of internal space but also the fact that the new block was not finished in time for the start of the school year, and was indeed still unfinished at the school open evening for prospective pupils in October

2009. The building was finally opened for use in February 2010, although some external areas were still being completed up until the official opening ceremony in April.

Tools such as BREEAM, designed to support a specific set of practices of environmental sustainability, had had a limited effect if any on design choices and practices. The imposition of consultation through the planning process, while apparently designed to encourage participation in decisions, was based on the use of a number of mechanistic artefacts which limited both understanding and possible responses from the lay stakeholders. Instead decisions at each stage were restricted to the choices of the local authority client, based on their own preferences and interests rather than on technical knowledge. The requirement for a reduction of carbon emissions through on-site renewables led to the choice, again by the non-technical Council client against the (weakly offered) advice of the technical experts , to a ground source heat pump system which is likely to have emitted more carbon *and* to have cost more both in capital and in operational terms than the standard 'non-renewable' option of a gas boiler (see also chapter 7). Only in the case of the Willmot Dixon 'playing cards' was there any evidence of a tool which effectively encouraged outcomes which would not otherwise have been achieved.

The description given above suggests that, rather than a shining example of what can be achieved by a large and thriving school with considerable technical expertise on its governing body, with additional apparent power conferred by being in a position to barter land in exchange for new buildings, this is instead a story of the impact of hierarchical power (that of the County Council) over technical expertise (design team members) and practice-based professional experience (the governing body, the teaching staff and school business manager), and of an ongoing power struggle between two powerful councils, in which those who would use the resultant building (teachers, children and their parents) were all but completely excluded.

5.3 Eastwick Field School case study

5.3.1 Introduction to Eastwick Field School and building project

Eastwick Field School is a large 11-19 comprehensive in a London Borough. OfSted rated the school as grade 1, 'Outstanding' in its 2007 inspection (OfSted 2007). They also note that 'over one third of the students are eligible for free school meals, well over half are from minority ethnic groups and nearly 40% speak English as an additional language. The number of students with learning difficulties is well above the national average.' The catchment area is described

by OfSted as an area 'characterised by extremes of wealth and poverty and a high incidence of violent crime' (OfSted 2007). Because of this the use of the school as a community resource is particularly challenging.

The existing brutalist three storey school buildings (see photograph) were built in the early 1960s using load-bearing brick with concrete floor slabs. While the main structure was still sound, the roof and windows were in serious need of repair and the gas-fired heating system was energy-intensive and ineffective. An additional problem, identified for some time by the school leadership team and governors, was the lack of disabled access; only about 5% of the existing buildings was accessible by wheelchair.

In 2005 the London Borough applied to be part of wave 2 of the BSF programme. Eastwick Field School, with two others, was identified as one of the three 'reference' schools for the first phase of the BSF within the Borough, to be followed by three others. A firm of architects was appointed to develop a feasibility design to RIBA Stage C. As well as responding to mandatory Building Regulations requirements and following design guidance from the Building Bulletins, the reference design also incorporated the requirements published by Partnerships for Schools (PfS) for BSF schools, principally a requirement for BREEAM Good (at that time) and use of the Design Quality Indicators tool (see chapter 4). The council's priorities and those of the school and governors were developed through a 'visioning' exercise. The school's resultant priorities included a desire for 'sustainability' at this early stage, but related to a BREEAM assessment rather than to any particular aspect. The requirement for disabled access, also present at this stage, later became a key focus:

> **'2 School Environment**
>
> We want the architects who design our school to take into account the following issues when designing our school….
>
> ….
>
> • Enabling disabled access to all areas of the building.
>
> • Sustainability. Design to be at least "good" when assessed under BREEAM.'
>
> School's requirements, Stage C Design Report, 05/10/2006

An initial Design Quality Indicator (DQI) exercise was carried out in July 2006 with six members of the Council client team, the reference scheme architect, and from the school the Head Teacher, Director of Resources, Chair of Governors and eight other school stakeholders, including a parent and two pupils. The DQI process assigned weightings to the school's

different priorities as F ('Fundamental – basic, essential'), AV ('Added Value – desirable, beneficial') and E ('Excellence – exceptional'). There are three main sections, with sub-sections shown in brackets: Functionality (Access, Space, Uses), Impact (The School in its Community, Within the School, Form and Materials, Character and Innovation), and Build Quality (Performance, Engineering Services and Construction). Two aspects were labelled as 'sustainability', one in the 'Engineering Services' section under paragraph 38, 'Minimising CO2, water and energy', and the other under the 'Construction' section, paragraph 39,'Climate change'. Paragraphs 38-40 of the outcome from the exercise are copied in Table 5.5.

Section	Issue	Q no.	Def-ault score	Work-shop score	Notes [Added by workshop participants]
Engineering services					
38 minimising CO2, water and energy	The building and engineering systems should enable efficient use of energy and water and be designed to minimise:	E1	AV	AV	Should be inspirational and educational in their use of sustainable resources
	CO2 emissions	E6	E	E	
	the requirement for heating	E7	AV	AV	
	the requirement for mechanical ventilation	E8	AV	AV	
	the requirement for cooling	E9	AV	AV	
Construction					
39 climate change	The building design should consider future climate change	C7	E	AV	
	have an efficient structure	C8	AV	AV	
	use sustainable and renewable systems and have low embodied energy	C9	AV	E	Utilise on-site renewable energy

Table 5.5 Extract from first DQI exercise at Eastwick Field School July 2006

Additional comments were added to section 3 on 'inclusion' in particular, showing the school's requirements for accessibility throughout the school for all. In response to the section 9 on 'enhancing learning' a comment was added that 'New knowledge includes sustainability. The building itself should be a learning resource.' Embodied energy is included as an issue for discussion, although as part of a very broad section.

The DQI exercise appeared to be enabling input by the school, to ensure that their opinions and concerns were taken into account in the design. However in fact the participants found the process confusing and frustrating. The Director of Resources for the school explained that *'we just didn't really understand the process … we got confused about what was essential and what was excellent'*. Furthermore she found it '*horrible! It was the worst thing we did!'* . She also felt that it had had no effect: '*luckily it didn't have any impact on the final design … so I don't really know what it was all about.'*

The tool did have three particular effects. Firstly it acted as Bachrach and Baratz's (1970) 'mobilization of bias' through determining which subjects were discussed, specifically enabling discussion of pre-determined subjects, but with no provision for the introduction of a completely new concern. The school *did* add to the DQI results a comment on the importance of the building as learning tool, reflecting a theme which recurred through the DCSF consultees (see chapter 4). Secondly the tool defined a specific interpretation of sustainability, as carbon emissions, energy and water use. Finally the only scoring options were positive – that is to say, no issues could be scored as not important or negative in value by the school. Here again it acted to limit possible outcomes.

The limitations suggest that although it may have been designed to support consultation, instead the tool was an exercise in demonstrating support for the pre-determined requirements of PfS for the new schools, while restricting alternative views.

The architect's Stage C Report included the responses to the DQI exercise and also to separate reviews of the design carried out by the school and the Client Design Advisor to the Council. The aspirations added by the school to the report were that:

> 'The building should contribute to the development of new knowledge and be used itself as an educational tool, in its construction and providing good practice examples, including sustainability.'

The feasibility 'reference' design that was produced had an important implication for the future buildings; the decision to retain and refurbish most of the existing school, providing only 20% by floor area of new build, drove the calculation of the funding. This was derived using the BSF funding model, which was built up by assigning a specific amount per metre squared for new build areas, a lesser amount for 'remodelled' areas, a third for 'refurbishment' and nothing for 'untouched' areas. Extra funds were awarded for specific site difficulties where

they could be demonstrated in advance. For Eastwick Field the total budget (including consultants fees as well as construction costs) was fixed at £20.9m.

Photo 5.6 The existing buildings at Eastwick Field: it was decided to retain most of these, in spite of problems with disabled access

5.3.2 Procuring the LEP and design progression

The design, as well as those of the two other 'reference' schools, formed part of the Borough's Outline Business Case (OBC) submission in October 2006. This was approved by Partnerships for Schools, and the Borough was accepted into the BSF programme.

The next stage was the procurement of the Local Education Partnership (LEP), a public-private partnership between the Local Authority (10%), BSF Investments LLP (10%), and a private sector partner, and a specific procurement process which had been introduced by the BSF programme. According to Partnerships for Schools:

> 'The expected benefits of the LEP include better design quality, significant cost efficiencies, shorter time scales and improved educational outcomes.' (reported in Price Waterhouse Cooper report 2007)

Once procured the new LEP would be contracted to manage the delivery of all the BSF projects for that authority. The procurement of the LEP therefore forms an important and extensive stage of the BSF programme for any local authority. It was also a valuable contract for the private sector partner; the six schools within this wave of BSF for the Borough had a total value of £168million, with the prospect of further schools being procured through the same LEP in later waves.

The Invitation to Tender (ITT) for the LEP was published in Autumn 2006. A process of tendering called 'competitive dialogue' was entered into with two consortia one of which was Mouchel Babcock Education (MBE).

The 'client' body of this London Borough was complicated. The education services were run by a not-for-profit company on behalf of the Local Authority. However this company did not take on the procurement of the LEP, but did retain a role as a stakeholder. The LEP was procured instead by a consultant to the Borough, an architect working for a project management consulting firm, who had the title of BSF Programme Manager. Other consultants were also appointed as part of the client team at this stage. At the initial meeting of the competitive dialogue process there were fifteen client representatives, including 4 council officers, 3 Learning Trust staff, one representative from Partnerships for Schools, and 7 external consultants to the council. The teams from the bidding consortia were even bigger; although the number who could attend meetings was restricted by the Council to twenty, the MBE list of contact details for the bidding team at this stage has 71 names, including MBE staff, their sub-consultant architects and engineers, and their partnered contractors.

The contract to form the LEP was substantially judged on the quality of the design submission for the three reference schemes, which meant that considerable attention was focused on this. However neither bidding team had been involved in the development of the earlier feasibility stage design, as a requirement of the bidding rules. The architects who were part of the MBE bidding team found that this scheme:

> *'..a) wasn't affordable, because it was basically a design retention scheme. It just kept the external façade and* replanned *the entire internal layout according to how they wanted it to be rather than recognising the structural limitations that this building has. And b) it didn't particularly represent the education aspirations of the school because it had been done quite a long time*

> *previously to when we actually got involved. …So I can't say it wasn't useful, but it did seem a little bit pointless because we basically did it again.*

During this stage the designs produced by the two bidding teams were commented on by the school head and governing body, within strictly programmed feedback sessions. However all those involved in the consultation had to sign a confidentiality agreement, and while the process of competitive dialogue was on-going there was no possibility for wider consultation. The lack of involvement of the students at this stage was a particular issue for the school Director of Resources:

> *'when a lot of the really important discussions were going on the student design group just couldn't be involved. I mean, the students set out their priorities so we could kind of look at their priorities and how they were met* and *both designed, but we couldn't show them the two designs or get their input in any way. So it was only when we were down to the one bidder and then by that stage the designs are, not completely set, but you know…*

The large number of consultants involved from the council did not decrease once MBE had been appointed preferred bidder. In 2008 Navigant Consulting took over as the key client representative for the Borough. Some of the other consultants had also changed and this, along with the large number of consultants involved as and on behalf of the client, created some ongoing confusion and fragmentation between stages. The quantity surveyor felt that *'Partly the trouble in BSF is that you never know quite who the clients are'.* The architects certainly saw the school as the primary client for this stage, but also that they had been given this right by the Council, who were clearly still the dominant party:

Architect 1: *I mean [the Borough Council] have been quite good, they've kind of put the school there as* the *client which I think is probably right, because essentially the school is [Eastwick Field] and it's actually [the head teacher] and [the Director of Resources] who are really our clients, whilst [the Borough] are the kind of ultimate client.*

On being appointed preferred bidder, the contractor who was on the bidding team decided they lacked the resources to cope with building all three reference scheme schools at once, and Willmott Dixon subsequently were given the contract with MBE for the construction of Eastwick Field. The architects who had been on the bid team were then novated to Willmott Dixon under a Design and Build contract. However since Willmott Dixon had not been involved

in the design development phase, the contractor saw the architects as retaining considerable loyalty to their original client, MBE, stating that '*they are fiercely protective of the client's[MBE's] interests*'.

A further discontinuity in personnel had been in the mechanical and electrical services design. The original feasibility design for services had been carried out by a sub-contractor to the then architects. The services engineers who then carried out the design development as part of the bidding teams were from different organisations. Once the preferred bidder had been appointed, in the case of Eastwick Field School the contractor changed, and the new contractor Willmott Dixon employed yet another services consultant, who then sub-contracted the work to a fourth company. The architect felt that '*M&E integration has been one of the major challenges we had.'* Navigant, representing the client, agreed that the fragmentation of the services design between different design stages had been '*one of our problems'.*

The impact of the procurement process was therefore already clear. The process had determined that the original 'reference' design for the feasibility stage was undertaken by a different set of designers to the subsequent bidding teams who developed the detailed designs. The contractor on the winning bid team then decided that they did not have the resources for three large building projects in the same area simultaneously, which is a common and predictable position to be in, and the construction contract therefore went to a new contractor and their sub-consultants, none of whom had been involved in either the feasibility stage or the design development stage. The 'competitive dialogue' process being carried out at the same time as design development also meant that there was little possibility of consultation during this critical phase.

5.3.3 Reaching 'Financial Close'

MBE were appointed 'preferred bidder' in October 2006. However this was not the final stage in winning the LEP contract, which would happen at 'financial close', planned to follow in December 2007. The PfS National Framework Guidance Document for BSF and One School Pathfinder Projects (no date) explains the purpose of this stage as follows:

> '2.5 Preferred Bidder and FBC
>
> Upon selection of the Preferred Bidder at the completion of the ITT [Invitation to Tender] process, the following is expected to take place:

> (a) The Preferred Bidder will be expected to develop their detailed designs further and apply for detailed planning permission;
>
> (b) The Local Authority, working closely with the Preferred Bidder, will be expected to produce a Final Business Case (FBC). …
>
> (c) The Local Authority and the Preferred Bidder will be expected to insert any project specific information into the Building Contract to be used. For the avoidance of doubt, the Building Contract is not open to negotiation and/or amendment. Any activity during this phase relates solely to inserting project specific data into the Building Contract.'

What actually happened during this stage was revealed by a blog, started by the school's Director of Resources after the first public consultation in order to keep the parents and wider community informed of progress. The blog ran from October 2007 to October 2008, and was then restarted in June 2009. It detailed in particular the school's intense frustration with the process, documenting the continuous negotiation and conflict involved in attempting to reach a finalised design before 'financial close'.

One particular aspect detailed in the blog which took more time than the PfS document seems to have expected was consultation. This was clearly seen as very important by the school:

> '…governors are absolutely clear, and quite rightly, that they won't approve entry into BSF until they feel we have had full consultation with stakeholder groups…..
> We need more student consultation. We need to know that what the students suggested was listened to and acted upon, and this hasn't been demonstrated yet.'
>
> Director of Resources blog entry for 11 November 2007

However consultation had not been possible before the preferred bidder was announced due to the legal requirements of the competitive dialogue process. By the time that MBE were appointed preferred bidder in October 2007, the designs were considerably developed. The school held their first public consultation exercise as soon as possible afterwards, on 30th October 2007, but the comments from attendees included several who felt that the plans had already been finalised with no consultation:

> *'this is* 'consultation' *as window dressing; it seems to me too late to have any significant input'*

While the school was particularly keen to include parents and pupils in the design, the procurement process had severely limited the possibilities for this.

On November 6th the blog itemised twenty-three design issues which still had to be resolved before Financial Close could be reached, planned for December. Most of the issues are considerably more fundamental than the further development of detailed design suggested by the PfS document. They included for example, the choice of cladding of the façade of the new building, which would form the elevation to the main entrance of the school. Three other examples under the heading 'Work Still Needed' were :

- quality of materials (not yet discussed)
- building fully accessible (although has gone from 5% to 85% accessible and full curriculum can be accessed)
- energy saving/environmental impact,

By 6 December the last of these had moved up to the heading 'Looking Much Better', but suggests limited input by the school:

> Energy saving/environmental impact (↑ I have now glanced at what's known as a BREEAM assessment, and it comes in as "Very good", but have not yet seen or discussed the full detail)

BREEAM appears by this stage to be taken as an unquestioned 'black box' which dealt with energy and environmental issues, supported by its identification at early stages with 'sustainability'.

The DQI exercise was repeated on 3rd December 2007, and showed some considerable dissatisfaction with the design, although dressed up in a positive light by the DQI facilitator:

> 'FAVE SCORES WEIGHTED
>
> The weighted FAVE scores show that respondents have scored the proposals well below the aspirational levels set at the FAVE workshop but they do follow a pattern which responds to the schools priorities. The proposals have only failed on two of the fundamentals, parking and access for SEN [Special Educational Needs pupils]. Providing sufficient parking in urban settings can, however, be difficult and full access for SEN can be problematic in existing buildings.' (DQI 03/12/07)

The design which had emerged from the Competitive Dialogue process was felt by the Governing Body to be 'uninspiring', and the Governor's Requirements had by now developed into a separate scheme drawn up by the architects called the 'Governors' Scheme'. The key dialogue during this stage seems to have been between the architects and the governing body,

who were clearly a forceful and influential body – 'our Governing Body are very much their own people' as the school's Director of Resources put it. By 8th January 2008 the Director of Resources estimated that this must have resulted in over 100 changes to the original bid-winning design since October.

At the same time as the design development meetings, a separate set of meetings were taking place between the Quantity Surveyor and the client group, including Navigant, MBE and the BSF Programme Manager for the Borough. The Quantity Surveyor (QS) therefore had to provide costs for the Governors' proposals while never having been present in the meetings where these were discussed. This obviously caused some friction for him:

> *'we have crossed swords a few times in the past with [the architect] – they like to dominate a bit and think they're the most important. They* presented *their design solutions to the school before they were checked by the QS, so we did have words a few times, but we're both professionals and we got on with it.'*

However he was instrumental in developing the options which were offered to the school:

> *'Oh yes* [laughing], *frequent compromises. Lots of value engineering decisions had to be made. There was a triangle really – the school would have their* views*, tell them to [the architect], then we would cost them – up to us to come up with a scheme that was affordable. We had to give a lot of options for the school to pick the ones they wanted for the Value Engineering exercise, to give the school a sense of ownership – that's right that they should.'* [Showed a typical VE sheet - £500,000 worth of savings listed, for the school to pick £100,000 from]

Although the school clearly did have some power through this process, here too it appears that their choice was limited to the options put to them at the time, in this case by the QS, who felt that it was 'up to us to come up with a scheme'. Like the DQI process, many aspects were either not included for negotiation, or their exclusion was encouraged through a simple cost estimate. Both of these processes themselves seem to be an example of Lukes' second dimension of power, in determining which issues were available for discussion while keeping other issues off the agenda. The use of the Value Engineering spreadsheet, which limited information about each diverse aspect to a single numerical cost rather than to any wider interpretation of 'value', turned the exercise into one which was essentially controlled by the QS, even though he was excluded from the design discussion.

Although originally scheduled for December 2007, financial close and a finalised design had still not been reached by March 2008. At this point the governing body were invited to discuss their ongoing concerns with the final design the Borough Council, including the Chief Executive. According to the Director of Resources:

> *'The meeting had a very* reasonable *tone, but I'm not sure how much further forward we were at the end of it.'*

Surprisingly this 'reasonable tone' seems to have been a continuing factor of all the negotiations, in spite of their length and the amount of effort and time they took up for all involved. Indeed although the governors were clearly determined to make sure that the design answered their requirements, most of those involved at this stage felt that they were on the whole working together to try to resolve issues, and there was no evident feeling of conflict between the council, MBE, the school and governors, the designers or the contractors. As the contractor put it,

> *'we're pretty even really, I* can't *think of anyone too domineering…we've been quite lucky here and things are on a fairly even keel.'*

Even so no-one seems to have been entirely satisfied with the outcome. The Chair of Governors stated in an email that

> *'It was weird how we had literally hundreds of meetings beforehand but still had a solution that didn't particularly reflect what we needed.'*

The contractor started on site on the 25th March 2008 as originally planned, in spite of Financial Close still not having been reached. An Additional Works Contract was used to limit the contractor's liability, passing most of the risk to the Council. This appears to have been agreed with the Council without informing the school until the week before. The blog entry for the 16th March says: 'This [starting on site] was completely unexpected because the Governing Body still haven't agreed to enter the programme.'

By June 2008 the temporary classrooms had been erected and half of the school decamped to them. Construction work on the existing buildings was now starting. The Director of Resources was still clear in her blog that the *'Governors won't sign the Governing Body Agreement until they are completely satisfied that they can live with what is being proposed',* but logistically and politically the decision not to accept the design was becoming extremely difficult now work had started.

Photo 5.7 Temporary classrooms installed at Eastwick Field School

After almost continuous negotiations, Financial Close was finally reached in November 2008, eleven months after originally scheduled and eight months after the contractors had started on site.

One issue remaining for the school was accessibility. Although most of the final design was accessible, the cost of changing the width of existing door openings in the areas which had been designated as 'untouched' at the Feasibility Stage (and had therefore had had no cost assigned to them) proved prohibitive, and this work was never done. The power of the costing model, crude as it was and carried out before the design, had nevertheless determined that one of the main aims of the school was not achieved. The Director of Resource's advice to other schools entering the BSF process was to realise just how important this early feasibility stage was in determining what was going to be finally possible.

As well as the personal cost in terms of effort and time spent in meetings, most of those involved believed that the BSF process itself had taken a huge financial resource. The Director of Resources stated that: '*It is the* most *crazy waste of public money that I've ever come across, and very few people involved in the process disagree*.' (blog entry 16 December 2007). The contractor, who had many years of experience of building schools under similar Design and Build contracts outside BSF, estimated the cost of bidding as having been between £1-1.5million, and believed that '*there is a hell of a lot of waste in fees and money*'. This had the effect of restricting the organisations who could afford to bid for BSF contracts in the first place. It also meant that the winning team recouped their costs from the project budget. According to the contractor:

> *'The preferred bidders we're working with have always seemed to be very open about the costs, and have told us that* all *the bid costs will be recouped from the … BSF "pot"'*

It can be assumed that the costs for bids which the team had entered and not won must also be recouped from the projects they do win. If only two consortia bids for each LEP contract (in fact it is often three), on average each contract which is won must recoup the cost of bidding for that contract *and for the one which was lost*. The Chair of Governors wrote a letter to a national newspaper on the cost aspects of BSF, although he was persuaded by the school not to send it so as not to upset the relationship with the LEP:

> 'Everybody involved in our programme - from the contractors to the lawyers to the BSF advisers – have told us that BSF is wasteful and does not provide good value. A local BSF official told our Governing Body "yes, it is wasting money. But it is not your money so you shouldn't worry about it".
>
> The governors do worry about it, believing that government money is indeed our money. But ultimately we have had to take on that view. Out of £23 million of BSF expenditure we believe we will get around £15 million of value, despite having a contractor that we have found flexible and responsive. But it is £15 million of investment we would not otherwise get and so, like public sector staff across the country, accept that this is the only way to get the money we need.'

The BSF 'process' was therefore very expensive. It also had wide-reaching effects on the outcomes. It limited who could bid for the contract to organisations big enough to cover the punitive costs. It imposed segregation of the different stages of design such that the feasibility and design development stages were always conducted by separate design teams. In this case the size of the work won at the same time resulted in the early stage involvement of the contractor in the design development stage becoming redundant as a new contractor was then appointed to construct the project. It determined the final contract sum from a very early stage design. Although consultation was included as part of the process, particularly through the use of the DQI exercise, the school did not feel that this had been a positive experience. The process also limited wider consultation through the most critical phase of design.

Ultimately the governors and the school felt forced to accept the design which was offered, in spite of several issues they remained unhappy about. There was clearly conflict, but rather than 'power' being held by an actor or group of actors, the results seemed to be determined by the structures, tools and processes which were imposed on both the council and the school.

5.3.4 Sustainability in design

The focus of the thesis is on the impact that these power effects had on the interpretation and translation of sustainability for the project. Importantly, and unlike the Backhouse School project, sustainability was a particular focus for several key organisations involved. The Council were seen by the project architects as having had a strong vision for sustainability from the start – '*Sustainability is one of [their] priorities, so it was mentioned a number of times during the bid process*.'

The interest of the contractor, Willmott Dixon, was discussed in section 5.1. The school's Director of Resources also felt that it was an important issue for the community and the school:

> *'it's something that is very high on the agenda with staff and the local population as well. You know this area I think there used to be sort of two Green Party councillors, so it's kind of a constituency that is really into environmental issues and sustainability, so no, it was something that was really important across the board.*'

During the bid stage in February 2007 the architects produced a Design Report which included their general approach to sustainability. This covered a number of areas including environmental and ecological conservation, minimisation of resource use, reduction of energy in use through passive and active measures, and careful specification of materials with respect to their effects on the environment, including their embodied energy. The passage also includes specific measures carried out in previous projects which used 'innovative and environmentally benign materials such as sheep's wool insulation, cellulose fibre insulation, timber cladding, lime render, clay plaster and earth bricks' and also 'renewable energy technologies such as photovoltaics, solar water heating, ground source heat exchangers (heating and cooling) and wind turbines'. None of the materials or renewable energy technologies mentioned were, in fact, included in the scheme design for Eastwick Field School, other than a small area of photovoltaics (see photograph below).

When asked about sustainability in particular, the contractor, architect and client consultant *all* mentioned *other* projects which were 'sustainable', as opposed to this one, suggesting that whatever their personal visions of sustainability, Eastwick Field didn't meet them. This seemed to affect the development of the case study; interviews were hard to arrange, and this seemed to be partly due to the negative feelings of the individuals about whether the project counted as 'sustainable'.

The Navigant interviewees also identified several additional consultant design advisors who gave advice on the sustainability options:

Navigant1: *'… there was a client design advisor who was an architect… there was also a client design advisor who was an ex-M&E consultant and there was an M&E consultant … who was ex-Max Fordham & Partners and so he was advising on the authority's behalf on M&E and sustainable strategies.*

Navigant2: *And then the BREEAM consultant too reminded us of sustainable issues….*

Navigant1: *So the BREEAM consultant is Mouchel, not that they advise you, they just tell you whether you get any points or not.*

The technology chosen to address the planning requirement for 10% energy from renewable sources and identified as 'sustainable' was a biomass boiler, which appears to have been chosen by the client and their design advisors. Willmott Dixon believed that this was an unsuitable option for an inner London location due to space on site and delivery issues, and suggested instead a Combined Heat and Power (CHP) plant. This would produce electricity on site and the waste heat from the process could be used to heat the swimming pool in the Leisure Centre which was being built at the time across the road. However :

> ... *it just ran out of time and the old capex thing came up whereby, you know, be a five year recovery, spend a bit more now but save the environment later and it got guillotined at that point in time …. and this guillotine motion, now ultimately that was the client, that was the London Borough … in this instance, whereas some parts of the energy side of it definitely wanted it, you know, and it started all these sort of battles. So we nearly got one here. George Martin [Director of Sustainable Development at Willmott Dixon] tried his best, he came along to try and encourage people and try and work out where the grants could be etc, but it was too late really.'*

The school's Director of Resources also regretted the loss of the CHP –

'One of the big shames is that there were proposals to have CHP installed here which would warm the water in the leisure centre and it would have been a real win-win situation… I think that's such a shame because I think that's something that really would have been sustainable.'

Photo 5.8 A small area of PV panels acting as sun screens for windows below. The photo also demonstrates the cramped site in a built up area, suggesting that biomass is an unsuitable choice due to its space requirements for storage and delivery of fuel

The Council appear then to have retained their power here, in an overt conflict against the wishes of the school, and in spite of direct technical advice from an influential and acknowledged expert, George Martin. The structure of the funding model, which focused on capital cost rather than either long-term cost or on a detailed assessment of the carbon emissions, was also at least partly to blame for the over-riding of specific advice from a leading expert.

In an email response to the researcher, the Chair of Governors stated:

'Interesting to see your subject: Sustainability is very important to us at [Eastwick Field] but that's an aspect that pretty much got lost in the mix and

> *complexity – apart from a token solar panel or two. It's hard to pt [point] to anything particularly sustainable in the new design (unless I've missed something) and our energy bills seem no lower than before'*

Partnerships for Schools expected the benefits of the LEP to be 'better design quality, significant cost efficiencies, shorter time scales and improved educational outcomes.' (reported in Price Waterhouse Cooper report 2007). This study has not considered the last of these issues, but found a negative outcome for Eastwick Field in all of the other three.

5.4 Conclusions: impacts of procurement and tools on sustainability

The projects at Backhouse and Eastwick Field Schools, designed and built at almost exactly the same time and by the same contractor, revealed evident differences during the design processes. Many of these were due, not to the different personnel and requirements of the schools, but to the ordering effects of the procurement processes. However, more striking is the similarities of the outcome. Two particular aspects, the definition and implementation of sustainability and the input to design by the school and other stakeholders, give some insight into the cause of both these different processes and similar outcomes.

Firstly, the original focus on sustainability was very different in the two schools. There were no evident intentions towards sustainability in the Backhouse School, and no stated expertise by the designers, or the client, either at interview or in the early project documents. On the other hand in the Eastwick Field project, there was considerable expertise and interest by the council, school, architects and contractor, and input by a large number of external advisors. Although the focus of actors was very different, outcomes in both projects were limited to regulatory minimum requirements for each school.

The processes through which the initial aspirations were developed into specific decisions, were supported by the use of tools, including the DQI exercise, and the BREEAM assessment tool. These limited what was included within the interpretation of sustainability, and therefore what was available for discussion.

In contrast, the Willmott Dixon in-house 'Playing cards for the Future' tool had the effect of widening the interpretation of sustainability, and of inducing change in practice and behaviour. The contractors from Willmott Dixon in both projects therefore embraced wide environmental and also social aspects within their own definitions of sustainability. This was further evident

in their actions on site. Two specific aspects encouraged by the playing cards were the reduction of embodied impacts of the construction, and a focus on consultation with the school end user. Both of these were aspects which had emerged in a number of the Government reports commissioned by the DCSF.

Consultation during the design phase was encouraged in both projects, at least ostensibly, again through the use of specific tools and regulatory procedures. At Backhouse the encouragement came from the planning process, which imposed on the client the need to 'be seen to have consulted'. While consultation did take place, the impact was negligible, partly because of the inaccessibility to the lay stakeholders of the technical artefacts used, which included drawings and room data sheets. The school stakeholders seemed to be completely accepting that their role and participation in the design decisions were deliberately limited by the Council–'that's the way of the world', as the chair of governors put it.

At Eastwick Field the DQI process seemed, rather than encouraging open discussion of all options, instead to have limited the options available for consultation. The school were frustrated and irritated by the process and felt that it had had no effect on the design outcome. Unlike the Backhouse School, Eastwick Field did *seem* to have been given considerable autonomy by the Council client, but in fact their choice of action was severely restricted by the formal procurement process. They in turn felt that real consultation with parents, pupils and the wider community was important and tried to ensure that it happened. However, in spite of best intentions and considerable effort, consultation of both the school and the public was also limited by the procurement process to: an agreed set of parameters during feasibility stage through the DQI process; a narrow group of respondents under a confidentiality agreement during the design development stage; and only open to wider stakeholders very late on in the design stage once the preferred bidder had been chosen and when all major decisions had been taken. Although the school did feel that they had eventually achieved some of what they wanted, they certainly hadn't got everything, and felt that it had been an exhausting and ultimately unsatisfactory struggle.

Law and Callon (1988) suggest that not only are technologies shaped by, but they also shape, societies. Foucault similarly saw technologies as regulating conduct and influencing decisions. The evidence presented in this chapter has suggested that the tools used to encourage consultation and sustainable design, that is BREEAM, the Design Quality Indicators and Willmott Dixon's playing cards, had the effect of inducing particular and limited responses. In

some cases these were implicit biases and interests that were inscribed as intentional aspects of their design, while other effects were unintended.

The BSF procurement system also had the effect of structuring and limiting which options were considered, and effectively what choices were made. Particular aspects were the fragmentation in the design process caused by the procurement process, which led to separate teams being responsible for each stage, and the funding model being applied at an early stage in the design process and then rigidly enforced, which excluded the possibility of creating full disabled access. The funding model also seems to have limited the choice of renewable energy technologies. The procurement process at Eastwick Field was widely felt to be inefficient, expensive, stressful and to have wasted a lot of time, an outcome not intended by its original designers at central Government.

One specific effect of the political focus on renewable energy was to clearly define sustainability as a technical issue. However this does *not* seem to have resulted in the technical experts having exercised any power in either case. Instead both the installation of the GSHP at Backhouse School and of the biomass boiler at Eastwick Field were clearly the choice of the Council clients, who chose them *in spite of* technical expert advice. No-one appears to have overtly confronted the powerful client in the Backhouse case, with the services engineer omitting their original advice from the planning stage report, and the school and governors left baffled about why they hadn't got solar panels. In the Eastwick Field case the Sustainability Director of Willmott Dixon, a national expert on sustainable construction, had attempted directly to change the choice of the Borough Council to a combined heat and power plant (CHP); this overt conflict had also proved unsuccessful. The clients were therefore dominant not just in their restriction of costs but also of technical design issues. Rather than rational, technical expertise wielding power, instead power made judgements on what technologies would be rational; power, as Flyvbjerg has said (1998), defined rationality.

The tools and processes which structured these two projects have certainly shaped what has been built; they have also structured and limited what has been considered. Carefully controlled and constrained, neither school appears to have achieved the outcome that they would have liked.

Chapter 6: Projects 3 and 4 - Professions and expertise

'Society is a distribution of knowledge. Power, as will shortly be argued, is an aspect of that distribution.'

Barnes, in The Nature of Power, 1988

6.1 Introduction

The third and fourth case study projects were built by the Kier Group. The largest division of the Group, Kier Construction, is sub-divided into a number of regional organisations who operate semi-independently, due in part to historical acquisitions. The resulting strong regional focus ensures that they have close ties with other regional bodies and with local Government.

As with the projects in the previous chapter, the two Kier case study schools were procured through two different routes (see Fig 4.3 in chapter 4), the first through competitive tender as a single project and second through the National Academies Framework.

These two case studies were specifically chosen as projects in which a particular vision of sustainability was evident within the projects, additional to that which was encouraged by regulation. The focus of the chapter is the process of successful translation of that vision into built form, looking particularly at the power effects which were supported by claims to professional expertise. As for the previous chapter, the ordering effects of the different procurement routes, and their impact on individual actors and on decisions, was also considered.

Key details of the two case studies are given in Table 6.1 below. Individual documents and interviews are not referenced through the text, except where directly quoted. For details of interviews, site visits and project documents which informed the case studies, please see Appendices A and B.

School/ Location	No. pupils/ Age range	Procurement route	Cost (total incl fees)	Feasibility	Design team appointed	Contractor appointed	Construction started	Construction ended
St Augustine RC School, East Anglian City	850 11-19	Competitive tender to the RC Diocese	£13m	2005	Summer 2006	Sept 2007	Nov 2007	Dec 2009
The Lane Academy, East Anglian City	950 11-19	National Academies Framework	£20m	2007	Summer 2008	Sept 2008	March 2009	August 2010

Table 6.1: Key details of St Augustine and Lane Academy case studies

6.2 St Augustine case study

6.2.1 Introduction to St Augustine School and building project

In 2003 a wide-ranging review of secondary provision was carried out by the City Council and an application put to the Department for Children, Schools and Families (DCSF) for funding. The application pre-dated BSF, but responded to the Government focus on providing new school buildings in areas of deprivation; the City Council were astute in their early application for funds, successfully winning funding for several new academies and further education colleges, and for the major refurbishment of several existing schools in the city. Plans for the refurbishment of the buildings at St Augustine were included in the council's review of educational provision. However St Augustine School is a Voluntary Aided secondary school run by the Roman Catholic Diocese of East Anglia, and because of this the Diocese was the formal client for the project rather than the Council; the application for funding and the procurement process was therefore managed by the Diocese. From that point on the only role of the City Council was as planning authority, and they appear to have had a fairly minor effect on the project.

The school was not educationally successful, having achieved a level 3 (the lowest being 4) in the 2005 OfSted inspection. The report stated that:

> '*The school has a high proportion of students eligible for free school meals compared to other schools and higher than average indicators of social deprivation. Around 36% of students have special educational needs. The school has a high percentage of students whose first language is not English.*

> *Approximately 58% of students are from minority ethnic groups*.' (OfSted, 2005, pg 1)

The existing buildings, a combination of load-bearing masonry and reinforced concrete frame, were built in the mid-1950s, with some later single-storey additions from the 1970s and 80s. The project manager described their state:

> *'when it came to demolishing parts of it you could actually push it over with your hand, you didn't need a crane, it was just awful. There was no doubt it needed to be substantially modified or upgraded or rebuilt.'*

Photo 6.1 Existing buildings at St Augustine

Unlike the Local Authority, the Diocese was an inexperienced client, with a small schools estate. For the last nine years they had therefore employed an independent buildings consultant to manage their school building projects. Rather than having a professional qualification in a construction-related area, the consultant had been a teacher and head teacher for many years, before becoming interested in buildings. He was therefore mainly self-taught, with an interest but little specialist knowledge in sustainable building:

> *'the things that are driving me on that are DCSF courses that I go on for people like me, project managers, building bulletins, DCSF building bulletins…'*

However he also worked as a project manager for Suffolk County Council, who had a strong policy on sustainability, and he admitted that he transferred this knowledge to his work for the RC Diocese, who had no particular aspirations of their own for sustainable buildings:

> *'…it's much more price conscious [than the Council] and it doesn't have a mission for sustainability, its mission is religion, not sustainability.*

In 2005 the diocese and the consultant, with the school and a small firm of architects, developed a feasibility study for a new teaching block, a new sports hall, and the extensive refurbishment of three existing buildings at St Augustine.

On the basis of the outline design the diocese and school applied for 'targeted capital funding' from the then Department for Education and Skills (DfES) in May 2005. The school was notified in October that their application had been successful and they were awarded just under £13m, which the project manager believed was '*probably the biggest grant that the DFES had ever given to a school of this type*'. It was certainly a far bigger project than the diocese or their consultant had managed before.

European regulation meant that the project management role now had to be tendered through the Official Journal of the European Union (OJEU). An appointment was made of a highly experienced manager (indeed this was his last project before he retired), from a highly regarded firm of quantity surveyors and construction managers. The independent consultant meanwhile was retained by the diocese as the client's representative; while this could have resulted in conflict between the two men, in fact they had an excellent working relationship.

At this stage the feasibility study was considerably developed and re-written as a project brief. The Project Manager who was by now involved in the process felt that this had been a key stage in the development of the client's requirements:

> *'So we went back to* the *Diocese and hammered out a brief, a very good brief in the en, with the client and again that comes through in the post-contract evaluation process as the brief was really good, it gave the designers 90% of what they wanted at that time. '*

This brief clearly detailed the roles, membership and responsibilities for the different actors involved. The 'Client Project Team', which included the diocese consultant and the school bursar, had responsibility to:

> 'ensure the project is well defined and then to monitor its delivery. This requires the production of a full and detailed brief that meets school, Diocesan, LA and DfES criteria. The key responsibility for co-ordinating and understanding the requirements of the various end users of the project in

> order to develop an acceptable project brief lies with the Client Project Team.' (Project Brief May 2006 p.15).

The Project Manager was assigned particular responsibility for 'Energy management and sustainability issues'. The brief also now included a very detailed section on 'Sustainability', which started with the statement: '*The project must be sustainable in social, economic and environmental terms'*. However, the first and second of these are covered in two brief paragraphs, while the section on 'Environmental sustainability' is far longer, and quite detailed. An extract reads:

> 'We want our design team to work towards achieving an environmental balance which:
>
> - Minimises adverse environmental conditions and their impact on areas surrounding the school and reduces emissions and pollutants (this includes consideration of the use of transport, and of energy and water consumption)
>
> .....
>
> - Ensures responsible use of materials with respect to their embodied energy, environmental impact, long-term maintenance and whole-life cost
> - We would like further discussion regarding specific requirements – green roofs, solar power and multi fuel boilers, etc.'

The mention of 'embodied energy' at this point was particularly unusual, and as discussed in chapter 4 had been specifically *excluded* from policy. Both the project manager and the client consultant, interviewed separately, felt that they had been the 'major driver' for sustainability, as the consultant put it. However, both also admitted that a further driver had undoubtedly come from the DfES funding requirement for the project to achieve 'BREEAM Very Good', which had been recently introduced. Right at the start of the project then, 'sustainability' formed an unusually (for the time) strong part of the vision, specified in environmental terms, although with little detail.

The school head and leadership team, the governors, and the student school council had also been involved in developing the brief, and the consultant felt that the students in particular had been involved in the requirements for sustainability:

> '*the students are very knowledgeable with regards to sustainability impacting the environment and the importance of it …. that was certainly key from their point of view and that fed into the project brief we put together*.'

The project architect commented on this early focus on sustainability at the brief stage as '*quite rare for a client to actually give you a fairly robust written brief that early on in a project'.*

In Summer 2006 contracts for the design team were tendered through OJEU. Interviews were led by the project manager, with the diocesan consultant, the bursar and the head teacher also present. The project manager described his two key criteria for selection, as the ability to work as part of a team, and the applicants' knowledge of sustainability*:*

> *'we asked. .. what are you going to bring in terms of sustainability? And that was a general question to all the consultants so when they were appointed everybody was on board with the sustainability issues.'*

A relatively small firm of architects from Northampton were appointed as architects. The services engineer appointed was from an established firm with multiple offices across the country; under a separate contract they were also appointed as the BREEAM assessor, marking out early on their connection to 'sustainability'. The structural engineers were the Cambridge office of Whitby Bird (now part of Ramboll), a highly regarded firm with links to the Cambridge University Engineering Department. Therefore the team that were put together could be seen to come from organisations with varying levels of influence and prestige, either through size or perceived level of technical expertise, with the architect potentially the least established. Furthermore the project was run by an architectural technician from the architects' practice who, although individually seen as likable and competent by other team members, may not have been considered to have the status, or have behaved with the level of authority, of a qualified architect.

6.2.2 Design development

As the design developed, sustainability continued to be a key part of the discussions and decisions. However it became clear that different team members had different ideas and definitions of sustainability, linked to their own areas of expertise. The architect explained that he took the interpretation of sustainability from the brief as:

> *'the need to incorporate sustainable technologies* and *to consider the environment and to consider where energy might be gleaned from the local site area'*

Although this interpretation therefore focused on the increasingly standard interpretation of sustainability as to do with on site renewable energy technologies (see chapter 4), it did also include a wider view of environmental issues. The architect's own approach to sustainability he described as:

> *'something that's maintainable and therefore sustainable in the long term for the school's point of view. It's actually about thinking about, what is the real effect of doing this. And how will you as a school actually benefit from it.'*

In addressing this he was particularly concerned with ensuring the participation of the school, and he focused on the importance of stakeholder consultation during the design stage, including the governors, the school leadership team and the student School Council. The public were also consulted, as well as the close neighbours and the nearby feeder primary school, which for the architect was a very important aspect:

> *'The consultation process is crucial, it really is crucial, because it's all of these people that are going to end up using the building. … so it's a really, really important thing to make sure that you're engaging with the right people, engaging in an appropriate manner and then once you have engaged take that feedback and actually feed it back into the design process and that's a crucial thing ….it also means that they've had an active contribution to the way that that design has developed and in its own way that makes the building and the development more sustainable.'*

This appeared a very different attitude to stakeholder involvement and consultation to that at the Backhouse School project in chapter 5. The definition of sustainability from other professionals differed from each other and the architect considerably, and each also appeared to see the area as their own remit. In particular the building services engineers' report, which formed part of the planning application in February 2007, was titled 'Sustainability statement'. The title suggests that sustainability in buildings is therefore the particular responsibility of the services engineers. The immediate interpretation is equated with energy:

> 'The project team and client are strongly committed to an environmentally sustainable development. The proposed development at [St Augustine] RC School provides an opportunity to introduce and adopt a range of innovative measures to minimise energy consumption and use renewable energy sources.'

While it follows with: 'The development will focus on creative solutions that meet environmental, social and economic objectives in a balanced and holistic way', the 'social and economic' objectives are not expanded on at any point in the following report. The report continues:

> 'The principals to be followed are as follows;
>
> Use less energy (be lean)
> Use renewable energy (be green)
> Supply energy efficiently (be clean)'

It then lists the ways in which these principals are to be achieved as:

> 'improving energy efficiency through increasing insulation values, increasing the proportion of energy use generated from renewable sources, minimising the use of treated water, utilising rainwater harvesting and grey water recycling schemes and incorporating sustainable drainage systems.'

In fact the rainwater harvesting, grey water recycling and sustainable drainage (all responsibilities of the civil engineers rather than of the services engineers) were not taken any further in the design, inspite of the brief having mentioned the importance of reducing water consumption. The bursar would have liked to have seen rainwater harvesting installed, and was left unsure why it hadn't been discussed further:

> *'we had discussed that and it sort of dried up after a while; we could have pursued that more. Because that will* have *quite an impact, you know, we're quite a big site and we are quite heavily water dependent.'*

Instead the focus of much of the following report was on the renewable energy options, which were clearly the professional responsibility of the services engineers who had written the report. The list included two technologies which had already been rejected by the services engineers; community heating systems (later to form one area recommended by the Zero Carbon Task Force), and biomass boilers. Both were dismissed, although 'multi-fuel boilers' had been specifically mentioned in the brief. Of the suggested list the main item proposed was a ground source heat pump for heating the teaching block, with some additional solar hot water panels for one of the refurbished blocks and two 6kW vertical axis wind turbines. One of the wind turbines was later removed from the design proposals.

The title of the report appeared to demarcate 'sustainability' as the professional territory of the services engineers. Although it mentioned aspects which were not their remit, these were

then dropped and there was no evidence that they had been discussed further. The solutions that *were* discussed in the report were therefore a) clearly and uncontestedly defined as the sustainable options, and b) supported the claim that sustainability belonged solely within the field of expertise of the services engineers. The choice of the options offered by the report *was* discussed with the rest of the team, but mainly in terms, again, of relative costs, linked with the efficiency of the options as set out by the services engineers. The architect saw the responsibility being clearly that of the services engineers, as it had been defined by the report:

> *'…you might be better off speaking to Roltons about that, because that report was very much centred around their input to the design.'*

Therefore the report was a claim to identify the area of knowledge of the services engineers as sustainability.

In fact this singular definition and the services engineers' claim to *sole* expertise in the area of sustainability, had already been contested some time *before* the services engineer's report was written. In December 2006 the structural engineers had proposed three alternative structural solutions for both the teaching block and the sports hall. Two of these were standard options, either standard load-bearing masonry, or steel frame with masonry infill panels. The third was a highly unusual option for the UK at the time, that of pre-fabricated load-bearing panels of cross-laminated timber (CLT). The report gave specific reasons for the choice of CLT, including its response to the client's requirement for sustainability as set out in the original project brief:

> 'Timber is a totally renewable resource and provides a significantly smaller carbon footprint when compared to production of most other building materials. The use of an all-timber construction therefore satisfies the client brief for low embodied energy and sustainable structural design.'

Although in common use in Austria and other timber-producing countries, CLT had previously been used on very few projects in the UK; Kingswood School sports hall in South London, completed late 2006, was the only other school building. Whitby Bird's own knowledge of CLT was restricted to a smaller education building and a domestic house, under construction at that time. No other members of the design team had any experience of using the system, and furthermore the proposed project at St Augustine would be the largest building in this material in the UK at that time.

Between the Stage C and Stage D reports the project team met twice specifically to discuss the alternative construction materials. At each, the CLT solution was strongly promoted by Whitby Bird. Through personal connections at Cambridge University Whitby Bird had also developed a research project to calculate the difference in embodied carbon between the alternative proposals (Vukotic et al, 2010). An additional 'Structural Frame Report' was also issued by Whitby Bird in January 2007, assessing the two alternative proposals 'against a set of specific criteria which are considered to represent the needs of the Client brief.' The first of these criteria was given as 'Environmental sustainability', and included for the cross-laminated timber:

1) 'Sustainability (structure materials only) - Excellent - truly sustainable resource through use of softwoods from managed forests
2) embodied energy (production of structure materials only): 1988 GJ1 654 tonnes Carbon Dioxide
3) energy efficiency (based on natural ventilation scheme): i) heating load capacity based on teaching block only slightly higher ii)carbon emission Slightly higher > 5 %'

The use of the numbers for embodied energy and carbon of the materials supported the claim to expertise in this area of the structural engineers.

The introduction of a new construction material however encountered resistance from some of the other design professionals. One of these was the QS, whose reasons were that he had little information on which to cost the system, as it was so new to the UK, and felt it was high risk both financially and because it was a sub-contractor design, it being generally accepted that more links in the design chain introduce greater design risk. The PM agreed that costing the timber *was 'difficult…because no one had got any experience of that.'* The structural engineer responded by getting his own quotes from the two leading companies supplying CLT, and addressed the risk of the sub-contractor design by taking on the design responsibility for the system himself.

Most resistance however, according to the structural engineer, came from the building services engineers:

> *'For some reason the M&E side were against it... a personal crusade, I think...very anti this being done in timber...went to the lengths of sending emails directly to the client secretively, attaching copies of building magazine articles saying things about various timber buildings burning down, saying see*

this is the sort of thing that's going to happen to your project...and was making claims about they wouldn't be able to fix their bits to the structure…'

The structural engineer did not understand the reason for this resistance, but one possible explanation was that the services engineers objected to the use of the term sustainable for an aspect that was not part of their remit.

By March 2007 the client and team had agreed to use CLT for the 2-storey teaching block, but it was still considered too costly for the sports hall. At that point the engineer arranged a visit for the design team and client to the supplier's factory in Austria, and included the contractors who were engaged in the bidding process at that point. Following the visit the client and the design team finally gave their agreement in July 2007 to use CLT on the sports hall, and a note in the minutes of a Project Review meeting on the 12th July stated that the trip to the factory had: 'confirmed confidence in the KLH structural system. ..It had also convinced Architect and Client/School that the solution would be appropriate for the Sportshall.' Therefore the claims of expertise of the structural engineer and the supporting calculations of embodied carbon and of costs, had not on their own been enough to gain the trust of the client. The visit to the factory, to see the material being manufactured and to see constructed buildings, were needed to provide support to the professional claims. Even so they had clearly won considerable trust from the other team members, after a concerted effort and specific campaign to get the material accepted.

The use of an offsite manufactured system, particularly coming from an overseas manufacturer, now required a high level of upfront design and services coordination compared with standard construction compared methods, in order to ensure that the panels were fabricated accurately. This meant a considerable change to the standard design programme, with different professionals being involved at different times. The structural engineer was also instrumental in leading this, taking on the extra (unpaid) responsibility for ensuring services were coordinated early on. It was clearly important to Whitby Bird that the project was successful.

Just as to the services engineers the renewable energy technologies exclusively defined sustainability, to the structural engineer the use of CLT was the key translation of sustainability for the project. He also saw himself and his own knowledge as having interpreted sustainability as low embodied carbon. Although his *own* report mentions that the solution proposed 'satisfies the client brief', he claimed in interview that the brief had not been a relevant factor in his decision:

> *'I think the first time I* looked *at this brief was after I had made these statements in this meeting and was selling this, if you like, to the team, and mentioned the sustainability issues and the potentials... I don't feel it was high on the client's list or agenda...but it's some of the classic phrases being used here in terms of sustainability - whether they were expecting a greenwash or whatever to get the [BREEAM] points I'm not sure.'*

His interest in using the material was not therefore a response to the brief. Rather it was part of a strategy to develop a new 'expert practice', and a (mostly hidden, and clearly not even understood by himself) contest with the services engineers over the definition and therefore the claims to professional expertise in sustainability, and the subsequent status that that ownership offered. Indeed the strategy subsequently the cross-laminated timber became the one aspect of the project that attracted visitors and comments, rather than either the measures taken to reduce operational energy or the renewable energy technologies; as the project manager said:

> *'We talked about sustainability and timber, but there's ground source heat pumps, under boiler piles, there's a wind turbine, there's all sorts of high insulation levels and triple glazing and solar shading and all that sort of stuff, it's not just timber, although it seems to get its name around the timber.'*

The structural engineer felt very strongly therefore that he was the instigator of not just the use of CLT but also of the 'sustainability' as a whole of the project.

> *'I genuinely believe that we, and I mean us, the structural engineers, by virtue of this system, and our awareness, knowledge and belief in issues surrounding sustainability, actually brought it [sustainability] into the clients' consciousness and dare I say the rest of the team.'*

This appears, from all other evidence, to have been a considerable misrepresentation of the facts. However the engineer clearly believed it, perhaps because his definition of sustainability was so firmly rooted within, and governed by, his own professional discipline. Thus in his opinion:

> *'We're talking about sustainability, what actually are we talking about? Well, we're talking about carbon, something physical, you know, which you can measure.'*

Meanwhile the focus of the Project Manager was on finalising the design as far as possible at each stage and making sure that the fixed budget was adequate for the work while retaining a contingency. Partly because of the unknown quantity of the CLT '*we had a problem pretty much at every stage really in terms of getting it within budget'*. However elements seen as responding to the sustainability brief were protected in his view, '*mainly because there was such a thrust from the BREEAM requirements'*.

BREEAM then had been influential in the design of the buildings, as well as the original choice of designers. Its influence on the design led to specific choices and outcomes; according to the Project Manager:

> *'… there's no air conditioning, because air conditioning, you can't go through BREEAM, you* can't *go through sustainability and build in air conditioning.'*

However there were mixed feelings within the team about both the efficacy of BREEAM and its ability to 'measure' sustainability. The project manager agreed with the fundamental principles of BREEAM:

> *'the aims and the aspirations of BREEAM in terms of developing more sustainable buildings and more responsible developments are exactly right and everybody in the industry should be working towards that'.*

The contractor's design coordinator also commented on the effect that the BREEAM requirements have for contractors:

> *'It's one of the forerunners of how we do things on site, how we set up site, and materials we do use, and how much waste we have and everything else. I think it's starting to make more of us a bit more conscious of our sort of responsibilities.'*

As a tool therefore it has clearly had a real impact on the behaviour and knowledge of the project team members. To an extent BREEAM appears to be a trusted and unquestioned measurement of 'sustainability', with the architect commenting that it has:

> *'almost become this name that you just associate with good technology and good building, oh I've got* to *have that, but you don't actually know what it means.'*

However the structural engineer thought BREEAM *'nonsense'* because it didn't rate the embodied carbon in the buildings materials; the change from steel frame and blockwork panels to CLT didn't score any extra points under the BREEAM assessment. Because of its omission of his own area of expertise he didn't feel that BREEAM provided a fair assessment and comparison of issues:

> *'the whole marking system, the credit system is wrong... the weighting of the structure and the structural frame in relation to the whole BREEAM assessment, is tiny'*

A review of the number of available credits through BREEAM, as carried out in the previous chapter, shows indeed that it is heavily weighted towards the aspects of operational every which fall within the remit of the services engineer. The tool, the the power of its association with 'good building' as the architect says, appears to embody a particular interpretation of sustainability and therefore validates certain claims to expertise while excluding others. BREEAM is therefore a system which assesses a project, but within the values and concerns of its designers rather than necessarily of the project designers or stakeholders. BREEAM therefore has an ambiguous relationship with the design professions, invoking both trust but also professional conflict.

6.2.3 Sustainability during construction

The construction contract was defined by the DfES as Design and Build; however the project manager decided to go to tender at a later stage than usual, around RIBA Stage E, after most of the detailed design had been completed, in particular because of the requirements of the timber panel system for early detailed design input, and because of the knowledge which had been developed within the team of the existing school buildings which were to be refurbished. This meant that in practice the contractual relationships were far closer to the 'traditional' JCT contract, in which the design team had a direct relationship with the client throughout the project, with a contractor appointed separately at detailed design stage having had no input to the design. Once appointed the contractor was here at liberty to appoint a new design team, but in this case the whole professional design team was novated to Kier, at the recommendation of the project manager, which he felt was important in order to retain the knowledge they had developed. Therefore the choice of process had ensured that the professional designers retained control of the design choices, and also had a continued contract through the construction stage of the project.

On choosing the contractor the Project Manager focused once again on team work; he therefore insisted on a second interview with the actual people who would be working on the site: *'I don't think it matters what form of* contract *you run … you appoint the right people at the end of the day.'* He took the further unusual step of inviting all three bidding contractors together to a special design team meeting on the 21st June 2007 together to discuss the proposals and the approach required for the construction, and the contractors were also invited on the visit to Austria to see the timber system for themselves.

In Summer 2007 Kier Eastern were appointed as Design and Build contractor under an NEC contract. Although they had not been included in the design phase, the contractors felt that they had already started to form a working relationship with the design team through the pre-tender meeting and factory visit. Having made the appointment the PM was also very definite about Kier Eastern being included at all meetings. The resultant relationship between the designers and contractors was evidently good; minutes of project meetings showed they were well attended and cooperative, and in interviews there was clearly mutual respect across the client-designer-contractor boundaries.

Work started on site in November 2007. Two circumstantial aspects both made a considerable difference to its smooth progress. The first was the retention of the contractor's design coordinator on the site for much of the construction period, because of the shortage of new work at that time. This meant that he was able to support the site manager in carrying out some of the coordination between the designers and the contractors, much-needed due to the new material and process. The second aspect was that another school had become vacant just before building work started, so the school was able to move out before work on site commenced, leaving the contractors an empty site to work on.

The site environment was exceptional, as noted by many respondents, partly due to the site set up itself. An example was the site carpark which was built of virgin tarmac, as opposed to the recycled 'shavings' used normally, and the designated access route across the site for pedestrian visitors. Both were visible demonstrations of the 'show-home' status of the site, which Kier was using as promotion for other schools work. Many groups did visit the site, including several directors from the Kier Group as well as other architects and potential clients (see Photo 6.2). Stakeholder engagement, originally championed by the architect, also continued during the building work, with the school council and other parties from the school being invited frequently to see the progress as a contractual requirement imposed by the client/design team: '*it was part of the tender that we would be willing to do that.'*

Photo 6.2 The timber system led to considerable interest and frequent visitors to site. This group included a potential school client and architect for a project which was later won using the same system.

The timber construction system itself had a number of aspects which made a noticeable difference to the site environment. Firstly its manufacture offsite radically reduced waste on site, as well as reducing waste from other operations due to the ease of fixing to the timber. Site waste management is an area which Kier has focused on for some years, and this was cited by the contractors as a particularly successful sustainability aspect of the project. They had also been impressed by the low levels of waste generated in production during the visit to the factory:

> *'bits of sawdust get used somewhere, there's offcuts that get made into pellets for biomass boilers... there's virtually no waste of any sort. You see farmers come along get sawdust straight off the production line.. so it's good from that point of view.'*

A second benefit to the contractors was the amount of time saved in construction using CLT. The site manager gave an example of the lift shaft; this would have taken two weeks to build in blockwork, whereas the three CLT panels were erected in an hour and a half. Although the refurbishment part of the project meant that the timber was not on the critical path, the contractor estimated that the system saved seventeen weeks from the construction of the

new buildings, and that more experience of the material would have allowed them to save even more time.

Photo 6.3 Prefabricated timber panels meant that erection was substantially quicker than conventional systems, an important factor in school building construction

The design coordinator also described the health and safety benefits of the timber system in terms of the likely reduction in reportable accidents due to fewer operatives, shorter time on site and less work at height. In addition, although not included by the contractors as a 'health and safety' issue, particular benefits noticed by all of those working on the site were the cleanness and lack of dust, the quietness of the site, and the lack of scaffolding, all of which made it a far better working environment:

> *'It's been very quiet – it's one of the most quietest sites I've ever run. We think that's because of silly little things you don't think of at the time, where we would have been drilling into concrete planks, or shot-firing into steel , all that noise generated through the process of building is gone with the timber because you're just screwing wood screws into wood. And you've got less dust. Knocking holes into blockwork, brickworks, creates dust and mess, with the timber you don't have that.'*

All contractors interviewed made the same point, stating that for these reasons they would much rather work in the future in the same material rather than going back to working with the construction materials traditionally used in the UK.

The contractors working on site, and the project manager, were also convinced that the timber system must have saved money for the contractor, in a way which would not have been evident through the standard costing process:

> 'I*t's time and savings on cleaning, labouring, all of that sort of stuff which actually doesn't really get priced in a tender, time does not but the rest of them.'*

In comparison, another 'sustainable' technology new to the contractor at the time was the ground source heat pump, which was designed and installed by a sub-contractor. The original site investigation had only gone to 12m depth, and the predicted ground conditions at lower levels had not been as expected. The installation of the system, in seventeen 100m boreholes under the sports field, took twelve weeks rather than four.

Meanwhile the consensus on the remaining wind turbine, from the school, designers and contractors, was that it made a statement, rather than that it actually produced enough electricity to make a difference either to the school's impact on the environment or to the budget:

> *'We do have a wind turbine, yeah, it's there. I'll pass if you want my personal opinion of a wind turbine.....it's doing 6kW per hour or something, which to ignorant builders like me I believe is a kettle...It looks very nice, people have shown a lot of interest in it, whether or not they're really going to benefit from it, I stand to be corrected...'*

The physical representation of sustainability given by the wind turbine, although limited in its technical ability to provide power, did however give the school a '*green jewel*' to shout about, as the architect put it (see Photo 6.4). It made a statement, and through doing so possibly had wider impacts on behaviour of pupils and teachers than a less visible but more efficient energy technology.

Photo 6.4 The 'green jewel' of the wind turbine, and cars parking along the kerb in an over-crowded carpark, at St Augustine School

The only additional sustainability requirements from the planners was on reducing private car travel to the school. However as the only secondary Roman Catholic school in the area, many of the pupils and teachers came from considerable distances, and the school bursar commented that:

> '*The only thing that was really forced upon us by the planners which always makes me smile is to give us 25% less parking spaces than we wanted to, that's an attempt to force people not to get into their cars which of course doesn't work, it just means we have a parking problem.'*

6.2.4 The final result

Although some of the time saved from the programme from the speed of erection using CLT was lost again due to coordination issues with services, the project was completed in the end on time, in December 2008, and on budget with some contingency money still available for overcoming any teething problems. The school moved back in to the site in February 2009.

The first Ofsted report after moving back mentioned the positive impact of the new school buildings on behaviour:

> *The pupils thoroughly appreciate the new buildings and are treating them with real respect. This was evident during the monitoring* inspection *in how the pupils' moved around the building and in the lack of litter following break.*
> Ofsted May 2009, pg 3

The bursar too pointed out the good behaviour of the pupils around the school and the lack of litter, and stated that there had been no incidences of graffiti or damage of any sort. She felt that the improved environment was an important factor in this. According to her the focus on sustainability throughout the building project had also spread to different areas of the school and had encouraged the school to join the Eco Schools programme. They were also sorting and collecting recyclable waste, and starting an allotment project to grow some of their own vegetables. Most importantly for her the school was a pleasant place to work: '*Natural light is about more than just sustainability, it's about quality of environment for the pupils and teachers.'* This and other, similar, statements showed that, as for the contractors on site, working environment did not form part of her definition of sustainability. Although she made the link with other environmental aspects, and even with growing vegetables, the particular definition of sustainability as an area of technical expertise to do with energy and carbon, as defined and promoted by the policies discussed in chapter 4, and by the professional design team for the project, appeared to have been accepted by the lay stakeholders.

By the time of the interviews (mid to end of construction period), and inspite of evidence that there had been considerable dissent to start with, there was consensus from all actors interviewed that the CLT was both a sensible choice of building material, for reasons of efficiency and buildability, and that it was 'sustainable'. The reasons for *why* it was seen as sustainable still varied between actors. The structural engineer who introduced it was adamant that the lower embodied carbon of the timber was its one sustainability aspect. The contractors however had been most impressed by the absence of waste in the manufacture of the timber, and it continued to be the low on-site waste, as well as the speed of erection, which led them to the conclusion that it was indeed 'sustainable'. Although they were hugely enthusiastic – 'passionate' as one put it – about the physical experience of working with the material, this was not considered as one of the sustainable aspects.

Interpretations of sustainability within the project were therefore mainly limited to those which formed part of the expert claims and defined roles of the services and now structural engineers. Waste could be seen in a similar light as part of the role of the contractors which had been defined as an issue of sustainability. Each of these aspects were also measurable in various ways. In contrast the resultant better environment for the school leading to better behaviour, and the very much better working conditions on site, were not interpreted as issues of sustainability by any of those interviewed, possibly because they did not have the support of any specific discipline.

Photo 6.5 The finished courtyard linking new and refurbished buildings at St Augustine. Behaviour and academic results at the school have improved since the project.

The project was a success, both by the industry standard measurements of being completed on time and to budget, and by the high levels of client satisfaction. The contractor's design coordinator summed up:

> *'We're …. proud of the fact that we're going to be handing them over something that they can … be proud of, and something that the pupils, it's going to be a better working environment for them to learn in. …And we're getting positive feedback from everybody, I've not … heard of anything negative from anybody.'*

In June 2009 the building project won a regional sustainability award from the Institution of Civil Engineers. The judges said that the project was:

> '… a show case of sustainable engineering and we hope all in the East of England including regional government will follow. The project has involved pioneering work in promoting and implementing timber construction to minimise embodied carbon'

The definition of sustainability as renewable energy, supported by central government policy, had led to the services engineers' title for their planning stage report as the 'sustainability report'. This suggested a wider move to 'rebrand' their profession as sustainability engineers, clearly gaining status and influence from this claim to expertise.

This claim was challenged by the introduction of cross-laminated timber specifically as a low embodied carbon material. The introduction of CLT by the structural engineers had been strongly supported by this definition, and by calculations of the embodied carbon compared with that of a conventional alternative. However it was also introduced for another reasons; the existing expertise of the engineers in timber design, coupled with their knowledge of a material which had been almost unknown in the UK up to that point, gave them an opportunity to promote a material which few others had experience of and to win more business (as will be shown in the following case study). The particular prestige that the 'sustainability' tag gave to their company and profession was certainly not lost on them, and it was this that made it worth their while to put considerable extra effort and time into making the project a success. However it was this that also caused particular conflict with the services engineers, whose own claims to expertise in the field of sustainability appeared to be threatened by this alternative solution.

6.3 Lane Academy case study

6.3.1 Introduction to Lane Academy and building project

The final project studied was the Lane Academy. This project was won by Kier while they were still on site at St Augustine, and they proposed using the same construction material as had been successfully piloted at St Augustine. This case study will therefore concentrate on the aspects which differ in this project, particularly in terms of the expertise which was claimed and the power it wielded.

The Lane Academy replaced an existing secondary comprehensive school, which was geographically located between two much larger schools, assessed as 'Excellent' by OfSted, and had suffered from a low intake as a result. Due to its poor exam results, in 2005 the school was put into 'Special Measures' by OfSted. However a new headteacher had since improved results, and the OfSted report in February 2007 had classed the schools as 'satisfactory and improving' (OfSted 2007). In 2007 the County Council decided that the school would become the first of two new City Academies. The original buildings that were constructed in the 1960s would be demolished, and a new building for the academy would be built on the existing site.

The new buildings for the Academy were procured by the County Council through the National Academies Framework (see Fig 4.5 in chapter 4). This was a very different structure of procurement to that used at St Augustine, which had two important effects. Firstly the structure of the client team was quite different. As part of the Academies process an Overall Project Manager (OPM) was appointed directly by the DCSF to develop the education brief. The Academies programme also encouraged individual sponsors for the new schools. In the case of the Lane Academy there were two sponsors, a local business entrepreneur, philanthropist and evangelical Christian (by far the greater influence of the two, from here on he is termed 'the sponsor'), and the Anglican bishop. Together they contributed an extra £1m towards the contract sum. In addition to these structural differences, and in particularly striking contrast to the diocesan client for St Augustine, the Council were very experienced clients. They had a large schools estate and therefore considerable experience of schools procurement, and in addition had just completed a major private finance initiative (PFI) programme for the county hospitals. The Council project manager from the hospitals programme was now appointed to manage the Academies programme. Trained originally as a civil engineer, and married to a contractor, she had subsequently retrained as a teacher, and had taught for some years before moving to the Council as a project manager. She therefore had a professional knowledge and experience across both education and construction, and also had considerable expertise as a client for major construction programmes, making her an experienced and effective client (see Photo 6.6).

The second major difference to the St Augustine project was an impact of the Academies procurement structure, which was that the project was let, as soon as the feasibility stage design had been completed (RIBA Stage C), as a design and build contract to a team that was therefore led by the contractor rather than the design team.

Photo 6.6 The council project manager 'snagging' the building with the contractor. Her own professional expertise in civil engineering and teaching made her a very hands-on and knowledgeable client, with an excellent working relationship with the contractor Kier.

As for the Eastwick Field School, the DQI for Schools exercise was used at the Lane Academy, at the start of November 2007 with the client PM and design advisors, the sponsor and others *'to evaluate what qualities the building… should achieve and … the impact of the building on people, the users, stakeholders and the community*.' pg 2 However the sponsor left in the middle of the exercise as, according to the project manager, he '*wasn't interested*', and the headteacher of the existing school, who would later be appointed principal of the new academy, was not allowed to be part of the process because at that point she had not been appointed. The project manager also would have like the school students to be part of the process but explained that '*We weren't allowed to have, we didn't have any children involved in it'.*

The building proposals were assessed in several specific areas against default ratings. Where the team felt there was a strong reason to differ from the default ratings the reasons were given in the report. Particular comments given in these areas were very much focused on the social and community focus of the new Academy '*to encourage the widest community participation and involvement*' and to '*encourage the widest participation in the Academy'*. A key aspect of the building design was that '*The materials should represent what the Academy is trying to achieve*' and that '*The building … should announce itself strongly, making a bold and exciting statement- iconic!*'

No change in rating, or additional statement, was made against either the statement: *'The building and engineering systems should be designed to minimise CO2 emissions'* or: *'The building should use sustainable and renewable systems, and materials which have low embodied energy.'*

Again, as for Eastwick Field, the project manager was dubious about how effective the DQI exercise had been in developing or informing the clients' decisions:

> *'It was too rushed, it was a hoop I'd got to jump through to get…I had to say in the OBC yes, we'd done the DQI so we had to hold the meeting really quickly …. We could have done a much better session but we just had to rush it so it wasn't done properly. … it was just a paper exercise. …. it does make you think, but I think actually a couple of really decent presentations and workshops where you focus and discuss might be just as good, in fact perhaps more helpful really because the marking becomes very repetitive and boring. But it's measurable, I suppose, isn't it?*

Having had their 'Outline Business Case' (OBC) first approved by the DCSF, the client group then developed the Invitation to Tender document during 2007 and 2008. This is a standard document, several hundred pages long, produced by Partnerships for Schools and adapted by local authorities to their own requirements. As well as contractual details, it included the brief, in three sections. First of these was 'the Vision'. The Vision for the Lane Academy appears to have been mostly written by the Sponsors. While it doesn't mention sustainability, it does include several aspects which might be interpreted as part of the broad definitions of sustainability discussed in chapter 1. It starts:

> '*The vision combines Christian values, the dual specialisms of Environment and Engineering as well as the embodiment of an emphasis on learning, a respect for the environment as a critical future resource and the importance of developing a strong and vibrant community*.'

The second part of the brief was the Education Brief, a process led by the OPM with considerable input from the sponsors and the County Council. For the Lane Academy the Education Brief determined the two specialisms mentioned also in the Vision, as 'Environment' and 'Engineering'. The former was of particular relevance to this research because, according to the Client PM, it 'sold sustainability' for the design of the buildings.

The Design Brief was led by the Council project manager with two firms of client advisors (architecture and building services). The client requirements for 'Sustainable Development' were included as section 2.6 of part 2, 'Strategic Objectives', of volume 5, 'The Authority's Requirements'. This section focuses on environmental issues in some depth, with six sub-sections on: 'Developing an Environmental Assessment', 'Water Conservation', 'Energy Conservation', 'Reducing Waste during Construction', 'Renewable Energy', and 'The Case for Higher Recycled Content'. A specific issue in the introductory section is 'Utilising materials which minimise embodied CO2 impact'. Therefore inspite of the omission of this aspect from regulation and policy by both DCLG and DCSF, as discussed in chapter 4, it was starting to be included by the governmental body Partnerships for Schools.

The specific changes made by the Council project manager to the standard document are a strong encouragement of a BREEAM rating of 'Excellent' (the standard requirement being for 'Very Good') (ITT, Volume 5, p.122) and the required use of the 'schools carbon calculator' to demonstrate 60% reduction of operational carbon emissions compared with the 2002 Building Regulations (ITT, Volume 5, p.124) (see chapter 4).

The timing of the proposal was fortuitous for maximising the budget, as the OBC was approved just before Partnerships for Schools reduced the funding due to a reduction in market costs of construction. This was also the first year that there had been an option of applying for extra money for demonstration of 60% carbon reduction through the use of the carbon calculator (see chapter 4), and was the last year in which sponsors were allowed to part-fund Academies projects. So according to the project manager, *'it was a comfortable budget, shall I say'*.

The ITT was published on 31st March 2008, and was followed by a bidding period of four months. While the procurement process was just for the Lane Academy, the teams bidding were given to understand that they stood a high chance of winning the second city academy (as indeed they went on to do).

The Council and the project manager had worked with Kier Eastern for many years, and most recently on the hospitals project, and had a good working relationship with them according to both sides. Kier Eastern, and one other company on the national framework agreement for Academies, were therefore invited by the Council to submit detailed bids for the Lane Academy. Kier's chosen original design team included Sheppard Robson Architects and WSP as civil, structural and building services engineers; both firms were also on the National Academies Framework. However several weeks into the bidding process the Kier bid manager

visited the St Augustine site, and was highly impressed with the cross-laminated timber (CLT) construction. He asked the structural engineers working on St Augustine if CLT would be feasible for the curved form of the building proposed for the Lane Academy. The structural engineer agreed that it was possible, although not ideal, and the Kier bid manager then decided to change the material proposed for the Lane Academy to CLT. Inspite of the fact that they were not on the Academies Framework, Kier then appointed Whitby Bird (by now part of Ramboll) as the structural engineers for the super-structure for the Lane Academy bid, replacing WSP in this role. WSP were retained as civil and building services engineers. Clearly the power within the team, not just to appoint (and sack) the designers, but also to make fundamental design decisions, was that of the contractor.

Kier asked the director of the Ramboll Cambridge office to give a presentation to the client team on the embodied carbon calculations for the CLT system, as part of Kier's bid. During the bid phase the contractors, design team and the project manager once again visited the CLT factory in Austria. As for St Augustine, this was a deciding factor in the acceptance of the system by the clients. The project manager also visited St John Fisher to see the system being used in practice; it was very important to her both that there was considerable experience of using the material in Europe, and that the contractor had previous experience of building a school in CLT.

The CLT option was also strongly supported by the architects on the team bidding for the Lane Academy, both for its 'beauty' and as a 'demonstrably sustainable' choice. According to both the architect and the structural engineer interviewed, the timber was seen as a particular 'glory factor', and a strong reason why the bid won. However the Council project manager claimed that it was mainly the response to the *education* brief that swung the vote in favour of the Kier bid. The scoring sheet for the bids from the two contractors was difficult to analyse for evidence either way, as it was hard to identify which aspect was scored within each category. Under 'Materials and specifications' the difference between the two bids was minimal. In the 'Environmental strategy/BREEAM' the difference was slightly more pronounced in Kier's favour, although in fact the choice of the timber had made no impact on either the BREEAM rating at this stage or the carbon calculator score. Major differences in the scores for the two bids were given in 'Approach to construction' and 'Whole life costs' (whole life carbon not being part of the formal assessment), and a small difference in 'Programme'. The expert input by Ramboll may have helped, but it did not appear to have been the deciding factor as claimed. Belief in the importance of the expert knowledge in this case, was therefore exaggerated by the experts.

The appointment of Ramboll in place of WSP however showed that they *had* been successful in creating a monopoly of expertise in the CLT system. This was supported both through the practical design experience they had gained, and through the calculations they had carried out to demonstrate the embodied carbon of the material. The fact that they were appointed in place of another firm of highly regarded structural engineers, shows the niche aspect of the expertise even within their own profession.

On 8th August 2008, Kier were appointed 'preferred bidder'. The Sponsors issued a joint statement which said:

> "We wanted the design to reflect the environment and engineering specialism for the school and we are delighted that the winning design also incorporates a sustainable aspect wherever possible."

This suggests that the evident sustainability of the design *was* an impact in the choice, although the statement does not detail which aspects were seen as sustainable. The press release from Kier on the same day identifies the 'green features' of the school as:

> 'a timber structure, biomass boilers which burn wood pellets or wood chip; movement and daylight sensitive light and water saving controls; zoned heating to make the building more efficient when it is only partly in use; rainwater harvesting and solar thermal water heating'

6.3.2 Detailed design

As for the BSF process, there had been little opportunity for consultation during the bid phase. The Principal of the new Academy was appointed in April 2008, after the ITT had been issued; although in fact she had been the head teacher of the existing school, her late appointment meant that she had had no input into either the education or the design briefs up until that point. With the Academy sponsors she was then invited to six meetings with the bidding design teams but, as for Eastwick Field, a confidentiality agreement meant that they were not allowed to discuss the design outside the meetings. Two consultations were also held at the start of the bid period, one with the staff and children, and one with the local community; the latter was very poorly attended, according to the architect because of the worry among the parents about the Christian ethos of the two sponsors:

> '*This community... were really apprehensive. They thought they were going to be getting a cathedral and religion was going to be pushed on the children*'.

On the other hand the local paper reported:

> 'There was some local anger about the public consultation exercise ... claims that it did not reach enough parents or give them the chance to comment.'

The architect agreed that this was an area which could have been improved, although she also felt that the existing negative feelings in the community could also have caused major problems with planning consent and delays to the programme:

> *'We probably should have had a few more community consultations but for instance, prior to planning it's difficult because you don't want to jeopardise your planning application so you can't give too much away either. You don't want to go into detail about the building just in case that actually leads to public opinions prior to the application going in and then as a result having a lot more objections.'*

Photo 6.7 This space for whole school Christian worship was a key requirement of the sponsor, which caused some unhappiness with parents

The only two aspects from the consultation during the bid stage which affected the 'sustainability', according to the architect, were dual flush toilets and the inclusion of solar photovoltaic panels:

> *just at bid stage, so the night before we found out we'd won, they said we haven't got any solar panels, can we have solar panels? So we ended up putting two solar panels on the roof… it's just a gesture and it's pointless, for the amount of money it cost it's absolutely pointless. …I think what we've been able to do is make sure that they're used in the kitchen so there is just one isolated area where the kids go okay, what's being generated is being used for that kettle or something like that.*

Further aspirations for and interpretations of sustainability came from the design team. In particular the architectural practice Sheppard Robson used an in-house 'Sustainable Design Matrix', 'designed to set sustainable design aspirations and monitor these throughout the life of the project'; three sections focus on different social, economic and environmental aspects of sustainability. As part of the bid process Sheppard Robson also sent a 'Client Environmental and Sustainability questionnaire' to assess the priorities of the client body, which was sent to the sponsors, the project manager and the principal.

In comparison with the Eastwick Field project this period between preferred bidder and planning was a quick process, with little evidence of conflicting views. One of the reasons for this may have been the more limited consultation. Design development continued until 22nd September 2008, when the layouts were frozen and the Kier Eastern team submitted the planning application. This included three pages on 'Sustainability', with an opening paragraph stating:

> 'A primary aim for the design of the Lane Academy is to create a healthy, enjoyable, low-energy, BREEAM Excellent sustainable learning environment which helps students, staff and school visitors to develop and fulfil their potential.' (Planning Application for the Lane Academy,pg 38).

The requirement for achieving 60% carbon reduction had led the team to choose a biomass-powered boiler. However several interviewees felt that the carbon calculator was heavily biased towards the choice of biomass boiler, with no impact of location taken into account; this is discussed further in chapter 7. Last minute changes added the two photovoltaic panels, but otherwise the use of renewable energy sources did not appear to be a high priority for the design team. Energy efficient design was more of a priority, using careful orientation, high levels of insulation, efficient cooling and high-tech lighting controls. The planning document therefore emphasised these features, suggesting that they could be used to replace the requirement for renewable energy:

> *'the high degree of air-tightness and superior thermal insulation properties of the external structural envelope …. It is possible that this can be used to offset the building's renewable energy demands.'*

The planning application also included a statement written by Ramboll on the *'unrivalled green credentials'* of the CLT system, due to it being *'the only truly renewable building material'* and the *'net carbon saving in the order of 2,300 tonnes of CO_2'.* However the designed renewable energy sources were retained as part of the planning requirements.

A strong vision of social sustainability of the school's role as part of the community was included in the planning document, both in *'achieving results and standards for the students that they can go on to achieve themselves in the future'* and in *'building a sustainable community.* Emphasis was also placed on the importance of the school environment as a place *'where people want to live and work'*. However unlike in the Eastwick Field school, this does not appear to have been translated into greater consultation of and participation by the students and community.

There was then a period of three months waiting for planning approval to be granted, during which time the detailed design was developed. Both the new principal and the sponsor were 'heavily involved' in the design during this stage, but consultation with staff appears to have been limited to peripheral details. According to the architect again:

> *'… we had about a three week process where we actually sat down with the staff and the children … We couldn't necessarily change room layouts and where walls were, but we could actually look at furniture, we could look as I said, the branding, the actual vinyl that we're putting on walls and things, colours, they were involved in that for, as I said, that three week process.'*

Similar to the views of the structural engineers at St Augustine, the architect was '*quite negative about BREEAM',* which she felt that it didn't adequately reflect 'sustainability', part of her objection being that it included aspects which did not form part of her expert knowledge and that therefore she had no professional control over::

> *'I think it's just one of those keywords that you add in, it doesn't necessarily mean it's a brilliant building from a sustainable point of view at all. It is often to do with procedures and how the site is actually managed, what's recorded on site.'*

Other objections were based on its power to encourage certain actions – '*often things are just done purely for the basis of giving a BREEAM point*' - or alternatively discourage them: *'the minute you fall short everyone thinks well I'm not going to bother …. let's not do it at all then.'.* both of which could act against designing a more sustainable building.

A further limitation of the system was demonstrated by the time and cost that the architect had taken to get the CLT rated by the BRE, so as to gain 3 extra BREEAM points. This was necessary because the system was too new to be included in the BRE Green Guide, and the cost had been too high for the St Augustine budget.

A similar story about rating an innovative material was told by the contractor for the Eastwick Field School. In his case they had decided to use carpet tiles in a school, so that if areas of the carpet were stained or worn they could be replaced without having to replace the whole carpet. They also had an internal requirement to use materials which were rated as A by the BRE Green Guide; however even after considerable effort they failed to find a carpet tile which had been rated by the Guide, although they did eventually use a manufacturer who was going through the process of accreditation:

> *They told that to get a grade A they have to invest and pay the money to Building Research Establishment to do all these final tests to get it into the brochure and that costs up to £50,000 …. there is nobody on the market with a grade A floor tile ….so we did it in the style of a grade A in the end and paid a little bit more money but we didn't get the BREEAM points.*

The use of the Green Guide, and of BREEAM, to assess the sustainability of the project is therefore limited to existing data and by financial considerations of individual companies. The result is that an assessment tool which is seen as rational and value-free is actually contingent on prevailing construction methods. Because the tool itself has been given such a powerful role in public procurement, it could have the unintended effect in some cases of deterring the use of innovative and non-standard components, resulting in an outcome which is less environmentally sustainable than if the tool had not been used.

Planning consent was granted on the 15th December 2008, at the same time as the draft 'contractor's proposals' were received. These led to the submission of the final business case to the DCSF in January 2009, and finalised contractor's proposals on 23rd February.

At this point the contracts manager from St Augustine was moved to the Lane Academy bringing his valuable knowledge in building in CLT. He had also worked closely with the

Council project manager on previous projects, and there was clear evidence of their good relationship in the smooth running of the construction. The month between the Contractor's Proposals and start on site was used by Kier to clarify the details of ground levels, which were carefully designed so as to avoid having to remove any earth from site, and to develop an innovative edge support system for the CLT which negated all need for scaffolding, saving time and money and allowing considerably easier access and therefore working conditions on site (see Photo 6.8). This was an adjustment of an existing system, and directly based on their knowledge gained at St Augustine.

Photo 6.8 The offsite fabrication and an innovative edge support system, shown here, obviated the need for scaffolding and greatly improved access during construction.

The contract was signed on 23rd March 2009, signaling financial close, and site set up started immediately after that. The first turf was cut on the 27th April.

6.3.3 Construction

The principal and the architect had ensured that the pupils were involved throughout the design stage, setting up teams to work on different areas such as landscape, interiors and building services. This had continued into the construction phase with a group of pupils even attending the turf cutting ceremony in their Easter holidays. However in the middle of the construction period, just before the end of the summer term in 2009, the head teacher left leading, according to the architect, to the end of the involvement of the pupils: *'She really did drive the kids and wanted them to feel part of it and that bit's been lost.'*

Construction was completed to programme in August 2010, with demolition of the existing school buildings and following landscaping work to follow.

While the use of the same construction material at St Augustine was again a noticeable and effective aspect of the project, the reasons for the introduction and acceptance of the material were quite different. While Kier had made the decision to use CLT again, it was highly likely that this was due to the benefits it gave them including reduced time on site. There was no clear evidence to suggest that the professional expertise of the structural engineer had affected the result of the bid. Instead although not stated explicitly, the continuing good relationship between Kier and the Council appeared more likely to have determined Kier's successful bid. The timber was appealing, both to the influential sponsor and to the architect, for its visual effect. More detailed calculations of the embodied carbon saved were made by the structural engineer, and used in a promotional video by Kier. Therefore the expert knowledge provided by the engineer, supported as Latour (1991) suggested by specific technical language and practices, has been supported by the (in this case more powerful) contractor. As well as its use in 'buttressing' the engineer's position (see Scott, 2001) the expert knowledge has been co-opted by the contractor to induce lay trust and acceptance of a technology which has turned out to have multiple other benefits to him.

The timber sports hall was the first superstructure to be erected, in June and July 2009, taking just six weeks, and from then on was used to provide on site dry storage for materials. This saved the building of temporary onsite storage and hard standing, and the considerable associated waste material and energy use on site. This, combined with the careful design of site levels and even the sieving of the topsoil to re-use as sub-base and topsoil, had the effect of reducing site waste to landfill to very almost zero.

As for the first case study, the contractors on site were overwhelmingly appreciative of the different working environment provided by the timber system – the lack of noise, dust and scaffolding, the dry storage provided by the quickly erected sports hall, and the general speed of erection with the related 'feel-good' factor, were all cited several times by many individuals on site.

6.4 Conclusions: impacts of professions and expertise on sustainability

These two projects, in many ways very similar to the Willmott Dixon projects covered in the previous chapter, were in other ways very different. *All* the respondents saw sustainability as an important issue; both schools were heralded as 'sustainable', with St Augustine gaining BREEAM Schools Very Good in 2008 and winning an award for sustainability from the Institution of Civil Engineers, and the Lane Academy gaining BREEAM Education Excellent in 2010.

The particular 'sustainability' aspect which led to the choice of St Augustine as a case study was the introduction of an innovative construction material, cross-laminated timber (CLT). While this material had been in use in Scandinavia for many years it was extremely new in the UK, with only one other school building under construction at the time. It's introduction, in such a traditionally conservative and risk-averse industry (Manseau and Seaden, 2001), was therefore unusual. The structural engineer, in successfully introducing the material to the rest of the client and design team, demonstrated his power to produce an outcome which would clearly not have happened otherwise, and which affected not only the physical attributes of the school buildings but also the subsequent practices and relationships throughout the project.

The aspect of the material that the structural engineer used overtly to support his arguments was its low embodied carbon. This was the issue that had been deliberately excluded from policy, as seen in chapter 4, but which, however, was well-known to most of the industry (as also demonstrated in chapter 4).

The persuasiveness of his argument was through his mobilization and demonstration of expertise through various methods. One was the creation of a spreadsheet programme to calculate the embodied carbon of various building constructions, based on the materials phase (see Appendix C for more details of the phases of embodied carbon), demonstrating and validating the engineer's expertise in calculation. His expertise in the practice of this particular

material was demonstrated through his design of two other projects. The engineer also had a further warrant of his expertise in this area in his link with Cambridge University, even though in fact the University actor was a masters student, who was heavily supervised and supported in his research by the structural engineers.

Therefore while making the case for the use of the material, the engineer was engaged in developing an argument for embodied carbon, which employed the calculations of the relative numbers and his knowledge of expert practices. The gap between his expertise and other, lay, knowledge, and therefore the power of his expertise (Scott, 2001), was further supported by these specific languages and practices, which only he had access to.

The engineer therefore described his own company and this particular argument for cross-laminated timber as having been responsible for introducing sustainability into the project, and even for bringing it '*into the clients' consciousness and dare I say the rest of the team.'* This view was not supported by evidence from the project brief, which had explicitly stated its sustainability aspirations, nor by other documents and interviews which showed pre-existing and varying views of sustainability which showed no sign of having been influenced by the structural engineer. The services engineer, for instance, produced a report on the design of mechanical and electrical services, their field of expertise, and titled it 'Sustainability Report', which contained details in particular of the renewable energy options.

Because of the evident power that expertise in this area conferred on the expert, it was clearly in the interests of each profession to promote their own area as 'sustainable'. The introduction of the innovative material, and the new claims and relationships which it was formed on, demonstrated the changing and contingent nature of expertise in this context, with the two engineers competing 'for rights over a particular sphere of activity' (Scott, p.201)

Scott saw that claims to professional expertise imply not only a power relation with the client but also with other professions :

> 'Experts establish professional jurisdictions in their struggles against others for rights over a particular sphere of activity. In establishing exclusivity and closure, they define themselves not only in relation to their clients but also in relation to other professionals.' (Scott, 2001, p.102)

Even so the structural engineer demonstrated absolute certainty in his own singular definition of sustainability as embodied carbon, and also believed in the neutrality of his own professional discourse, supported by the fact that the language used was that of numbers:

> *'We've got the numbers, and we've done the numbers as you know as a practice, actually trying to put the science down, turn it into numbers, an actually tangible measure.'*

However, as for the structural engineer, the services engineers appeared equally convinced that their interpretation of sustainability, as renewable energy provision, was correct. A similar effect was also evident in interviews with both the structural engineer and the architect, who both saw BREEAM as limited in its assessment of 'sustainability' because it didn't include aspects of their own fields of expertise. Because of much of the focus of the tool being on site management practices, the architect therefore claimed that '*it doesn't necessarily mean it's a brilliant building from a sustainable point of view at all*'. Its very limited inclusion of embodied carbon (as one factor taken into account in rating building materials through the BRE Green Guide (BRE, 2007, Mistry, 2007)) led to the structural engineer's claim that '*the whole marking system, the credit system is wrong … the embodied carbon …. to me is what BREEAM should be about … sustainability, embodied carbon, in terms of the actually tangible thing*.'

Foucault saw systems of expertise as being 'discursively formed' not just produced by individuals within that profession, but also an effect of the system of knowledge on the professionals. In both cases, the professions of the engineers had actively formed, as well as informed, their views and knowledge. Their disciplines had disciplined their thoughts within their professional context and, on the whole, they were unaware that this was so.

While the timber solution did not conflict with the renewable energy solutions, however the claim of the structural engineer to expertise in sustainability was clearly a challenge to the services engineers competing claim to expert knowledge of sustainability. The definition of sustainability as renewable energy, supported by central government policy, had already allowed the services engineers to create a claim to expertise in sustainability at project level, which was now confronted by an alternative definition of sustainability. The quantity surveyor also objected to the introduction of the material; as CLT was new to the UK, he was unable to cost it in the industry accepted manner, based on existing price data. Therefore the use of the material also conflicted with his claims to expertise, with the structural engineer costing the system for the project by gathering quotes. Therefore the new definition of expertise in sustainable construction as low embodied carbon reduced other claims to expertise within this project setting.

The collective professional expertise of the design team had held the balance of power at the St Augustine project, supported through the procurement structure which allowed the late appointment of the contractor and the following novation of the design team, who had developed by then extensive knowledge of the existing buildings and the detailed design.

The second project had a different trajectory. As a framework project, the bid was managed by a team led by the contractor, Kier. Several weeks into the bidding process the Kier bid manager decided to use the same CLT material at Lane Academy as had been used at St Augustine. The reasons for the use of the material on the second project were somewhat different. Kier used the sustainability credentials of CLT as a low embodied carbon material to sell it to the new client, through a presentation on its embodied carbon given by the structural engineer. However their choice of the material was due to the benefits of the construction process, including greatly reduced time on site, reduced risk, improved health and safety in terms of reportable accidents, and possibly reduced costs to the contractor. For the contractors on site it was clearly also a far more pleasant working environment – clean, quiet and with easy accessibility due to the lack of scaffolding. Therefore as well as supporting the engineer's position his expertise had been co-opted by the contractor to induce lay trust and acceptance of a practice which had multiple other benefits.

The appointment of Ramboll on the team in the place of WSP, another firm of highly regarded structural engineers, showed the former's success in creating something close to a monopoly of expertise I this area within the UK, supported both through the practical design experience they had gained, and through the calculations they had carried out. Thus their expertise was formed through the development of specific languages (both words and calculations) and practices (Latour, 1991).

According to both the architect and the structural engineer interviewed, the timber as a 'demonstrably sustainable' choice was seen as adding particular kudos by the client, and a strong reason why the bid subsequently won. However there was clear evidence, from interviews and from project documents, that it was the response of the bid to the Education brief, combined with the existing relationship between Kier and the Council which were most instrumental in Kier's success. While it may have helped, it did not appear to have been the engineer's definition of sustainability as low embodied carbon that was the deciding factor.

While it was the particular demonstration of the timber as a low embodied carbon material, and this reflection of the prevailing concerns about sustainability, which helped the material to be introduced at the St Augustine School, it was the interest of the (in this case more

dominant) contractor in the low waste and quick erection properties which led to its use at the Lane Academy. The introduction of this innovation in the UK construction industry, supported through the technical, numerical arguments of the professional experts, was therefore nevertheless contingent on its alignment with existing interests within a number of institutions.

Chapter 7: Power, politics and numbers

'The number of primes less than 1,000,000,000 is 50,847,478: that is enough for an engineer, and he can be perfectly happy without the rest. So much for Euclid's theorem; and, as regards Pythagoras's, it is obvious that irrationals are uninteresting to an engineer, since he is concerned only with approximations, and all approximations are rational.'

G H Hardy, A mathematician's apology

7.1 Introduction

The first question asked by this thesis was 'How is sustainability being interpreted, and translated into practice, in the construction of new school buildings?' The three previous chapters considered this question in the context of UK policy (chapter 4), and in four individual school building projects (chapters 5 and 6). These chapters have demonstrated that the aspect of sustainability which has formed the dominant political concern has been the mitigation of climate change, based on very valid fears of its predicted widespread effects on society and the economy as well as on the global and local environments. For the construction sector this concern has been translated into a focus on constructing buildings with low, or even zero, carbon emissions. In turn this has resulted in the proposal and application of a number of technical 'solutions' for the construction of 'sustainable buildings'.

The second question asked, 'How have political, social, professional and technical decisions and concerns led to this particular interpretation and translation of sustainability for construction?' Chapter 2 set up a theoretical framework to answer this question, through the consideration of power effects. Different forms of social power were discussed, and different sites or applications of power which were found to be particularly relevant in such political and socio-technical areas. These have formed the focus of the empirical chapters, through an analysis of political lobbies and central Government in chapter 4, the impact of tools and technologies in chapter 5, and the relationship between disciplinary expertise and power in chapter 6. This chapter now considers the last of these applications of power, examining the numbers and calculations which have supported the choice of technical solutions. The concern of the chapter is firstly whether the technical solutions had the effects claimed by the calculations. Secondly whether the numbers used to justify the solutions were value-free, or whether they were (as suggested in chapter 2) used as a resource to invoke trust, or to repress

conflicting views, by those wishing to cause a specific effect in their own interests. Thirdly, whether they were part of the professional knowledge systems of their designers.

The technical solutions which are considered are those which dominated the regulations for sustainable buildings, and those which dominated the decisions made in the name of sustainability in the four projects. They cover in turn: the reduction of operational energy through energy efficiency measures; the choice of renewable energy technologies, focusing in detail on the main technologies chosen by the four case studies of ground source heat pumps and biomass boilers; and the reduction of embodied carbon.

7.2 Reduction of operational energy

Chapter 4 demonstrated that UK regulation for sustainable building has focused on reducing operational energy, in response in particular to the Energy Performance of Buildings Directive. The revision of the Building Regulations Approved Document part L 'Conservation of fuel and power' in 2006 included measures to reduce operational energy use and carbon emissions compared with the 2002 regulations, by 23% for naturally ventilated, and 28% for air-conditioned, non-domestic buildings. This was to be achieved through 'higher performance fabric, heating, ventilation, air conditioning and lighting systems designs' (ODPM 2006 part L2A, p.1).

The new Regulations required, at the design stage, the calculation of the Target CO2 Emissions Rate (TER), expressed as follows:

$$TER = C_{notional} \times (1 - \text{improvement factor}) \times (1 - \text{LZC benchmark}) \text{ (p14)}$$

$C_{notional}$, the notional carbon emissions, are for a 'notional building' of the same physical dimensions, calculated using the Simplified Building Energy Model (SBEM) or other approved method. The 'improvement factor' is based on the 'services strategy' (ODPM 2006, p.14), based on the assumed improvements to energy efficiency in the heating and ventilation systems. The 'LZC benchmark' term, the provision of 'Low or Zero Carbon energy supply systems', is considered further in section 7.3.

Part L also required a check that the 'actual building emissions rate' (BER) did not exceed the target (TER). There were two differences in the calculation of the BER; it included the effect of any design changes since the TER had been calculated, and it was based on a pressure test of

air permeability of the finished building. However it did not incorporate the actual performance of the building services, or the carbon emissions from their operation.

This is an important omission from the calculation. In practice research has shown repeatedly that the actual behaviour of occupants can cause major deviation from the design performance. For example the Carbon Trust monitored a block of identical flats and found that energy use from different identical units differed by a factor of two (Carbon Trust, 2007); Tovey and Turner demonstrated further that the *same* occupiers making small changes to their behaviour can have a marked and instant effect, concluding that 'with concerted effort low energy strategies can be significantly enhanced by promoting awareness of building users' (Tovey and Turner, 2006). Similarly Yun et al (2008) point out how the designed energy use of a space is compromised as soon as someone opens a window. A lack of understanding of the behaviour of occupants can also lead to solutions which were originally developed to reduce energy use resulting in the opposite effect. Conservatories provide one well-known example; designed originally as 'buffer' zones between the external and the internal climates, and considered to act technically as a large cavity to *increase* thermal insulation to the house, research has shown that in fact they are often used as rooms in their own right, and therefore heated to the same temperature as the rest of the house. The subsequent loss of heat through the poorly insulated walls and glazing leads instead to a huge *decrease* in thermal efficiency (Oreszczyn, 1993).

School buildings too have been shown to use more energy in practice than the calculations at the design stage predicted. A database provided by Carbon Buzz (Carbon Buzz, 2010) also shows a performance gap between forecast and actual emissions for schools, of on average 64%. While Carbon Buzz collects raw data, it does not reveal the reasons for the discrepancies, and more detailed published cases of energy use in schools are few. One however is provided by Adebayo (2011) of a school in the London Borough of Sutton procured through an innovative process that included the school as a contractual member of the core partnering team. While the final outcome was not ideal, the overall CO2 emissions of the building were considerably lower than the average consumption for schools in the Carbon Buzz dataset. This supports the conclusion of the Zero Carbon Task Force, reported in chapter 4, that the involvement of the school stakeholder in the design stage is the most important step towards reducing carbon emissions.

A less positive story comes from a case study which has been written but never published. The study was of the Greenwich Millenium Primary School, intended to be the first exemplar low energy school for the new century, a 'best practice' example of low consumption of gas and electricity. This was to be achieved mainly through passive design measures such as orientation and the use of natural daylighting and ventilation, as well as the innovative use of a new technology, the 'TermoDeck' floor system, which allowed cool air to circulate at night. The school was opened in 2001. In 2004 the BRE on behalf of the Carbon Trust commissioned an independent case study of the school (Eclipse, 2005). The study found that, rather than 'best practice', the electricity use in fact put the school 'among the highest users of electricity of English primary schools' while the gas use was only just within the 'good practice' category from the Carbon Trust. The target daylight factor of 4% was 'widely missed' and the lights were generally on during the day, even in summer. Some aspects worked, such as the air quality in the rooms, and the school was generally liked by its occupiers. However there were also several areas of dissatisfaction including the temperature of the classrooms, which were too cold in winter and too hot in summer, and the lack of control over heating and ventilation. The case study was never published by the Carbon Trust or by BRE. When asked why not, the author of the report replied

> '*When it was discovered that it was no good, no-one wanted to know. When it was first started people said, if it's successful we want to know about it, and if it isn't we want to know why. But it wasn't really true.*' (Personal communication, 25/11/11)

Any detailed investigation into why the building did not perform as it was calculated to do was therefore suppressed. With the lack of technical examination of the original calculations and assumptions, there was no rational conclusion that could be drawn. The problem and solution having been set up as technical issues, where the performance is not as expected and calculated, the blame is therefore laid on the irrational occupants.

Many papers therefore present the human occupants of buildings as 'barriers' to the idealised technical solutions. Others also identify similar human barriers to the uptake of such technical energy efficiency measures (Ko and Fenner (2008), Osmani and O'Reilly (2009)). One approach to energy efficient design therefore attempts to design out the human factor. This is 'building physics', which is 'the science of optimising the physical characteristics of buildings and their systems to balance these energy demands, exploit natural energy sources and minimise the

reliance on artificial energy' (RAEng, 2010, p.2). The Royal Academy of Engineering report is titled 'Engineering a low carbon built environment' (therefore, and not surprisingly, clearly defining the solution as technical). Building occupants are mentioned only in terms of their physiology 'particularly relating to comfort and task performance' (p.9) and their imperfect interaction with the technical systems:

> 'Manually operated systems need human intervention to operate and therefore need a strict management procedure ... Often these systems are left unused …. With these problems in mind, we decided to take a new approach … free from any electronic or human intervention.' (RAEng, 2010, p. 32)

The Local Authority project manager of Lane Academy stated that the new school buildings in the county were not just using more energy than had been estimated at design, they were using even more energy than the buildings they had replaced. In her view this was due to the ICT provision in the schools. She also explained that it was being kept deliberately quiet by Partnerships for Schools, the county clients and the building designers:

> '*Because nobody wants you to see it, because actually the schools are not performing as they thought they would. We've done all the building regs stuff so we know they're more energy-efficient actually than they were, but actually they're still using more and that's probably because of the ICT quite frankly. … and what I am getting the drift of now with Partnerships for Schools is there are clear concerns about the amount of energy being used by the ICT side of things. … But it's almost like a taboo subject that nobody will actually dare mention.'*

The Kier Education Director supported her view that the increase in energy was likely to be due to the ICT provision:

> *'as an example we used to probably put one data point in per four pupils… now we're putting in probably one and a half data points per pupil, you know, so what used to be a 1,500 place school might have 300 or 400 data points in it has now got 2,200 data points in it. So you can imagine the amount of PC and technology that is going in there and the heat gains that you get from all this ICT and the energy consumption that you get from all this ICT'*

A more recent review of the published Display Energy Certificates (which show actual energy used) for school buildings shows indeed that carbon emissions from Academies in particular were about 20% higher than for other, existing, secondary schools. The paper concludes that

> 'CO2 emissions have actually increased in recent years, on both a per m^2 and a per pupil basis. This confirms the fears in the GAP et al. (2006) report that overall schools emissions would rise due to increased electricity use.' (Godoy-Shimizu et al, 2011, p.550).

It too concludes that this is due to the increase in provision of ICT.

So energy efficiency measures in buildings are the principle method through which policy aims to achieve 'sustainability' in construction. Both energy efficiency of fabric and building physics solutions are primarily concerned with reducing energy in use, and are intended to also have the effect of reducing carbon emissions from that energy. In real life, as has been shown frequently and in diverse ways, buildings and occupiers do not perform as the design calculations estimate. Even so legislation remains focused on methodologies (such as SBEM and the TER) which measure the designed energy, rather than the actual building performance in operation.

The calculations used to estimate energy in use include a number of assumptions about construction and about occupant behaviour. These calculations are proscribed by regulation for all new buildings, and are not subject to scrutiny. With very little collated data about the real performance of buildings, this means that the assumptions made in the calculations and the real causes of energy use in buildings are not investigated, and most of the assumptions made at the design stage are still subject to an unrealistic assessment of the building's operation. Thus the calculations themselves, and their numeric results, are given considerable credence through the regulatory structure that has incorporated them. The resultant trust in these calculations is suggested most strongly by the ICT argument for schools, which is based on the assumption that the numbers produced through the regulated calculation method therefore can't be wrong. The (highly technically competent) project manager for the Lane Academy gives an example of the views of many of the informants when she says, *'We've done all the building regs stuff so we know they're more energy-efficient actually than they were.'*

The numbers derived from the calculations, supported by the implied rationality of the building regulations, have become trusted ('we *know* they're more energy efficient actually than they were') inspite of multiple evidence to the contrary.

In fact in 2002 the energy use of the ICT in schools was 2% of the total (DCSF, Oct 2007, p.3) If now multiplied by 6 as suggested by the Kier Education Director, the energy consumption due to ICT would be approximately (not quite) 12% of the new total energy consumption. Even allowing for extra energy use to cool the server room or the IT suite, this does not explain the discrepancy of 64% revealed in the Carbon Buzz database.

The framing of the issue as technical, combined with the lack of detailed scrutiny of the reasons for discrepancies, suggests that the number can't be wrong. Therefore the mis-match between the calculated and the actual energy is seen most often seen as a failure of the occupier, not of the calculation. In the specific case of schools, this mis-match has taken a new slant. Evidence is emerging that the new buildings are using more energy than predicted, and indeed more energy than older buildings. However the reason is widely put down to the high level of ICT provision, which leads to the developing focus on a new technical solution for low energy computing. No respondents suggested that the reason for the discrepancy might be due to the inadequacy of the assumptions made in the initial calculation to accurately determine operational energy used. This is therefore an example of simple trust in numbers.

7.3 Renewable energy

7.3.1 Policy and projects

The Building Regulations 2006 (Part L2A) also encourage the provision of onsite renewable energy through the Target Emissions Rate:

$$TER = C_{notional} \times (1 - \text{improvement factor}) \times (1 - \text{LZC benchmark}) \text{ (p14)}$$

The 'LZC benchmark' is the provision of 'Low or Zero Carbon energy supply systems', and 'implements the requirement in Article 5 of the Energy Performance of Buildings Directive to give consideration to the incorporation of low and zero carbon energy supply systems before construction starts' (p.14). This factor is defined as 0.1 in the Building Regulations, or a target of 10% carbon emissions reduction. The calculation does not make the provision of such systems ('renewables' in common parlance) mandatory, but does add the statement that: 'In appropriate circumstances, LZC energy supply systems such as solar hot water, photovoltaic

power, bio-fuels …combined heat and power….and heat pumps can make substantial and cost effective contributions to achieving TERs.' (p.16) The provision of 10% renewables has also been particularly encouraged by the local planning requirement started in the London Borough of Merton, the 'Merton Rule'.

The DCSF published 'The use of renewable energy in school buildings' in 2007, which describes 'the multiple benefits of renewable energy technologies' as 'Educational/social', 'Environmental', and 'Economic'. Under the second of these the report states that:

> 'All technologies will provide carbon savings compared to fossil fuel powered equipment and therefore contribute to local and national carbon reduction targets. The presence of a renewable energy installation can often encourage building occupants to use the building in a more energy efficient way, saving further energy and carbon.' (DCSF, 2007, p.2)

Further information on the choice of technologies is provided by an inter-disciplinary group of researchers from several prestigious UK universities including Oxford, Imperial, UCL and Loughborough, funded by the UK Energy Research Council as 'the Microgeneration Group'. The introduction to their concluding paper reads

> 'In many situations, local generation has the potential to achieve much higher efficiency, and consequential carbon dioxide and cost savings... Microgeneration also has the potential to help combat fuel poverty, add to the diversity of energy supply, offset some of the looming shortfall in centralised generating capacity and avoid the need to replace or extend electricity transmission infrastructure.' (Bergman et al, 2009, p.23)

The result of the encouragement of renewable energy technologies had another powerful effect. 'Renewables' formed the *dominant* definition of sustainability, from respondents from across all professional groups who were interviewed, cited more often than any other answer. This was inspite of the fact that the 2006 Building Regulations, newly published for these case study projects, were considerably more onerous in their demands for improved energy efficiency through fabric improvement (23-28% mandatory reduction in operational energy compared with the 2002 regulations) than for renewable energy (optional supply of 10% of the operational energy requirements). However, inspite of renewables being a recurrent

interpretation of sustainability, many respondents were also rather negative about the specific results from these technologies –

> '*Some stuff is a bit gizmo-ish really'* Client, Backhouse School
>
> *'I'm not sure of what the benefit of a wind turbine of that size is really going to be over, I think there's a payback of about 15 years before it really starts. .it's doing 6kW per hour or something, which to ignorant builders like me I believe is a kettle...'* Contractor, St Augustine
>
> *'..with wind turbines there, I'm not certain they produce anything other than the maintenance costs'* Bursar, St Augustine
>
> *'token displays of sustainability and sticking on a couple of solar panels as opposed to actually the inherent ideas which will save the running costs of the building later further on down the line'* Architect, Lane Academy

While the provision of renewable energy technologies was not a specific requirement, all four case study schools provided an element of 'renewable' low/zero carbon energy, as shown in table 7.1.

Schools	**Technology**
Backhouse and St Augustine	Ground Source Heat Pumps (GSHPs)
Lane Academy and Eastwick Field	Biomass boilers
St Augustine	Solar hot water panels
Lane Academy	Solar photovoltaics
St Augustine	Wind turbine

Table 7.1 Renewable energy technologies installed in the case study schools

The following section considers the main two solutions chosen, in terms of percentage of energy supply. These were the ground source heat pumps and the biomass boilers.

7.3.2 Ground source heat pumps

In contrast to the generally negative views expressed about the technologies, at St Augustine opinions about ground source heat pumps were very positive from all respondents:

> '*…ground source heat pumps, everybody tells me are really, really good and that's where I ought to be going*.' Client/consultant, St Augustine

> '*I mean the ground source heat is a fantastic one and I'm really pleased at how we've pursued that.'* Bursar, St Augustine

> '*The ground source heat pumps …. are probably the most effective of the lot of them.*' Architect, St Augustine

Backhouse School also had a GSHP installed, but while the choice at St Augustine was clearly agreed by all the actors, at Backhouse the local authority client chose the ground source heat pump (according to the services engineer and project manager) because it was the lowest cost option, and inspite of advice (quickly withdrawn) from the services engineer that they should be installing an electricity generating technology instead. In fact the GSHP is likely to have cost far more than predicted, and possibly more than the alternatives (see chapter 5).

This section will focus on the details of the ground source heat pump technology in order to understand its claims to be a 'low or zero carbon energy supply system' in the definition of the Building Regulations.

A ground source heat pump (GSHP) uses a heat exchange fluid pumped through pipes in the ground to extract heat. This heat is transferred to water which flows through an internal pipe system. The ground pipes are either looped horizontal 'slinky' pipes laid between 1 and 2m below the ground's surface or, where there is limited space or unsuitable soil types, in deep boreholes typically of around 100m depth. Performance reduces with lower ground temperatures and is dependent on soil type. The ratio of the energy heat output from the system, to the power input to the pump, is called the Coefficient of Performance (CoP), and is a direct measure of the efficiency of the system. This can also be measured as the Seasonal Performance Factor (SPF), which is the output over the input measured for a calendar year.

GSHPs have received considerable positive press. An example comes from the Environment Agency, who commissioned a report in November 2009 'to ensure that the Environment Agency is suitably prepared to support the future deployment of ground source heating and cooling pump systems' (Le Feuvre and StJohn Cox, 2009, p.iv). The report is clearly supportive of the growth of the market sector for GSHPs, as demonstrated by defining as 'barriers to growth' issues such as the higher capital costs of the heat pumps, the 'disruptive and

expensive' aspects of retro-fitting pumps, and the fact that the '72% of households are on the gas network and can therefore use cheaper and more conventional gas boilers' (Le Feuvre and StJohn Cox, 2009, p.iv-v). A further 'barrier' is given as 'the carbon intensity of the UK grid'. The implications of this are discussed below in more detail. The clear focus of the report, inspite of these 'barriers', is to encourage the provision of GSHPs. 'Pronounced market growth' is reported in London, Cornwall and the South West, Yorkshire and the Humber, and the East of England, with reasons as the 'impact of the Merton Rule', particularly in London, and the prevalence elsewhere of the absence of the mains gas network. However, as the report admits, it is difficult to assess the actual number of installations, and the Environment Agency has estimated this from the answers given by 'stakeholders' from the GSHP industry. Even more limited is information about how much heat is actually generated by the installed GSHPs – bluntly, 'The thermal capacity associated with these units is unknown' (Le Feuvre and StJohn Cox, 2009, p14).

Even so, relative carbon emissions of the GSHP compared with a system it might be replacing are given on p 35:

> 'A heat pump with a Seasonal Performance Factor (SPF) of 3.5 can deliver 1kWh of heat at 0.15 kgCO2/kWh, while a gas boiler at 90% will deliver heat at 0.228kgCO2/kWh. This is based on an average grid intensity of 0.527 kgCO2/kWh. '

This sounds good, inspite of the cautionary note below, which states that

> 'This suggests that a heat pump must achieve a minimum SPF of 2.3 to deliver carbon savings over a gas boiler, which is not always possible.' (Le Feuvre and StJohn Cox, 2009, p.35)

As the report has already stated, it has no knowledge of the heat generated, or of the efficiency of the heat pumps.

Bergman et al (2009) estimate 'lifetime carbon dioxide emissions reductions' of different microgeneration technologies, giving that for GSHP as the second highest at 36 t CO2 (second only to a biomass boiler). The paper bases this on a coefficient of performance (CoP) of 4.1 (Bergman et al, 2009, p.27).

A slightly lower coefficient of performance is reported by Andy McCrea, in 'Renewable energy: a user's guide', which states on page 54 that: 'A typical residential heat pump system might be operating with a CoP of 3.4', although it does follow this up with the statement that 'Heat pumps that deliver a CoP of three to four are performing well' (p.55). Again no data of systems in practice are given.

Between 2009-2010 the Energy Saving Trust attempted to fill this remarkable lack of real data by monitoring the actual performance of 83 heat pumps, including 47 GSHPs and 36 air source heat pumps (ASHPs). The report is equally upbeat about the potential of GSHPs, with a statement on the first page stating that 'DECC considers that heat pumps have an important role in achieving Government policies to reduce CO2 emissions' (Energy Saving Trust, 2010, p.1), and a positive-sounding list of key findings which include, for example:

> '1. The performance values we monitored in the sample heat pumps varied widely; the best performing systems show that well-designed and installed heat pumps can operate well in the UK.'
>
> '2. The 'mid-range' ground source system efficiencies were between 2.3 and 2.5, with the highest figures above 3.0.
>
> …..
>
> '9. A comparison between carbon emissions from heat pump installations and electric or gas heating (based on the UK government's current predictions for grid decarbonisation) shows that a well installed heat pump can lead to carbon savings, both at present and over the lifetime of the pump.'
>
> (Energy Saving Trust, 2010, p.9).

In fact the actual Coefficient of Performance (CoP) of the GSHPs was found to be between 1.2 and 3.2, and the mean value was 2.3. *No* pump in practice reached the figure of 3.4 which McCrea based his calculations on, or 3.5 in the Environment Agency report, let alone the 4.1 from the academic microgeneration group.

However, a coefficient of performance of 2.3 is still an efficiency measure equivalent to 230%, which sounds good compared with a gas boiler operating at an efficiency of 90%. It might be expected that this would equate to considerable reduction in carbon emissions. The following

calculation therefore compares the emissions from a GSHP of average efficiency, as measured by the Environment Agency, with the conventional gas heating system.

A CoP of 2.3 means that for every 1kWh of energy used in driving the pump, 2.3 kWh of energy is produced. The energy used for the pump comes from grid electricity delivered to the site. Because the losses from the power station and the electricity supply network are such that only 0.36 of the energy entering the power station actually reaches the user and is metered, each 1kWh metered electricity actually comes from the production of 1/0.36 = 2.78 kWh electricity at the power station. This is reflected in the Defra/DECC figures for the carbon intensity of 1kWh electricity delivered energy (2008 figures), which is far greater than for 1kWh energy delivered as natural gas, which has fewer losses. Including scope 3 losses (upstream of the power station),

1kWh electricity = 0.61707 kgCO_2e, whereas

1kWh gas = 0.22554 kgCO_2e (based on Defra/DECC figures)

Incidentally, these figures are different to those cited by the EA, which has a noticeably less carbon intensive figure for electricity. There was no information about where the figures came from in the report, but it is likely that they were using data which excluded scope 3 losses, and data from an earlier year. In fact with the reduction in nuclear power the UK grid *increased* in carbon intensity between 2002 and 2008.

So, using 2008 figures, if 1kWh electricity is converted to 2.3kWh energy (in the form of heat) through a heat pump of average CoP,

<u>0.617</u> kgCO_2e will be emitted in the production of 2.3kWh heat energy from a GSHP

If this 2.3kWh energy comes instead from gas, this will emit 0.22554 x 2.3 = 0.519 kgCO_2e. This is not quite equivalent, because the gas still needs to be converted to energy as heat through a gas boiler. If a 90% efficient gas boiler is used (as used in the Environment Agency report, Le Feuvre and StJohn Cox, 2009, p.35), then 2.3kWh heat energy will use 2.3/0.9 = 2.56kWh input energy, equivalent to 0.22554 x 2.56 = 0.576 kgCO2e. Therefore,

<u>0.576</u> kgCO2e will be emitted in the production of 2.3kWh heat energy from a gas boiler

This would suggest that the use of the GSHP emits *more* carbon than the gas boiler, not less.

There is another issue to be taken into consideration in this calculation, which is the mode of use of the GSHP. This method of producing heat works best at low temperatures – typically between 30 and 40 degrees C. Therefore rather than using the heat from a GSHP to heat radiators to around 80 degrees, as in a conventional heating system, the heat is best used (and was in the two schools who installed a GSHP) as under-floor heating. This works by heating up a large area of thermal mass, usually a cement screed over the top of a system of small bore heating pipes. This has a large thermal inertia, which means that it does not respond quickly to changing demands. Unlike a radiator system which can be controlled quickly by thermostatic valves, an underfloor heating system will take several hours to heat up, and to cool down again, as opposed to a conventional system which might take up to one hour (for a detailed explanation see McCrea, 2008, p.66). In fact the DfES publication on 'Schools for the Future: exemplar designs concepts and ideas' for this reason recommended against the use of underfloor heating for schools:

> 'Heating methods have been carefully considered and underfloor heating has generally been avoided, as it responds too slowly to react to the fast changes of utilisation in a school and therefore requires a supplementary form of heating.' (DfES, 2004a, p.27)

A school, unlike a residential building, is typically occupied between 8am and 4pm, with only a few areas in use later in the evening. If the underfloor heating is switched on (a minimum of) 4 hours before 8am each morning, and turned off at 4 (assuming any after school users are left to gradually cool down), the percentage extra energy used by this system over a conventional system will be:

[(4-1)hours] / [8hours] x 100 = 37.5% extra

So the CO2 emissions will increase by this much for the GSHP system. Therefore factoring up each unit of energy, the GSHP system will emit the equivalent of 0.617 x 1.375 = 0.848 kgCO2e for each 2.3kWh of heat during the school day:

0.848 $kgCO_2e$ will be emitted in the production of 2.3kWh usable energy from the heat pump

Therefore, and has been assumed in these calculations, if the GSHPs installed at the schools have an efficiency equal to the average installed system in the UK as measured by the Energy

Saving Trust, then the percentage extra carbon emissions will be ([0.848-0.576]/0.576)x100 = 47%:

> **The ground source heat pump will have <u>47% higher</u> carbon emissions than a conventional gas boiler.**

This figure will reduce in the future if the carbon intensity of the grid progressively reduces, as predicted, but there is little certainty about the length of time this will take. Therefore, while heat pumps reduce carbon emissions when replacing electric heat, they actually have higher carbon emissions than heat provided by gas.

This conclusion is *not* the same as that arrived at by Professor MacKay in his book 'Sustainable Energy Without the Hot Air' (2009), in which he states:

> 'Let me spell this out. Heat pumps are superior in efficiency to condensing boilers.' (MacKay, 2009 p151)

So who is right? When questioning MacKay's numbers it is clear that he has made the same assumptions as other authors when considering the CoP of heat pumps:

> 'For every kilowatt of power drawn from the electricity grid, the back-to-front refrigerator can pump three kilowatts of heat from the garden, so that a total of four kilowatts of heat gets into your house. So heat pumps are roughly four times as efficient as a standard electrical bar-fire. Whereas the bar-fire's efficiency is 100%, the heat pump's is 400%. The efficiency of a heat pump is usually called its coefficient of performance or CoP. If the efficiency is 400%, the coefficient of performance is 4.' (p147), and furthermore
>
> 'the best air-source heat pumps (which require just a small external box, like an air-conditioner's) can deliver hot water to normal radiators with a coefficient of performance above 3.' (p151)

But the Energy Saving Trust didn't find any case where a ground source heat pump was working at a CoP above 3.2, and in fact found that the 28 monitored Air Source Heat Pumps, of the type being described by MacKay in the second paragraph above, had an even lower average CoP of 2.15. So MacKay's figures might be correct for a heat pump installed in an extremely energy efficient house, with perfect ground conditions, and occupied by a

knowledgeable and environmentally aware owner; in fact they might be true for his own house, to which he has added an ASHP as well as other energy efficiency measures. However he is clearly not average. The Energy Saving Trust data, although relatively small, was large enough to indicate that MacKay, McCrea, the Environment Agency, and the academic 'microgeneration group' were not basing their figures for the CoP on operating performance but on design performance, which as we see once again is a very different thing.

Although detailed calculations (based, one assumes, on the design CoP rather than actual) were likely to have been made by the sub-contractors responsible for the design and installation of the systems at Backhouse School and St Augustine, for both schools the decision to install a ground source heat pump was taken *before* the specialist sub-contractor was appointed, and (critically) before the ground conditions were known; therefore the decision was made before the calculations were carried out. The contractor project manager at Eastwick Field explained the arbitrary process at this early stage:

> '*they're never really designed very detailed upfront, it's, we could create a ground coupling scheme, there's a lot of work to be done to work out the strata and how many holes will be needed and …. say look, a scheme will cost about £250,000'.*

The calculations for energy performance as well as for cost were likely to have been based on as little information, and indeed little information could therefore be offered to the clients other than a statement of predicted cost and energy output (see Services Engineer's report to Backhouse School in Chapter 5). This lack of real information was also reflected by several comments in interviews:

> *'…on reflection, I would have liked more information about what value the wind turbine is compared to the ground source heat pumps….'*
> Client/consultant, St Augustine

> '*Certainly when we went to the ground source heat pumps, the data available for the costing was very sketchy really*.' PM, St Augustine

The lack of real information also perhaps explained the lack of consultation about different options in the Backhouse School:

> *'We never got involved in anything about photovoltaics or solar or ground soil heat pumps or anything like that…..I'm just interrogating my own memory and I sort of think well why the hell not actually?'* Chair of Governors, Backhouse

The report by the microgeneration group suggests that the actual energy generated in practice not meeting the predictions at design stage must again be a fault of the user:

> '…microgeneration capacity is determined at the design stage; once the building is in use the 10% target may not be met in practice due to the behaviour of its occupants.' (Bergman et al, 2009, p.25)

This neatly passes responsibility for the design CoP not having been reached away from the designer and on to the occupier.

In fact, the Government 2006 publication 'Low or zero carbon energy sources: strategic guide' which is referred to in the Building Regulations 2006 Part L2A, states that:

> 'Ground source heat pumps for residential applications are feasible *if they replace electric heating and hot water*, and in this case meeting 100% of the demand is recommended. For non-residential buildings, the GSHP system can be sized to meet either the full heating and hot water demand (100%) or part of it. Economically viable installations provide at least 50% of the heating and hot water demand for the building.' (ODPM, 2006, p.19, emphasis added).

The report 'The use of renewable energy in school buildings' (DCSF, 2007) in a table comparing different technologies notes that ground source heating systems 'can't provide instant heat', and in the section giving further information on GSHP on p. 9 asks 'Is the school off the gas network, or currently using electric heating?', although giving no further explanation.

Neither school was replacing *electric* heating and hot water, and neither was using the GSHP to provide more than 10% of the heating and hot water demand. Both schools were connected – and continued to use – mains gas for heating the rest of the buildings.

However several statements made by respondents suggest that it is only cost of operational energy that clients and designers are really interested in saving:

> '*Environmental sustainability personally I think is perhaps a bit more of a fad. …But to have a good look at putting in a ground source heat pump for example, or system*

> *within a school, which is going to help to reduce the lifetime cost of running the school, that's an entirely different thing, that's well worth doing, even though it might cost a bit more money as a capital investment*.' Client/consultant, Eastwick Field

This view is also questionable. The Ofgem Quarterly wholesale/retail price report of February 2009 showed that electrical power cost about 3.5 times the equivalent quantity of gas power (Ofgem, 2009, p.7-8). If these ratios are reflected in costs to the consumer, a CoP of over 3.5 would be necessary in order for heating using a GSHP to be cheaper than heating using a gas boiler, hour for hour. The evidence suggests that neither cost nor carbon is likely to be saved where the GSHP replaces gas heating, as was the case for both schools, with the carbon intensity of the current UK fuel mix.

The question remains, why are ground source heat pumps a popular choice of technology? It seems unlikely that any of the sources reviewed have a vested interest in supporting the nascent industry. The manufacturers of ground source heat pumps have a very small share of the market in the UK at present, and seem unlikely to wield great influence with the government or local authorities. Perhaps the answer lies partly in the successful advertising of the laboratory performance of the pumps, from which the high coefficient of performance emanated, or in the simplicity of factoring this in to calculate how much energy is produced from energy input, or from the lack of understanding about the relative carbon emissions from electricity compared with gas.

Inspite, or maybe because, of the fact that numeric engineers and professors of physics are some of those engaged in promoting GSHPs, their real draw may be in the seductive power of the numbers themselves.

7.3.3 Biomass boilers

The other two case study schools, Eastwick Field and Lane Academy, installed biomass boilers. The ODPM 'Low or Zero Energy Sources: Strategic Guide' states that

> 'For non-domestic buildings, relying solely on biomass entails some risk because of the possible unreliability of the fuel supply and need for short periods of down time for maintenance. As biomass boilers are significantly more expensive than gas or oil boilers, it is both safer and cheaper to size the biomass boiler to meet a base load, and to provide additional top-up/back-up gas or oil boilers.' (ODPM, 2006, p.11)

Therefore it is standard practice to provide two parallel systems, one which runs on biomass, and one on gas. In the DCSF publication 'The use of renewable energy in school buildings' in a table comparing different technologies on page 5 it is further suggested that biomass boilers are unsuitable for town centres because of the turning circle needed for large fuel delivery vehicles, and the space needed for fuel storage. Furthermore under 'disadvantages' it lists 'May be no savings on running costs' and 'Additional maintenance costs'(DCSF, 2007, p.5).

Eastwick Field School is in a densely populated area of inner London, but the biomass solution was chosen by the council client at Eastwick Field School above the proposed alternative because of the lower capital costs, with no obvious understanding or awareness of the government guidance documents quoted above. In the case of the Lane Academy, it was the Faithful and Gould 'carbon calculator' (see chapter 4) which was responsible for the choice of the biomass boiler. This solution was 'shown' by the tool to demonstrate a 60% reduction in CO2 emissions, resulting in the awarding of an extra £50 per m^2 capital funding. The fact that the simple spreadsheet-based programme promoted the use of biomass boilers was commonly known, both at the project level, as well as to the policy-group actors. The view of George Martin, head of sustainable development at Willmott Dixon, of the carbon calculator was:

> '*It's seriously flawed in that it is very difficult to get it to work if you don't use biomass*',

The Kier Education Director also commented that:

> '*actually the calculator itself, it's not that good, you know, it's not brilliant as a tool, but it enables you to get the tick in the box and get the 60%. …the shame of all of these renewable technologies at the moment is that biomass is almost the default position*'.

And a CABE senior advisor admitted that

> '*to get their 60% reduction in carbon then they sort of do…normally they end up getting a biomass boiler because that seems to be the only option….I think it's…I don't know…I just think it's very confusing, I'm confused by it, I'm not really clear what's driving it, if anything is driving it.*'

This might explain the reason behind the claim of the Kier Sustainability Director, which was that there were a large number of schools to his knowledge which had installed biomass

boilers in order to get the 'sustainability points' and had never switched them on, instead using the 'backup' conventional system. This was, indeed, the case in the Kingsmead School , which has received wide press coverage for its sustainability aspects (Palmer, 2006 and others). A biomass boiler was one of several technologies installed with the aim of reducing carbon emissions. However in practice Palmer found that

> 'the biomass boiler was used for only two weeks in the first 13 months of operation, and the gas boiler has provided most of the school's heating.' (Palmer, 2006, p.44)

This was due to problems of running the biomass boiler at low temperatures, and the teething problems were improved after some time and effort. Palmer concludes that:

> 'This is evidence that sustainable technologies offer no automatic guarantees of good performance' (Palmer, 2006, p.44)

In fact it could also be seen as evidence that biomass boilers and other energy technologies have no automatic claim to 'sustainability'.

The Kingsmead School was widely publicised and has a constant stream of visitors interested in its sustainability aspects, giving it a very strong incentive to make sure that the technologies did work in the end. Unlike Kingsmead, in the space-restricted inner London site of Eastwick Field, connected to mains gas, it seems likely that the installed biomass boiler will not be used. The site manager's view during construction was that :

> *'there is this I believe change coming up where we recognise that it's a bit daft to put a wood burning thing in the middle of town by the time you've brought all the stuff in'* Site manager, Eastwick Field

A comment from Andrew Thorne, engineer in the School Design Unit at the DCLG, suggests that this change might be slower than the site manager expects:

> *'the carbon calculator, there's a couple of things, one of the things it does is make sure that all schools are assessed in a consistent way, but the other thing it does is give a sign of what's happening out there. Previously we wouldn't see specific proposals for a particular school and how they meet a carbon*

> *reduction, but we are now seeing how they plan to meet that 60% reduction, so 90% or so are planning to meet it with biomass, for example.'*

This suggests that, certainly at the time of the interview, the DCLG were unaware of the effect of the carbon calculator; rather than realising that it was itself instrumental in determining what happened, they saw it instead as a neutral tool. Because the solution determined by the tool, seen to be a rational calculator of carbon reduction, was almost always biomass, this was taken as evidence that biomass was the best route to reducing carbon.

The ZCTF report publishes information on the 'low zero carbon energy supplies' which have been used in new school buildings following the use of the carbon calculator, which shows that the most common technology installed was biomass boilers. The report comments that,

> 'The common choice of biomass reflects its effectiveness in reducing carbon emissions at relatively low capital cost.' (DCSF, 2010)

In fact once again while it is effective in an idealised calculation using a limited number of parameters, it has clearly not been effective in reducing carbon in the many places it has been installed and not used. The commonness of its choice does *not* reflect its effectiveness in practice, as this has not been investigated. Therefore there is no 'real' data on which to make the decision at design stage, only the simplified calculation and the cost. It is these (often misleading) numbers which have made it a common choice.

Andrew Thorne also showed a similar assumption of the Energy Performance Certificates:

> *'CLG have done a report which just pulls out all of the EPCs for schools, … and there are a few patterns that are emerging, there are a few A rated schools all of which have biomass. Most of the B rated schools look as if they've got ground source heat pumps, so we're starting to see a pattern.'*

The Energy Performance Certificates are based on the calculated 'Building Emissions Rate' (BER) as described in section 7.2 above. As has been shown, this reflects design considerations and assumptions rather than actual performance during the operation of the building. Therefore adding a biomass plant at the design stage will produce an A rated EPC, *even if it is never switched on* and the standard 'back up' gas boiler is used instead.

The carbon calculator was designed to compare the potential carbon savings from different design options. The EPCs were designed to measure the potential energy savings from the different designs. Neither calculation has included enough information to be able to model what happens in practice. Therefore both have produced the same solution that biomass boilers will reduce carbon emissions. Not only has this conclusion had the effect of large numbers of biomass boilers being installed in unsuitable places, they have also created a closed feedback loop which has helped to justify the *repeated* choice of biomass boilers as a route to reducing carbon emissions.

7.3.4 Why renewables?

The question of why renewables are chosen over other carbon reduction measures appears clearly to be an effect of the legislation, and is understood as such by the construction professionals:

> *'…unfortunately to some extent we're driven partly by the legislation and the way building control and things work. Instead of minimising the energy use of the building, you are driven to provide a renewable look, well actually if you can stop the building needing to use energy in the first place you wouldn't need any renewables...'* Contractor, Backhouse School

The original stated aim, implied in the 'Target Emission Rate' calculation in the Building Regulations, was the reduction of carbon emissions by 10% through the use of renewable energy sources. In practice a number of approximations and assumptions have been made in the application of the calculation. Firstly all 'renewables' have been assumed to uniformly provide energy at zero carbon in all situations. Then a calculation is made of (design) operational energy (actually likely to be rather lower than actual energy use, as shown in 7.2), and 10% of that is provided by these 'low or zero carbon' technologies. The choice of technology is then made at an early stage in the design. These choices are often made by the non-technical clients (as the case in the Backhouse and Eastwick Field Schools) and based on a simple cost comparison provided by the services engineers. In the Lane Academy, the choice of a biomass boiler was made by a quirk of the carbon calculator and the promise of extra funding. In the case of St Augustine, the choice of a ground source heat pump appears to have been discussed by the team but ultimately based on the services engineer's report. The assumptions and estimates made in the calculations which supported these figures were not in the report or stated by the tool, but hidden, as part of the engineers' expertise.

In no case had the school who would be using the system been involved in the decision. In at least two cases studies, Backhouse and Eastwick Field Schools, the choice of technology was made on financial grounds based on very limited information, by the non-technical Local Authority client, and against the advice of technical experts. At Lane Academy the choice was made by a tool, the carbon calculator. Few other aspects of the technologies therefore appear to have been taken into account in assessing their effectiveness in these situations.

George Martin believes that the focus on the provision of 10% of the operational energy,

> *'…whilst great in concept, now needs to be changed so that it is about carbon reduction….. 10% carbon reduction and this is how I'm going to achieve it. I might decide to achieve it by using three times the amount of insulation that anybody else is using and airtightness, and I can demonstrate and I can prove that it's worked and that might just be a fraction of the cost of me plastering PVs all over the place, or even saying that I've got a couple of urban wind turbines that are not going to produce any appreciable energy.'*

However legislation to encourage renewables is continuing through the Code for Sustainable Homes (DCLG, 2006), and in turn the forthcoming Code for Sustainable Buildings. According to Bergman et al (2009), 'Microgeneration within the dwelling is currently the only method by which code level 5 zero-carbon status can be achieved, and microgenerators exporting electricity to the network would normally be required to displace emissions related to on-site energy consumption and thereby meet code level 6 *truly zerocarbon'* (Bergman et al, 2009, p.25, emphasis added).

One possible political reason for the continued focus on encouraging renewables therefore possibly comes from an alternative argument '…microgeneration is considered to be one area that could aid meeting the ambitious emissions reduction targets for the sector in a cost-effective manner, while also providing a measure of energy security through diversity and geographical distribution' (Bergman et al, 2009). However it appears unlikely that renewables are only being produced because of the energy security they offer while knowingly increasing carbon emissions.

The belief in a technical fix to solve climate change is widespread. However technologies do not stand isolated from the world, working in idealised solutions separate from social impacts. In the case of on site renewables, the technology becomes an integral part of the physical and

social environment. A technical engineer, a client focused only on capital cost, or a simplified tool choosing a technology without including the social parameters in the calculation, will produce an approximation that, contrary to Hardy's statement, is so far off reality that it is irrational. The four case studies were not chosen with any prior knowledge of their renewable energy technologies; they appear as likely to have made the right or wrong choices as any other four projects. However three of the four appear to have made an inappropriate choice. Therefore it would seem likely that this is common. In contrast to the DCSF's claim that 'all technologies will provide carbon savings compared to fossil fuel powered equipment' (DCSF, 2007, p.2), this section has suggested that inappropriate choice of technology may actually increase carbon emissions.

7.4 Embodied energy and carbon

There is a further aspect of the renewable technologies which has also been omitted from calculation. While Bergman et al (2009) consider the 'payback' period, that is the length of time it takes for the savings in cost of energy to pay for the installation of the technology, they, along with the Building Regulations, fail to consider the payback period for the carbon. In other words, while the capital financial cost is considered and compared with the operational financial cost, the capital (embodied) carbon cost is ignored, and only the operational carbon taken into consideration. Those who do calculate carbon payback have widely varying results; for example Nawaz and Tiwari (2006) calculate that for photovoltaics the carbon payback time is around 26 years, whereas Allen et al (2008) suggest that it is only 4 years. McManus et al (2010) have carried out a comprehensive review of previous research into microgeneration and conclude that, whatever the actual numbers are, 'at least currently, embodied impacts are far from negligible' (McManus et al, 2010, p.2017). This section considers the politics and numbers behind the measurements of operational and embodied energy and carbon of buildings.

The two Kier case study schools, St Augustine and the Lane Academy, specifically addressed the issue of embodied carbon in their design, through the use of a construction material which was highly innovative in the UK at that point, cross-laminated timber (CLT). This material was suggested by the structural engineer in the Stage C design report, therefore part way through the design stage, as a direct response to the client's brief for a sustainable building. The report explained that 'The use of an all-timber construction … satisfies the client brief for low embodied energy and sustainable structural design.' For St Augustine the structural engineers

calculated the carbon of the timber superstructure only compared with the original proposal of a steel frame with masonry panels as 179 kg CO_2/m^2 as opposed to 255 kg CO_2/m^2 (Vukotic et al, 2010). However the calculation did not take into account the sequestration of carbon by the timber. The manufacturer of the CLT material included sequestration in their own figures, and calculated the embodied carbon of St Augustine as *minus* 752 tonnes CO2, and of the Lane Academy of *minus* 2,335 tonnes (KLH, 2010).

These calculations assess the 'embodied energy' of a building as that used during the manufacture of the building materials and components. It is usually taken to also include the energy used in transporting materials to site, and during the construction processes, and may also be taken to include the energy needed for refurbishment and replacement of components over the lifetime of the building, and the net energy and carbon impacts at the end of life. To give a financial analogy, the embodied energy of a building is equivalent to the capital expenditure (Capex) on the building, as well as the cost of replacement and refurbishment, whereas the operational energy is equivalent to its operational expenditure (Opex). Further information about embodied energy and carbon is given in Appendix D.

There was much *academic* interest in embodied energy and carbon of buildings in the 1990s (see in particular Feist (1997), Adalberth (1997), Treloar (1998), Cole (1999)). Evidence that it was also being discussed in construction *practice* in the UK, at least for symbolic sustainable buildings such as the Earth Centre in Yorkshire, is given by Pinnegar (2000). However, unlike the focus on operational energy, there is no current policy or regulatory driver for reducing, or even measuring, the embodied energy and carbon of a building. Therefore while operational energy and carbon reductions have been adopted by the engineering professions as a key design issue, embodied energy and carbon calculations are seldom carried out.

Pressure, however, has continued to be applied to include calculations of embodied energy and carbon in policy. This was clearly shown by the responses to the consultation on 'Building a Greener Britain' which are reported in chapter 4. These attempts were mostly ignored by the DCLG, with the resultant policy statement that:

> We do not believe a full consideration of embodied carbon is practical or realistic in the short-to-medium term. (DCLG, 2007b, p 14)

More recently the Innovation and Growth Team, chaired by the Chief Construction Advisor Paul Morrell, a quantity surveyor with many years of experience at the firm Davis Langdon, made embodied carbon the subject of its first two recommendations to Government:

> 'Recommendation 2.1: That as soon as a sufficiently rigorous assessment system is in place, the Treasury should introduce into the Green Book a requirement to conduct a whole-life (embodied + operational) carbon appraisal and that this is factored into feasibility studies on the basis of a realistic price for carbon.
>
> Recommendation 2.2: That the industry should agree with Government a standard method of measuring embodied carbon for use as a design tool and (as Recommendation 2.1 above) for the purposes of scheme appraisal.' (HM Govt, 2010)

Meanwhile the European Standards Committee CEN Technical Committee, TC350, has developed a suite of standards on 'Sustainability of Construction Works'. These were under development for several years before being finalised and adopted by national standards bodies across Europe. One of the key standards is BS EN 15643:2011 'Sustainability assessment of buildings', which includes sections on methods of assessment, and on environmental, social and economic performance of construction projects. The standard follows the International Standards on Life Cycle Analysis (LCA) ISO 14040:2006 and ISO 14044:2006. The individual elements of the life cycle of a building given in these standards are given in Fig 7.1 below. Just one of these elements, 'B1 Use', equivalent to the operational energy and carbon emissions, is the focus of the current UK regulations. The other elements each have associated energy use and carbon emissions, most of which are included in definitions of embodied carbon.

It appears likely therefore that considerations of embodied carbon will be included in UK policy at some point. However the calculations encouraged by the EU standards are again restricted. The first approximation that is made is to limit the number of aspects of embodied carbon which are included, with only emissions from the first phase of the manufacture of materials compulsory, allowing the carbon emitted from the transport and construction processes, and the refurbishment and end of life processes, to remain optional. Adalberth's (1997) figures suggest that including these other stages could increase the embodied carbon by as much as 60%. As buildings become more heavily serviced, this figure may even increase, as mechanical and electrical services have a relatively short lifespan.

The second aspect of the calculation which will also affect the result is the life cycle analysis approach used. The standards prescribe a process-based methodology for the Life Cycle Inventory. This method considers the building as a number of separate components, materials and processes, each with their own impacts, and adds these impacts together. There are two implications in using this method in the life cycle analysis of buildings. Firstly, unlike factory-fabricated products, the complexity and variability of buildings means that the materials and processes will be different, and extensive, for every building. The use of sub-contractors for different construction packages, each of whom has responsibility for procurement of materials, makes the collection of this data extremely problematic (Sahagun and Moncaster, 2012). Secondly the secondary services associated with the construction of the building, including finance, insurance, government administration and related office buildings, are usually omitted from the model.

An alternative LCA approach is input-output (I-O) analysis, which instead considers the economic or environmental inputs to, and outputs from, a specific industry sector or sub-sector (Gerilla et al, 2007, Crawford, 2008). The total impacts of the construction of a building come from a number of other sectors as well as construction; by considering the inputs and outputs from and to other sectors, the input-output model can calculate the total environmental impact of construction, including the upstream processes commonly omitted by the process analysis. Input-output analysis therefore overcomes the problems with process analysis by considering a complete system boundary, and focuses industry attention on the processes which are most carbon intensive. The method assumes homogeneity of buildings, as figures are not broken down beyond the level of sub-sector. It also assumes proportionality, equating carbon emissions to financial cost; therefore for example 'green materials', which often have relatively high costs because of reduced economies of scale, would be assigned a higher carbon cost too. While Input-Output analysis is useful for demonstrating to industry sectors where their highest concentrations of carbon emissions are, its use in the design of individual buildings is therefore limited (Acquaye et al, 2011). To overcome the problems with both approaches, some researchers have developed hybrid methodologies (Treloar, 1998, Crawford, 2008 Acquaye et al, 2011).

A number of academic papers have been published which calculate the embodied energy or carbon of individual buildings, and recent reviews of results have been conducted by Sartori and Hestnes (2007), Hernandez and Kenny (2007) and Dixit et al (2010). These show considerable variations in the reported results, with Dixit et al (2010) suggesting that reasons

for the variations include system boundaries and methods of analysis, as well as limited and varied data. The reviews show that the papers using hybrid methods tend to result in higher values of embodied energy and carbon (Fay et al, 2000, Crawford, 2008). Lenzen and Treloar (2002) also demonstrate that a re-calculation of Borjesson and Gustavsson (2000) cases using a hybrid analysis results in a doubling of the calculated embodied energy. This suggests that other methods, such as the European standards' proposed use of a process-based analysis, may be significantly under-calculating the actual embodied energy and carbon in buildings.

Embodied carbon calculations which are restricted to the materials phase (A1-3), and are calculated using a process-based analysis, as recommended by the European standards, will give an underestimate of emissions, potentially very significantly so. The impact will be to reduce the perception of calculated embodied carbon as a percentage of whole life carbon costs, and a focus on only the operational carbon stage will be supported.

Yet another reduction of the perceived importance of embodied carbon is a function of how results are reported. The majority of the embodied carbon emissions will occur at the construction stage, and therefore at the start of the building life. A plot of cumulative energy use or carbon emissions against time would show a peak at year 0, when the building is constructed, with operational carbon accumulating through the lifetime of the building, and small 'jumps' due to extra embodied energy/carbon incurred at points of refurbishment. However, DCLG defines the metric through the Code for Sustainable Homes as kg of CO_2 per year (DCLG, 2006), and embodied carbon is frequently considered as an equivalent 'annual cost' in order to compare with operational carbon. The review by Sartori and Hestnes (2007) similarly divides the total embodied carbon into equal annual increments over the expected lifetime of the building, and plots these values next to the operational energy for each year. While in principle this allows an objective comparison between embodied and operational, it also implies both that the timing of carbon emissions is not relevant, and that future carbon emissions are as predictable as current. Initial embodied energy and carbon are difficult to calculate, as already described; however, they have a far higher certainty than future operational energy and carbon as has been shown in section 7.2. Furthermore Jones (2011) has pointed out that if the UK Government's plans to decarbonise the electricity grid come about, then the ratio of carbon emissions to operational energy in the future will be a fraction of what is predicted using the current fuel mix, and a fraction of the carbon intensity of the embodied energy at year 0. This will make the total proportion of carbon emissions from the embodied impacts, expended at today's high carbon fuel mix, far higher.

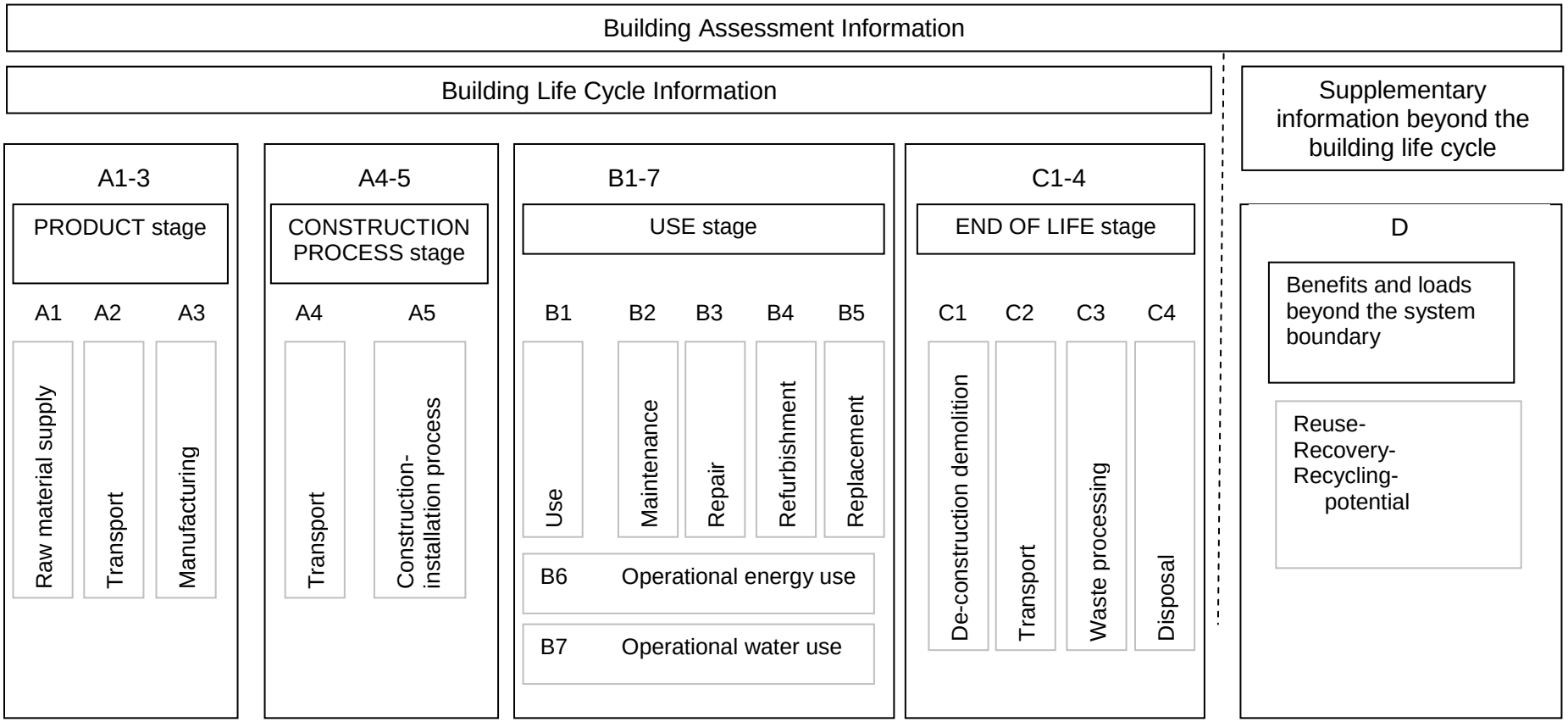

Fig. 7.1 Display of modular information for the different stages of the building assessment, BS EN 15978:2011Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method

The combined impact of using a process-based analysis, of focusing on the materials phase only, and of displaying embodied carbon as spread equally over the lifetime of the building, all have the result of reducing the perception of embodied carbon. These choices of calculations, and of ways of portraying the results, reduce the perceived impact of embodied carbon, and support the conclusion that a focus on the operational phase only is a 'rational' decision. The complexity of the calculations and lack of raw data make this difficult to disprove.

Embodied carbon, inspite of interest and pressure from the construction professionals and academics, has for many years been kept out of the policy decision arena. It *is* contested, as has been described in chapter 4. Within the development of policy there was direct evidence from the responses to the consultations that the issue was there, in the background, wanting a place at the decision-making table, but denied access. This was also clearly evident through the emergence of the issue in practice in the two Kier case studies. However, the focus on reducing the operational, while ignoring the embodied, carbon of buildings supports the focus on increasing economic growth and development.

This seems therefore to be an example of Lukes' second dimension of power, the deliberate suppression of an issue rather than the accepted order of the third dimension. However not only is the subject for discussion limited by political power, in this case the decision to omit it is supported by the complexity of the calculation for embodied carbon, itself helping to keep the issue off the agenda.

7.5 Conclusions: the reality of numbers

Numbers are used to rationalise choices made in the name of sustainability; the suggestion is that if it can be measured, it must be true. MacKay suggests that numbers are not in fact, used rationally: 'Numbers are chosen to impress, to score points in arguments, rather than to inform.' (MacKay, 2009, p.3). However Toke (2011) disputes MacKay's own claim to rationality:

> 'MacKay's claims to master the high ground of number-crunching rationality can be challenged as being an exercise in itself in number selection. The values or 'emotions' that he claim to set aside are implicit in his own analysis.'

An example is set out in chapter 2 showing that MacKay's calculations which support the use of nuclear power are based on value judgements and approximations. It certainly isn't coincidence that MacKay is Professor of Physics at Cambridge University, having also studied

natural sciences at Cambridge. Not only does this give his claims of rationality credence with his audience, it also gives them credence with himself. The long-term effect of 'acting' as a physicist could be said to have determined what he believes. As Toke shows, MacKay doesn't 'prove' that nuclear power is an essential part of the UK energy mix; but he certainly believes that he has proved it.

Flyvbjerg sees rationality and power as directly linked, and demonstrates the semi-conscious ability of power to determine what is accepted as rational. However it appears here to be a more complicated issue, suggesting that there is something more akin to a Foucauldian ordering effect. A similar effect is seen at the scale of the school building projects. There is widespread support of renewable technologies, and in particular ground source heat pumps, as a 'truly' sustainable solution, with little or no demonstration of actual reductions in carbon emissions.

This chapter has shown that in some cases numbers have been manipulated or ignored, as in the case of embodied carbon in the policy statement Building a Greener Future (DCLG, 2006), or with-held, as in the Millennium School, in the interests of political ideology.

But secondly numbers themselves have had a powerful effect. As with technologies, there is an innate trust in numbers, in particular it would seem by the professions who use them. They appear to offer a rational and value-free comparison of options. However the numbers, whether a financial cost or the carbon emissions saved, disguise the hidden assumptions which have produced them.

Jasanoff states that 'The brute objectivity of numbers is often gained at the expense of subjective values that democratic societies also hold dear' (Jasanoff, p.86). The fact is that the 'brute objectivity' is so appealing that the numbers often obscure even themselves. Society, perhaps *particularly* the parts of society such as engineers and physicists who have been taught to use numbers, want to believe in them. It is not, in other words, just the subjective values that are lost, but also other objective values. There is something intrinsically persuasive about numbers. However in the complexities of real buildings, real technologies and real societies, the simple numeric argument is frequently based on so many approximations that, unlike Hardy's statement that 'all approximations are rational' it in fact becomes irrational.

Chapter 8: Deconstructing sustainable construction

'Science and engineering produce 'know-how'; but 'know-how' is nothing by itself; it is a means without an end, a mere potentiality, an unfinished sentence.'

E F Schumacher, Small is beautiful, 1973

Theories of social power have been used to analyse the processes through which sustainability has been interpreted, and then translated into practice, for UK construction. It has been shown that at each stage the process of translation is strongly influenced by those who have the power to push for the solutions which accord with their interests. This power is exercised both overtly and covertly, through the restriction of options and of participants in decision-making. However more subtly the thesis has also shown the power effects of the procurement processes and the design tools in their (unintentional) defining and limiting of possibilities, and similarly both the restricting and enabling power of the professional systems within which the actors operate.

The result has been that the initially broad concept of sustainable development has come to be narrowly interpreted as carbon emissions, which for buildings has been further narrowed to include only the operational phase, and then translated into two specific technical solutions, improved energy efficiency and the addition of specific on-site energy technologies. A numerical analysis of the choices made in the four empirical case studies showed that the solutions failed even to achieve the singular aspect of sustainability claimed, that of reducing carbon emissions. This combination of power effects at policy and project levels, and the embedded assumptions in the resultant processes and tools, has therefore had a significant effect on shaping decisions and outcomes, and in turn on the performance of buildings.

8.1 The starting point

The research which has been described in this thesis began in 2007, at a point when the concept of sustainable development, growing from the desire to reconcile environmental protection with economic development, had become increasingly established as an important political and social goal across much of the World and in particular in the UK. Combining two important but potentially contradictory aims within one term it was seen as necessarily value-laden, and it was

claimed that stakeholder involvement in its interpretation within any particular context was therefore essential.

At the same time significant changes within the UK construction industry had been occurring (Adamson and Pollington, 2006), originating in particular from two Government-commissioned reports at the end of the last century. *Constructing the Team* (Latham, 1994) and *Rethinking Construction* (Egan, 1998) both called for, and appeared to have resulted in, changes at a deep cultural level, including a decrease in hierarchy and confrontation, more integrated teams, collaboration between designers, contractors and the supply chain, a stronger role for the client, and wider stakeholder participation in decision-making (Newcombe, 2003, Kershaw and Hutchison, 2009).

The specific responsibility of the construction sector to sustainable development was introduced in a later report *Accelerating Change* (Egan, 2002), in which Egan interpreted the term broadly as 'maximising economic and social value and minimising environmental impacts' (p35). However in subsequent influential reports including *Rethinking construction innovation and research* (Fairclough, 2002) and *The social and economic value of construction: the construction industry's contribution to sustainable development* (Pearce, 2003), mounting concerns over the effects of climate change led to a more narrow focus on increasing technological innovation with the aim to improve energy efficiency and reduce carbon emissions.

This narrowing of sustainable development for the construction sector has been mirrored by the change in focus in construction research. A broad interpretation including futurity, environment, equity and public participation was introduced in the 1990s by Palmer et al, 1997 and others; however ten years later Kibert stated that 'It is likely that the dominant measuring stick for all aspects of sustainable construction will be energy', in the editorial to a special edition of the Building Research and Information journal on *The next generation of sustainable construction*(Kibert, 2007, p. 599). The focus on technical solutions to energy and carbon reduction from both politicians and industry suggested too that the claims of participation of lay stakeholders may in practice have little effect.

The focus on sustainable construction became particularly evident in the major public school building programmes of the first decade of the 21st century. The concept of 'sustainable schools' was introduced by Tony Blair in 2004 in a seminal speech in which he clearly identified the

solutions in terms of technological responses to climate change. Following Blair's speech, policy documents and initiatives ensured that the programmes, originally envisaged as instruments of social change, concentrated increasingly on achieving low and even 'zero' operational carbon. The political focus on sustainability was therefore first showcased in the schools sector; this had resonances with past building programmes, in which not only have schools been at the forefront of responses to socio-political concerns (Seaborne and Lowe, 1977), they have also been used as deliberate attempts to create social change in line with political goals (Cooper, 1981).

The increasing political focus on sustainability, the apparent superposition of technical solutions onto political aims for school buildings, the claimed cultural changes in the construction sector, and the apparent increase in stakeholder involvement both in design decisions for construction projects and in defining sustainability for a specific context, prompted two research questions: how is sustainability being interpreted and translated into practice in the construction of new school buildings? and, how have political, social, professional and technical decisions and concerns led to these particular interpretations and translations of sustainability for construction?

This thesis has addressed the questions by exploring the complex relationships between the multiple actors and technologies involved in case studies of four school building projects, and in the policy discourses which emerged in the first decade of this century, and by critiquing the technical outcomes of the chosen solutions.

The conclusions and implications of the empirical chapters are discussed further in the following sections of this chapter, and the final section completes the response to the research questions, discusses the limitations of the method, and makes some recommendations for future action and research.

8.2 Industry and policy

Chapter 4 reviewed the regulatory and political context in which the schools were built, and applied interpretations and perspectives of social power theorists in order to examine the formation of UK policies for sustainable buildings and schools in the first decade of the 21st century and the role of the construction sector in their formation.

The relationships between industry groups and policy makers, and the impact of these relationships on policy formation, have been a frequent subject for researchers. While pluralists

(Dahl, 1957, Polsby, 1960) saw policy as a neutral response to lobbying by industry in their own interests, others recognised the impact that the Government could have on the formation and membership of such groups, and the fact that their power may be limited to fit in with pre-existing politically-determined interests (Domhoff, 1979); Laumann and Knoke (1989) suggested that the groups fitted along a continuum between these two extremes. Within the UK context Smith (1990) had considered the relative power of the farming industry, through the National Farmers Union (NFU), and central Government. However the approach has not previously been applied to the UK construction sector.

Policies and regulations which had a particular impact on the interpretation of sustainability for schools builtings came from two Government Departments, for Communities and Local Government (DCLG) and Children Schools and Families (DCSF). The DCLG held considerable formal power through its responsibility for the publication of the *Building Regulations* (ODPM, 2006 and other dates) and the development of the *Code for Sustainable Homes* (DCLG, 2006). The interpretation of sustainability which fed in to these regulations appeared to have been set initially, at least in part, by an industry focus group convened by the DCLG in 2003, the Sustainable Buildings Task Group (SBTG). The remit for the group was defined by the DCLG, who also directly appointed the members. The task group included in particular a number of housing developers, which was relevant because it related to the parallel and perhaps dominant concern of the DCLG about the increased provision of housing, reflected by the two influential reviews on this topic commissioned by the DCLG during this period. The first of these reviews was chaired by an economist, Kate Barker (Barker, 2004). The second was commissioned just after the SBTG had concluded, and was chaired by a former member of the SBTG John Callcutt (DCLG, 2007). Callcutt, former Chief Executive for housing developer Crest Nicholson, had also by then been appointed Chief Executive of English Partnerships, the Government regeneration agency. The subject of both the Barker and Callcutt reviews was clearly related to the expert knowledge areas of the individuals; however the conclusions, that house-building should rapidly increase in particular in areas of economic growth such as the South East and East of England, could also be seen to be in the sectoral interests of at least one of the two Government-selected authors. However, the concerns of other relevant professional organisations, such as the Environment Agency and the Institution of Civil Engineers, who were both concerned that the proposed growth areas were already seriously water-stressed, were excluded from consideration.

This seemingly deliberate choice of which industry interests to include and which to exclude was further apparent in the publication of the policy statement, *Building a Greener Futur*e (DCLG, 2007), which was particularly influential as it set the definition of 'zero carbon' buildings for following policies and regulations. A public consultation in December 2006 was the route through which, in this case, the views of the construction sector and others were sought. The responses to the consultation were published in June 2007; these highlighted one issue in particular, with many of the respondents to the consultation calling for the inclusion of the embodied carbon of construction materials and processes in the definition of zero carbon, limited by the consultation document to operational carbon. Embodied carbon was not a new concept to either industry or policy, having already been introduced by Egan in *Accelerating Change* (Egan, 2002) and included by the Department for Environment, Food and Rural Affairs in its publication *Procuring the Future*(Defra, 2006). However the final policy statement on *Building a Greener Future* published in July 2007 dismissed the issue of embodied carbon, and retained the definition of zero carbon which had already been proposed (DCLG, 2007). Following this document, consideration of embodied carbon was also then *explicitly* excluded from the terms of reference of the group subsequently set up to define and support delivery of zero carbon homes, the Zero Carbon Hub (ZCH, 2009).

As well as the deliberate choice of issues, the DCLG also retained its power in selection of industry representatives, continuing to appoint a small number of industry representatives to key positions; following John Callcutt, another former member of the SBTG, Paul King, was appointed first to head the Green Building Council, set up in response to the SBTG recommendations to represent the interests of industry, and then to head the Zero Carbon Hub.

The formation of the industry focus groups and commissioned reports suggests that the DCLG was keen to be seen to be consulting with industry. However the political domination of appointments, which included housing developers while on the whole excluding designers, and the limitations imposed by the terms of reference for the groups, resulted in a noticeable restriction of the issues which were subsequently included in the policies for sustainable buildings. Furthermore responses to the public consultation for *Building a Greener Future* which conflicted with the pre-determined conclusions of the Government were pushed aside. It appeared therefore that the power of the wider construction industry to set an alternative agenda was deliberately restricted. The existing political agenda of the DCLG during this period, which was to

ensure that sustainable buildings were predominantly identified with the reduction of operational energy and carbon, was retained to the exclusion or reduction of several other potential issues. In particular excluding embodied carbon from the definition of zero carbon implied that the DCLG could continue to encourage increasing housing development as a 'sustainable' solution, provided the houses were built to high energy performance standards. John Callcutt was able to conclude in his review of house-building that 'the housebuilding industry and its supply chain have the potential to deliver 240,000 new good quality homes a year by 2016 and to achieve the zero carbon targets' (DCLG, 2007, p.9).

The final regulatory outcome of the political process has been two specific changes to the Building Regulations: requirements for improved energy efficiency, which has been a recurrent theme since the 1970s energy crisis (Guy and Shove, 2000, p.1) and so could be seen as 'business as usual'; and the encouragement of on-site energy production from low-carbon technologies. The actual impacts of these measures, in terms of carbon emissions from the school building case studies, are discussed further in chapter 7 and section 8.5 below.

The second Government Department which had a marked impact on the school building programmes was that for Children, Schools and Families (DCSF). While the Department had fewer regulatory powers than the DCLG, the means by which it tried to ensure that its priorities were realised were in many ways similar. For example, the DCSF also set up an industry task group, the Zero Carbon Task Force (ZCTF), which was again given clear terms of reference by the minister, who had already published his aim to make all schools 'zero carbon' by 2016 in the Children's Plan (DCSF 2007c). This task group too was limited to considering carbon emitted during the operational phase of the schools, and embodied carbon was excluded. Also similar to the Sustainable Buildings Task Group (SBTG), the chair of the ZCTF was appointed by the DCSF. However unlike the SBTG, the chair of the ZCTF was an architect; other members of the task force were then substantially appointed by the chair, and many of these were also architects of other design professionals.

The close relationship between the DCSF and the architecture profession was further revealed by the DCSF's appointment of the Commission on Architecture and the Built Environment (CABE) to publish advisory documents for Local Authority clients, and to provide individual procurement and later design advice for the BSF projects. The DCSF also commissioned and published 'exemplar'

designs for sustainable schools, mainly from architects but also other designers, as well as reports on the costs of sustainable schools from the BRE and quantity surveyors Faithful and Gould. The DCSF's specific choice of architects and designers as the industry expert consultees was notably different from the predominance of developers appointed by the DCLG.

A further method through which the DCSF sought to influence the school projects was the use of design tools. A specific version of BREEAM, the BRE's environmental assessment method, was commissioned for schools, and the DCSF imposed a higher BREEAM rating on schools than was required for other public buildings. Further encouragement for carbon emissions reduction was supported by the introduction of the schools carbon calculator, commissioned by the DCSF from BRE and Faithful and Gould. The DCSF also required the use of the Design Quality Indicators (DQI) on the BSF and Academy projects, a tool developed by the Construction Industry Council (CIC) to facilitate stakeholder participation in the design of buildings (Cole 2005).

The DCSF therefore clearly had a shared focus with the DCLG on reduction of operational carbon emissions. Indeed the extent of this focus was such that the Sustainability Manager for Partnerships for Schools described it as a 'moral crusade'. However a further issue which emerged from the DCSF process as an essential aspect of achieving sustainability in schools was one which was *not* evident in the DCLG documents; this was the inclusion of stakeholders in coming to design decisions. This was a recommendation of the 2006 report on *Sustainable Schools: Case studies* commissioned from independent design researchers (DfES, 2006d, p.6), as well as the 'essential first step' of the ZCTF report (DCSF, 2010, p.28), and the focus of the CIC's DQI tool. Therefore the focus appeared in this case to have come from the industry consultees, rather than from the politicians. While the choice of consultees was again mostly controlled by the Department, the issues which emerged were *both* those already seen as important by the Schools' Minister *and* those seen as important by that sector of industry.

While the task groups and consultants appointed by the two Government Departments were similar to the policy communities identified by Laumann and Knoke (1989), in which Government retained much of the control over membership and issues, other groups who were actively engaged in attempting to influence the agenda for sustainability in school buildings were also evident. These organisations were lobbying to influence the outcome of particular issues in their own interests, similar to the special interest groups described by Domhoff (1979). Several were

connected to the professional institutions of the construction sector, and these groups shared some of the members of the policy communities identified above. This ensured some commonality of discussion and cross-fertilisation of ideas, and also had the effect that the equating of sustainability with low operational carbon had already filtered through to the design professionals; that the framing of the issues and possible solutions had already been established before the policies and regulations came into force meant that little persuasion was needed that this was the right path to take.

Other groups, such as the National College for School Leadership (NCSL) and the British Council for School Environments (BCSE), were part of the education sector; these too attempted to influence policy, and the construction industry, in this case through the publication of reports (Wilkinson 2008, Bunn, 2006) and participation in construction industry events (Westminster Education Forum, 2009, Building Schools Exhibition and Conference, 2010). There was evidence to suggest that these education sector groups did have some effect on the approach to sustainability at the project level. For example the Willmott Dixon Accounts Manager for the Backhouse School was involved in a school refurbishment project with the BCSE, and the Sustainability Manager for PfS suggested that the NCSL had the potential to make a real difference to carbon emissions through their influence in the management of schools. However these groups, in spite of their clear interest in influencing this area, were not represented on any of the task forces close to policy formation. The impact of the policy communities close to Government being drawn solely from the construction rather than the education sector therefore further reflects the dominant political focus on purely technical construction solutions for sustainable schools revealed in Blair's speech in 2004 (Blair, 2004, reported on p.26 of this thesis). It also suggests that the inclusion of stakeholders in the design stage of projects, as encouraged by the policies and tools emerging from the DCSF, was likely to be limited in both intent and impact.

In conclusion, both the DCLG and the DCSF clearly exercised their authority through their choice of consultants and reviewers, and through defining and restricting the issues which were discussed. Ideas emerging from consultation, such as embodied carbon, which might challenge other political priorities, were squashed. Therefore although the industry lobby *appeared* to have considerable input to policy, in fact their influence was controlled and restricted by policy-makers to non-contended issues which had already been identified. The DCSF accepted and indeed strengthened the DCLG's interpretation of sustainability as low operational carbon, and the provision of low

carbon technologies. In addition it encouraged, through a variety of measures, the involvement of stakeholders in project decisions. However the involvement of wider stakeholders in setting policy agendas was still clearly lacking, with bodies such as the BCSE and NSL not being included in the Government's consultation groups. Since Blair's speech in 2004, the Government has therefore continued to frame sustainability for school buildings within the discourse of low carbon, and has further reduced this to particular technical solutions for energy efficiency and the promotion of small scale low carbon energy production technologies. The processes of task forces, reviews and consultations, allowed the introduction and control of issues without the necessity of explicit command and overt demonstration of political domination. Through this method industry is seen to have been represented in the formation of policy, while its power to alter or disagree with the pre-existing political intentions has been considerably restricted. The choice of advisors from differing professions by the two Government departments further suggested that their technical expertise was being used as a resource to support the political preferences of the Departments. The apparently deliberate omission of the embodied carbon from the definition of 'zero carbon' implies a greater political interest in increasing construction than in reducing carbon; if so, then the focus on on-site energy production may also be more a response to fears of energy security than an attempt to reduce carbon emissions. As Hopwood suggested, the politicians may be saying one thing while meaning another (Hopwood, 2005).

8.3 Processes and tools

The focus of the analysis of the first two case studies, in chapter 5, was on the power effects of tools and of processes. Bijker and Law (1992) saw such 'technologies' through which actions are ordered as shaping and influencing decisions, while Foucault interpreted them as an integral part of a social system, 'producing what is considered as truth' (McHoul and Grace, 1993, p.90). This section re-considers the limitations and possibilities allowed by the design tools and the procurement processes, both as an intentional resource for their designers to determine specific social outcomes and also with the potential for unanticipated consequences.

The projects at Backhouse and Eastwick Field Schools, both built by the same contractor Willmott Dixon at almost exactly the same time, were procured through very different routes, the first through a traditional contract and a local framework agreement with a design consultancy, and the second through a Local Education Partnership as part of the BSF programme. The actors in the two projects were also very different in their knowledge of and interest in sustainability. While

the local authority client and consultants in the Backhouse project had a limited understanding of sustainability, and no intention of taking any measures above the minimum planning requirement for 10% 'renewables', at Eastwick Field the local council, school, and architects, and a number of external advisors, were particularly interested in sustainable construction in a much wider sense. Although the construction stage environmental and social impacts in the former case were considerably above the minimum requirement, the resultant design outcomes in both projects were however limited to the minimum standard required by regulation and local planning policy.

Responding to the focus on stakeholder involvement which had emerged from the DCSF policies, each project included a specific requirement for consultation with the school community and wider stakeholders about particular aspects of sustainability. This requirement was supported by the use of tools and processes, including for both projects a BREEAM assessment and the public consultation procedures required by the planning process, and at Eastwick Field the additional Design Quality Indicator (DQI) tool.

However the actual result of the processes and tools was very different to their purported intentions. At the Backhouse School the planning process ensured that consultation did take place, but the technical artefacts including room data sheets and drawings which were used were difficult for lay stakeholders to interpret; the artefacts themselves therefore had the effect of restricting possibilities, and the resultant impact of the consultation on the design was negligible. At Eastwick Field, the additional DQI process was also found to be both confusing and limiting by the stakeholders. Furthermore the confidentiality requirements of the competitive dialogue process considerably limited who could be consulted and when. The planning consultation processes and the DQI tool, both of which had been specifically designed to support stakeholder consultation, therefore worked to restrict rather than enable participation in decisions, reinforcing the perception of the building project as a technical expert realm.

Further unintended effects of the BSF procurement process at Eastwick Field School were seen in the enforced fragmentation of the design process, in which three separate teams were responsible for decisions through the project, resulting in the noticeable coordination problems for the services design. The requirement to apply a rigid funding model at a very early stage in the design resulted in the key requirement for the school for full disabled access being unachievable, and the choice of renewable energy technology being based on capital cost rather than the expert advice of the best option for the location. The final result at Eastwick Field was a design which was

prevented by the structure of the procurement process from addressing issues seen as important by the Local Authority, the school, and the designers and contractors. The procurement process therefore clearly had the effect of ordering and restricting the outcome in ways which had not been envisaged by its creators.

Meanwhile the effect of BREEAM, a tool designed to *measure* sustainability, was that for many respondents within both projects sustainability became *defined as* BREEAM. This had the result of restricting issues considered as sustainability to those which were already included in BREEAM. More positively, however, construction site practices appeared to be influenced and widened in both projects by the Willmott Dixon in-house 'Playing cards for the Future' tool, designed to change behaviour on site, which clear effects on practice including improved relationships between school and contractor. Both positive and negative effects can be seen as explicit demonstrations of technologies defining what is accepted as knowledge and truth (McHoul and Grace, 1993)

The carbon calculator introduced by the DCSF as a support tool to develop design solutions which reduced carbon emissions provides one further example. By a quirk of the design, an approximation which was incorporated into the algorithm, led to the calculator producing the default answer of biomass boilers. 90% of the schools that have used the calculator to demonstrate their carbon reductions have therefore installed biomass boilers. This has led in turn to the belief that biomass boilers must be the way to reduce carbon emissions in schools. In a way unintended by its designers, this tool too has created its own 'truth, that biomass is the most sustainable solution.

The tools and processes, including planning requirements, procurement, BREEAM, the Design Quality Indicators, the carbon calculator and Willmott Dixon's playing cards, all had intentional and overt agendas to encourage certain types of behaviour and specific measurements of sustainability. However they also resulted in the unintentional exclusion of other issues, imposing rigid limitations on the possible consequences and outcomes. Thus as Guy and Shove conclude, 'design tools do not simply translate between the languages of science and practice. Like it or not, they have hidden agendas and qualities of their own.' (Guy and Shove, 2000, p. 50). The impact of the technologies, tools and processes which were used in these two projects shaped what was built, and to a great extent determined how sustainability was translated into the final built form. Through allowing and encouraging certain issues and interpretations, while excluding others, they

have shaped and constrained not only the material forms of these buildings but also the boundaries of knowledge of the social actors.

While the tools therefore can be seen to embody the choices, aspirations and values of their designers, they also embody unintentional consequences of decisions taken in their own design, and transfer these to the designs they influence. In turn they shape and influence not just the material world but also the social world. As Bray has said,

> 'Technologies …. are specific to a society, embodiments of its vision of the world and its struggle over social order. In this sense, the most important work that technologies do is to produce people: the makers are shaped by the making, and the users shaped by the using.' (Bray, 1997, 16)

8.4 Experts and expertise

Chapter 6 examined the power that is held by professional disciplines through their claims to expert knowledge, demonstrated in a particularly overt manner through the third and fourth projects. These were chosen as cases to study for their particular interpretation of sustainability as a reduction of embodied carbon, an issue which had been, seemingly intentionally, excluded from policy. This interpretation was produced within these two projects by the structural engineers, who introduced the use of an innovative construction material, cross-laminated timber (CLT), as a 'truly sustainable' response to the client's brief. The introduction of the material at the St Augustine School however caused conflict with other professions, particularly the services engineer, who even sent emails to the client warning them about the dangers of timber construction. This behaviour could be explained by the fact that the two-fold solution for sustainability as renewable energy technologies and reduction of operational energy as developed by central government had allowed the services engineers to 'rebrand' their profession as 'sustainability engineers', gaining respect and influence from this claim to expertise. In the case of the St Augustine School they had also won the separate contract as BREEAM consultant, further identifying them as 'sustainability experts'. They therefore titled their RIBA Stage D services engineers' report as 'Sustainability Report'. However this apparent monopoly of expertise in sustainability was now called into question by its new interpretation as low embodied carbon. The quantity surveyor also objected, on the grounds that CLT was so new to the UK that he was unable to cost it; instead the structural engineer took it upon himself to get quotes for the

material from the two main manufacturers. Therefore the increased expertise of the structural engineer was competing with other professional claims, and resulting in a shift of the power balance within the design team, and the creation of a new system of language and practices which redefined expertise in sustainable construction had the further result of excluding 'others' as non-experts.

Expertise can therefore be seen to be created through the development and protection of specific languages and practices; expert knowledge is deliberately socially constructed by professions in their own interests. It is then supported by maintaining the boundary between this professional expertise and lay knowledge (Scott, 2001). In the case of the St Augustine project, the lack of expertise of the client's representative, who had been trained as a teacher rather than a construction professional, was very apparent, allowing the design team and their professional expertise to dominate the decisions around sustainability by retaining them within the technical realm. The project manager, a former quantity surveyor, increased the uncontested power of the designers by ensuring that the 'design and build' contractor was not in fact appointed until the detailed design stage, and that the contracts for the whole design team were then continued through novation to the contractor. However this autonomy also appears to have allowed the 'negotiation space' (Law and Callon, 1988) required for the innovation to be successful.

The second project had a different trajectory. As a framework project, the bid was managed by a team led by the contractor Kier, who had by then been appointed to construct St Augustine. Several weeks into the bidding process the Kier bid manager decided to use the same CLT material at Lane Academy as was being used at St Augustine. The reasons for the use of the material on the second project were somewhat different. Although Kier too used the sustainability credentials of CLT as a low embodied carbon material to sell it to the new client, through a presentation on its embodied carbon given by the structural engineer, their choice of the material was more likely to have been due to the benefits to the construction process, including reduced time on site, reduced risk, improved health and safety in terms of reportable accidents, and possibly reduced costs to the contractor. For the workers on site it was clearly also a far more pleasant working environment – clean, quiet and with easy accessibility due to the lack of scaffolding. Therefore as well as supporting the engineer's position, his expertise had been co-opted by the contractor to induce the client's trust and acceptance of a practice which had multiple other benefits.

The appointment of the structural engineer from St Augustine on the bid team for the Lane Academy in the place of another highly regarded firm of structural engineers, showed the former's power in having created a specific expert practice, supported both through the development of practices and specific languages (both words and calculations) (Latour, 1991).

According to both the architect and the structural engineer interviewed, the timber was particularly appealing to the client because of its visible demonstration of sustainability, and was a strong reason why the bid subsequently won. However there was clear evidence, from interviews and from project documents, that it was in fact the response of the bid to the Education brief, combined with the existing relationship between Kier and the Council, which were most instrumental in Kier's success. While it may have helped, it did not appear to have been the engineer's definition of sustainability as low embodied carbon that was the deciding factor.

The professional knowledge system of the structural engineer had led to his certainty that the timber solution was sustainable, and had therefore 'won' the bid with the Council. This certainty also led him to state that *'We're talking about sustainability, what actually are we talking about, well, we're talking about carbon, something physical, you know, which you can measure.'* The suggestion that the use of timber might have other additional benefits in terms of ecology and of working conditions were dismissed by him as irrelevant to the issue of sustainability. Thus the effect of the development of disciplinary expertise was also to restrict the understanding of the expert; the system of knowledge is not only constructed by experts, it also has the effect of constructing experts. This effect was further evident in interviews with both the structural engineer and the architect who, unlike most other respondents, saw the environmental assessment method BREEAM as *not* reflecting 'sustainability' because it didn't reflect their own expertise, the architect claiming that '*it doesn't necessarily mean it's a brilliant building from a sustainable point of view at all. It is often to do with procedures and how the site is actually managed, what's recorded on site.*', and the structural engineer that '*the whole marking system, the credit system is wrong … structurally, the embodied carbon which to me is what BREEAM should be about … sustainability, embodied carbon, in terms of the actually tangible thing*.'

The belief of the services engineer that sustainability was defined as renewable energy was as strong as the belief of the structural engineer that it was embodied carbon, as demonstrated through their titling of the report for planning on renewable energy technologies as the 'Sustainability Report'. The emerging consideration of embodied carbon, as developed into a

material solution in these two projects, disturbed the relative hierarchies of the design professions The professional disciplines and knowledge systems of the different engineers had governed, not just their practices, but also their beliefs. They had both created their systems of expert knowledge, and were themselves both empowered and limited by those systems. Relative power of expertise within the industry is not therefore static, but instead is shown to be developing iteratively and interacting with the discourse of sustainability.

The knowledge of the structural engineers was a resource which they mobilized within these two projects to increase their claims to specialist expertise and to support their own professional position within the teams. However the validity and importance that is attributed to any knowledge by society is dependent on the relevance of that knowledge to the social concerns governing that society. It was the particular confluence of the timber material with the prevailing concerns about sustainability which helped the solution to be introduced at the St Augustine School, and the interest of the contractor in its properties of low waste and quick erection which led to its use at the Lane Academy. The introduction of this innovation in the UK construction industry, supported through the technical, numerical arguments of the professional experts, was therefore contingent on its alignment with existing interests within a number of professional institutions and commercial organisations. The change in the power structures evident in both projects demonstrates a further property of power. While both the accepted cultural norms and contractual hierarchy of a situation such as a construction project may inherently empower some actors more than others, there is still freedom to act; power (powerlessness) is not an inevitable function of position in society, but through strategies and expert claims may be competed over and ultimately won. The 'apparent neutrality of expertise', as identified by Scott (2001), effectively disguises its power.

8.5 The social construction of numbers

In order to increase the credibility of their proposal for a low embodied carbon solution the structural engineers for the St Augustine project worked with researchers at Cambridge University Engineering Department (Vukotic et al, 2010) to develop a spreadsheet-based tool. The numbers produced through this tool formed the main thrust of the presentation on the use of CLT to the client at Lane Academy. The numbers were produced after the choice of material had already been made, to add power to the structural engineers' argument. Even so in interview the engineers exposed a fundamental belief in the rationality the numbers provided – '*we've done the*

numbers as you know as a practice, actually trying to put the science down, turn it into numbers, an actually tangible measure'

This belief in the absolute rationality of numbers was further exposed through the conviction of the engineer at the DCSF that the carbon calculator had demonstrated that biomass was a low carbon option for all the schools that had installed it. While a descriptive tool, such as the Government report on *Low or zero carbon energy sources: strategic guide on the use of renewables* (ODPM, 2006), deterred the use of biomass for built up areas, the carbon calculator appears to have had far greater impact, through its demonstration of the answer through numbers rather than text. The belief in numbers is shown to form such a strong part of the professional knowledge system of the engineer that it allowed a simple tool to determine a complex issue.

Porter (1995) suggests that measurement and numbers are used in order to encourage trust, through their (supposed) demonstration of objectivity. He suggests that this is particularly the case in the use of numbers by weak professions, and in matters of particular public and political importance, where numbers may be seen to provide an apparently non-political basis or support for a judgement or decision. Either or both of these may be seen to apply to the structural engineers for St Augustine. Their professional influence could be seen to have been recently weakened by the services engineers' rebranding of themselves as 'sustainability' engineers. The issue of carbon reduction is also undoubtedly one of public and political importance. Both professions in fact were competing for influence in this area, through their quantified assessment of the problem, but each was focused on a different problematisation (that is, operational versus embodied carbon).

Flyvbjerg (1998), MacKay (2008) and Galvin (2010) have shown a different impact of numbers, their deliberate use in order to *establish* trust, often to encourage support for political objectives; rather than purely objective, they showed that the selection of the assumptions and parameters used in their calculation, and in the presentation of the results, were often in fact subjective and value-laden. The decision by the DCLG to exclude embodied carbon from the definition of zero carbon appeared to be one such issue.

Chapter 7 therefore looked in particular at the numbers and calculations which have been used in the assessment of three solutions: the reduction of operational energy through energy efficiency

measures; the choice of renewable energy technologies, focusing in detail on the two major technologies chosen in the case studies of ground source heat pumps and biomass boilers; and the reduction of embodied carbon. It focused on answering the research questions firstly, by considering whether these technical solutions do indeed reduce carbon emissions, as claimed, secondly, by considering how the calculations have been determined and what assumptions and approximations have been made, and thirdly, asking whether the resultant numbers have been deliberately used to invoke trust, or to supress conflicting views, by those wishing to cause a specific effect in their own interests.

The first issue considered was the progressive reduction of operational energy, through energy efficiency design measures. This was a regulated requirement of the Building Regulations. The calculation of energy use is based on a number of assumptions and has been shown repeatedly not to reflect the real energy used. Recent evidence shows that new school buildings are using more energy, not less, than those they have replaced. This may be, as commonly suggested, due to increased ICT use. However without extensive and detailed analysis of the buildings in use, which is not currently funded by Government, it is not possible to explain why the expected carbon savings are not being realised.

This does not appear to be a case of deliberate choice of the use of numbers by a social agent in their own interests; rather the assumed rationality of the calculation and the assumptions that it is based on are so powerful that this is believed to be 'the truth'. Evidence to the contrary, which conflicts with this belief, is either suppressed, as in the case of the Millennium School (Eclipse, 2005), or is explained by another aspect of the building, such as ICT use, which does not challenge the original assumptions (as shown in the interview with the Council project manager for Lane Academy).

The second issue considered was the use and choice of low carbon energy technologies. These are promoted, but not mandated, through the Building Regulations, but are often also imposed by local planning requirements to provide at least 10% of the power for the occupied building, as assessed at design stage. All four case study schools incorporated some of these technologies, with the main energy sources being ground source heat pumps for Backhouse and St Augustine Schools, and biomass boilers for Eastwick Field School and Lane Academy.

The ground source heat pumps, considered first, were chosen for different reasons. At the Backhouse School the choice was made by the Local Authority client, based on a simple and early stage cost estimate and against the advice (although not very powerfully stated) of the services engineer. At St Augustine the choice appears to have been made on the recommendation of the services engineers, considering a number of aspects which were discussed with the diocesan client, the school and other designers, and appeared to be popular with all stakeholders.

Ground source heat pumps have a number of high profile supporters, including the Environment Agency and Professor David MacKay, Chief Scientific Advisor for the Department of Energy and Climate Change and Professor of Physics at Cambridge University. However the ODPM suggested that GSHPs are only feasible where they replace electric heating (ODPM, 2006), and the DfES advised against underfloor heating (the most effective use of ground source heating) because of its slow response time (DfES, 2004).

A detailed review presented in chapter 7 of the likely carbon savings from a GSHP connected to underfloor heating, replacing heat from a conventional gas fired boiler and radiant panels, as was the case in both schools, showed that carbon emissions from the GSHPs were likely to be *higher* by as much as 50%. Furthermore they were unlikely to save the school money.

Again the numbers produced by the services engineers on limited information at an early stage in the design have been trusted, and have not been re-considered at a later point. Furthermore they have been trusted by those who it could be assumed are genuinely concerned with reducing carbon emissions. It appears to be the apparently rational nature of numbers themselves which had led to the earnest desire to believe them with no further evidence. Numbers themselves therefore appear to have an inherent power of their own.

The second renewable energy technology studied was that of biomass boilers, installed at both Eastwick Field School and Lane Academy. Again there were different reasons for the choice. At the first school it appears to have been the choice of the Local Authority client, on the basis of an early design estimate and again on cost. The choice of biomass at this inner London school was not supported by the contractor, nor by advice given in the ODPM guide to 'Low or zero energy sources' (ODPM, 2006), which concluded that biomass is not a suitable solution for densely populated areas because of the space requirements. The guide also suggests that running costs may be no cheaper than for conventional systems.

At the second school the choice of biomass was the result of the use of the school carbon calculator. This tool was known by a number of the case study interviewees, including the contractor for the Lane Academy, to be designed such that the biomass option was almost inevitably the resultant solution. Because of concerns over security of biomass supply it was also general practice to install a parallel conventional heating system. Anecdotally there are a number of schools that have installed biomass boilers but never switched them on, instead using the 'back up' system. This suggestion was supported by a report on the exemplar Kingsmead School, which showed that the boiler had not been used for the first eighteen months (Palmer, 2006). However biomass continued to be promoted by the DCSF, partly due to the fact that the information fed back by the users of the carbon calculator showed that 90% of the schools which had used the calculator had used biomass to demonstrate their carbon emissions reduction; Energy Performance Certificates similarly showed that all A rated schools had biomass. Both tools are reflections of design considerations rather than of actual performance. However because the calculations which feed these tools are seen as rational, they have once again been trusted as producing a rational result. Rather than realizing that the tools had the effect of encouraging biomass, they were seen as neutral assessments of the best solution for reducing carbon emissions.

The intentional choice of numbers has also been seen in the definition of zero carbon being defined deliberately so as to exclude the capital (embodied) carbon costs (DCLG, 2006). Unlike the unintended inaccuracies of the calculations of carbon savings through energy efficiency measures and renewable energy technologies, consideration of embodied carbon was excluded by the Government department responsible for regulating building design. This suggests that numbers can also be involved in other power struggles, through their deliberate omission. Further, the invoking of an absolute number, rather than a relative measure, can be seen to have even greater power, particularly when that number is zero.

The fact that embodied energy was excluded from the metric of zero carbon, even though it had been discussed and calculated within both academia and industry for many years, is also the clearest evidence that this particular framing of sustainability for construction is not, as is frequently claimed, merely a focused technical response to climate change as the 'biggest threat' (HM Govt 2005), but in fact grew out of deliberate social and political processes and negotiations.

However the situation is not stable. A method for the calculation of embodied carbon as part of the life cycle analysis of buildings has recently been introduced through non-mandatory European and British standards. However, in these, there are three aspects which have the effect of reducing the calculated embodied carbon. The first is that only the carbon emitted during the manufacture and processing of materials and components is mandatory. The calculation of emissions from other stages of the building life cycle, including transport of materials to site, construction processes, refurbishment and replacement of components, and demolition and end of life stages, are optional, even though it has been shown that these emissions may be as much as 60% of the total. The second aspect is that the method proposed by the standards is a process-based life cycle analysis. Previous research has suggested that this method is likely to underestimate the embodied carbon, and that input-output analyses, or hybrid methods which combine the two, may give a result which is a factor of two higher (Lenzen and Treloar, 2002). A further underestimation comes from the choice of presentation of results. Applying the DCLG metric for carbon of kg of CO_2 per year (DCLG, 2006) to embodied carbon requires it to be divided into equal annual increments over the expected lifetime of the building. While this appears to allow an objective comparison between embodied and operational carbon, it is in fact based on several subjective assumptions. Firstly it requires an assumption to be made of the lifespan of the building, which assumption directly affects the calculation of annualized embodied carbon. Secondly it implies that there is equal certainty in estimates of embodied and operational carbon. As shown earlier, estimates of operational carbon, based on predictions of future user behaviour, have a high degree of uncertainty; those of embodied carbon on the other hand, while dependent on the quality of data and the method of calculation, are more predictable because most stages are dependent on the design information. Thirdly it assumes that the future carbon intensity of the national grid is the same as the current. In fact, the carbon intensity is predicted to fall considerably, meaning that operational carbon emissions in the future will be much lower, while embodied carbon, most of which is emitted at year zero, will still be high.

These assumptions, implicit in the CEN standards, combine to reduce the perceived impact of embodied carbon compared with operational. Therefore the issue of embodied carbon compared with operational carbon is likely to remain one in which the assumptions made in the calculation encourage actions which may increase rather than decrease whole life carbon emissions.

Numbers are therefore seen to rationalize particular and limited notions of sustainability; the suggestion is that if it can be measured, it must be true. MacKay believes: 'Numbers are chosen to impress, to score points in arguments, rather than to inform' (MacKay, 2009, p.3). In the case of the deliberate omission of embodied carbon from the Government definition of 'zero' carbon, this would appear to have been the case. In the failure of the calculation for operational energy to reflect real emissions, and in the promotion of renewable energy technologies (including that of ground source heat pumps by MacKay himself) which may emit more rather than less carbon than the conventional technologies they are replacing, something more complex is happening. In this case, numbers do impress, but they do so through their *own* power, rather than through the deliberate intentions of their promoter.

Jasanoff stated that 'The brute objectivity of numbers is often gained at the expense of subjective values that democratic societies also hold dear' (Jasanoff, p.86). In this case the fact is that the 'brute objectivity' is so appealing that it has obscured the assumptions which have fed into the numbers. Society, perhaps particularly the parts of society such as engineers and physicists who have been taught to use numbers, want to believe in them; indeed they are the very basis of their disciplinary belief system. It is therefore not just Jasanoff's alternative subjective values that are lost, but also the true objective values. There is something intrinsically persuasive about a simple numeric argument. However in the complexities of real buildings, real technologies and real societies, the simple numeric argument is frequently based on so many approximations that, unlike Hardy's statement that 'all approximations are rational', in fact the solution thus reached is irrational.

This trust in the truth, the rationality, of numbers, has been shown to have supported decisions already made on grounds of a value-based belief in a technological solution to climate change. This does not mean that the belief is in itself wrong. However, the belief in the rationality of numbers frequently appears to replace the requirement for scrutiny of calculations or evidence of performance in practice. Numbers can therefore persuade and produce outcomes, and cause effects, which would not otherwise have been. Furthermore as shown by the calculations of embodied carbon by the structural engineers, the choice of numbers can also have an effect on the understanding and defining of a situation. As Porter has said, 'Quantification is not merely a strategy for describing the social and natural worlds, but a means of reconfiguring them. It entails the imposition of new meanings and the disappearance of old ones.' (Porter, 2004).

8.6 Answers, limitations and recommendations

This thesis has shown that sustainability for new school buildings has been increasingly narrowly interpreted as low operational carbon emissions. This has been translated into two particular technical solutions, design measures to improve the energy efficiency of the buildings, and the addition of on-site low-carbon energy technologies. That the breadth of the original definition and intention of sustainable development should have been reduced to such a narrow issue, for schools in particular, is perhaps surprising. Furthermore the analysis in chapter 7 demonstrates that the likely impact of this focus, for at least three of the case study schools, is an *increase* rather than decrease in carbon emissions.

The imposition of a single metric of carbon has also failed to unite different interests. Instead sustainability for construction has been shown to be a contested arena, in which practices, expertise and knowledge are being defined and redefined through a complex and shifting network of power effects.

In some ways this thesis has painted a gloomy picture, of powerful vested interests masking mistaken decisions, of outcomes limited by the structures of procurement processes and professional practice, and of the unintended and undesirable consequences of tools and technologies. But as Guy and Shove (2000) have said, there are many stories that could have been told; others would have been more positive. The thesis has also documented purposeful change initiated within the construction industry, with the introduction of cross laminated timber construction in the two Kier projects resulting in an actual reduction of embodied carbon (Vukotic et al, 2010) as well as improved working conditions, and the 'Playing cards for the future' tool introduced by Willmott Dixon encouraging wider concepts and practices in sustainability including improved stakeholder involvement.

These issues, on the sidelines of the original focus of the research, suggest some of the limitations of the chosen framing of the research. Other concerns and values which could have formed part of a wider definition of sustainability were omitted from the analysis, which concentrated instead on sustainability as consciously interpreted by policy and project actors. Within the case studies individual respondents had been considerably exposed to the prevailing discourse of sustainability as low carbon, and many appeared to assume that this was the most important, or even the sole, aspect.

The number of case studies and number and type of interviewees were restricted by the time available. This led to the omission of the pupils' perspective; their potential depth of knowledge and understanding of sustainability was referred to by some of the adult respondents, and is also reflected in the two statements by school pupils added as the Afterword to this thesis.

An assessment of the final built and occupied schools was not included as part of this research, and therefore there were no assessments of actual energy use and carbon emissions or any other measures of sustainability; however, many of the arguments made in chapter 7 would have appeared stronger if they had been supported by post occupancy data from the case study buildings.

This research project could be usefully extended by several further studies. The first would be to analyse the whole life (embodied as well as operational) carbon emissions from the schools as built, in order to assess the impact of construction materials, technologies and design choices on the actual greenhouse gas emissions, and to provide some specific explanation for the general increased emissions from schools found by Godoy-Shimzu et al (2011). The second related study would be to investigate the impact that the involvement of the end users in the design process has had on the energy behaviour in occupation, augmenting research in this area carried out by Adebayo (2011). The third area would be to assess the buildings in terms of the four quadrants of sustainability of futurity, equity, participation and environment as suggested by Palmer et al (1997). Fourthly the staff and pupils of these particular schools could be surveyed to discover the effects of the design decisions on behaviour, academic achievement, and well-being, following research by Samad (2008).

Within this thesis, theories of power have been used to demonstrate how social, political and professional interests have constructed and limited the technical solutions. Some reference has also been made to actor network theory, and to other conceptual frameworks within the field of Science and Technology Studies. These concepts have been used alongside those of power to show how the technologies and numbers have not only been governed *by* the politicians, professionals and stakeholders, but also appear in turn to have governed *them*, through limiting their choices and even their understanding of sustainability. They also demonstrate the limitations of the chosen theoretical framework to adequately explain the complex two-way relationship which exists between social actors and technical objects. Further research should be

carried out developing this alternative theoretical approach, in order to better understand the impacts of both the design tools such as BREEAM and of the low carbon technologies on the understanding of sustainability for construction.

The conclusions of the thesis have implications which reach far beyond school buildings, to the wider construction industry. The academic contribution of this research is to have demonstrated the effects of the often hidden power relationships governing decision making at policy and project levels. These have constrained thinking, action and possibilities in design. The conclusion leads to suggestions of some important changes that should be made in practice as a result of this demonstration. For the construction sector, there is a strong need for education about the effects of social and political decisions and interests on the interpretation of seemingly technical problems, in order to help professionals to use their technical expertise more wisely to the greater benefit of society. More specifically, and as recommended by the report of the Government Innovation and Growth Team (HM Govt, 2010), assessing the embodied carbon for the whole life cycle of a building alongside the operational carbon, should be carried out as part of a standard carbon-cost benefit analysis at frequent stages during design; any such assessment should now use the published TC350 standards as a template in order to ensure consistency with other calculations. For those involved in setting policy and regulation for sustainable buildings and schools, both from industry and from the policy community, the research has demonstrated the importance of ensuring the meaningful inclusion of *all* stakeholders, listening and giving weight to their concerns, in order both to achieve their stated goals and to understand what will benefit the wider society. Finally there needs to be a concerted Government-led initiative to carefully and critically assess what has been built, in terms both of the carbon emissions and of other aspects of sustainability, and to trace the effects of procurement processes and design-support tools on these outcomes. Such an assessment should influence the development of new procurement structures and processes which could contribute to a lower carbon and more sustainable future built environment.

Afterword

Views of sustainability from two school pupils (daughters of the author)

Cicely Moncaster Bridgeman
Poppy Moncaster Bridgeman

Sustainable Schools

The 10 things we remember about sustainable schools:

1. Energy
2. litter
3. Waste
4. Water
5. transport
6. healthy living
7. Biodiversity
8. School grounds
9. Pupil Participation
10. Friendship

By Cicely Emma Moncaster Dredgeman

Age: 9

Geography Eco-House

By Poppy Moncaster Bridgeman

I am Alice's 13 year old daughter, and this is my contribution to her PhD. For a geography assessment we had to design an eco-house. This is my write-up for mine, and I hope you enjoy it.

X

The house I have chosen to make is a dome shape. This is because it can be built almost anywhere – it can withstand strong winds and hold a vast weight of snow. The shape is strong and fuel efficient as it can be heated easily by the biomass boiler and the hot air will spread around the house. This is enhanced by the ground floor being mostly open plan. Although building the dome will be labour intensive, it uses very little material, and the material that it is made out of can usually be found locally to wherever it would be built.

1) **Embodied Carbon**

   Embodied carbon is the carbon used in the manufacture and stored in the product. The embodied carbon of this house is very low. It is made up of five stages. The first stage is C1, which is materials, will be very low because it will be timber which is one of the lowest embodied carbon materials you can get. Trees absorb carbon as they grow and release oxygen. Sequestration is the carbon that is stored in the timber. For every tree that is cut down for construction, three more will be planted.C2 will be from transporting the timber planks, but as wherever possible the wood will be local this would be almost non-existent. For C3, which is the carbon emitted during construction, it will be very demanding in labour, but in the end it will be worth it because it will be a durable long-lasting house. Refurbishing the house (C4) won't be all that carbon intensive again because it is all very durable. This is because all of the material will have protective varnishes against weather, and the windows will last for a very long time – all you would have to do is clean them! The most expensive and carbon intensive item of refurbishment would be replacing the photovoltaic panels as these would not last for more than thirty years, maximum. C5 is the last, and is the carbon emitted during demolition and afterwards. Because it is a timber frame structure, the house is largely burnable so that if you should ever have to tear the house down, you could burn it and turn it into biomass fuel for other houses or offices The idea of 'whole life costing' can easily be applied to this dream house as although compared to an average house, it is more expensive (especially in England as we do not have a mainstream of eco-houses, unlike Germany with the passive house), it will pay off through time because energy bills in light and heating will be cut much lower, the water bills too will be virtually non-existent.

2) **Triple-glazed windows**

   All the windows will be triple glazed. In-between the layers of glass is a gas called argon. The triple glazing will insulate better than a single, or even double, layer of glass. This is partly due to the argon, and partly due to the numerous layers of glass. Even though triple-glazing is expensive, it will save you up to 20% on your energy bills alone, as well as, if you would ever decide to move from this wonderful house,

increasing the re-sale price. The windows will sever any drafts, ensuring that the house is comfortable and pleasant to live in. just by having the windows in place means that they absorb and disperse solar heat around the house. They reduce condensation, which is good for health.

I made sure that the larger windows were on the south side, but were not too big in case the house was built in a very sunny area. I made sure that the large windows were not on the east or west sides because when the sun is low it would be too hot. Not only this, but it has windows on the back and the roof to capture as much natural light as possible.

3) **Insulation**

The insulation will be made of recycled newspapers. This is called Warmcel, and is made of Cellulose fibre. It is carbon negative as it uses old papers and recycles them, so that no new material is made. The fact that it is as good as airtight ensures that energy bills will go down as virtually no air can escape. It is a healthy, no harmful chemical, safe to handle material that has no waste, which means no cost for waste! It is easily installed with instant results. Like the triple-glazed windows, the insulation is an amazing sound-proofer. The insulation is fire resistant. It is also a 'breathing' building, which means that in summer the warm air passes through it leaving the house comfortably cool, and in winter the warm air is trapped making the house warm.

4) **Green Roof**

Over the rear end of the house, there will be earth with plants growing on it. This is great because it gives extra insulation while helping the environment with the plants – they take in carbon dioxide, and release oxygen – and the wildlife such as birds to have a pleasant environment to be in and around. The earth stops flooding in urbanized areas because it absorbs heavy rainfall.

5) **Operational Energy**

The house will be run with a biomass boiler for heating, solar thermal for hot water, and other electric power from photovoltaics and wind. Biomass is 90% efficient, whereas electricity is only a mere 20% efficient. The house will have energy security as all the energy sources will be renewable. The indoor lights will be LEDs. Because they almost directly link up to the combined photovoltaic and solar thermal panels (set into the exterior wall of the house) a miniscule amount of energy is lost through the 'links'. They don't waste energy because they use a very small amount of energy for a lot of light. The house will also have one space efficient wind turbine for if the house is placed in a windy area, or just to make use of wind when it is there. The wind turbine will be an EIL Vertical-axis Wind Turbine (VAWT) that can employ wind energy from every direction. Unlike some, it has an almost silent movement mechanism, as well as being rather light. It has a high reliability and safety rate that can stand up in and extract power from strong winds. It has less moving parts too, meaning less maintenance!

6) **Electricity**

I will install a low voltage D.C. ring around the house. A D.C. ring is a direct current ring around the house. This is different from usual houses because the vast majority of houses have A.C. (alternating current) 50% of energy is lost in heat when you convert to and from A.C. to D.C. Having all of this energy lost means that it is highly inefficient,

and in an ideal world we would have both A.C. and D.C rings around all houses as this would be the most efficient. As I wanted to have an ideal house, I added a D.C. ring around the house (you cannot see it on the model as it would be in the wall) to ensure that the 50% of energy being lost in converting between A.C. and D.C. To conclude the benefits of a D.C. ring around the house will be that, although it might be an extra effort to install, and they can link directly up to your photovoltaic panels, as you could probably work out; it will save you a lot on energy bills. There will be an A.C. ring too for the high energy appliances such as hoovers, washing machines and dishwashers (whereas D.C is for low power appliances such as phone chargers, games, T.V., radio and other things that require D.C. power).

7) **Water**

The water that you use will be virtually free as it would be all harvested and processed on site. This is because I have designed an inlaid 'trough' that circles all around the house that will collect the water from the roof. This is just like any house would have a drain; apart from it is on the ground. From the 'trough' the water will travel down a pipe. Then it will be split into two, one of these the water will be kept as it is and could be used to flush toilets, and also go to the hose to water the garden. The other amount of water will go to a purifier where it is filtered, using as little chemicals as possible, and is used for showers, baths. All you would have to do to be able to drink it is pass the filtered water through an Ultra Violet light to purify it and kill off any germs. There could be a grey water system too. This is when the waste water from washing machine, dishwasher, sinks, and showers (etc.) is given a minimal clean and used to flush toilets.

8) **Waste**

My toilets will be composting ones. This means they won't use water to flush, but if managed properly you can use the waste to fertilize the veg patch.

9) **Transport**

There is a sedum-roofed bike shed. This needs only a light-weight structure to support it as it can live in very little earth. Sedum is low in maintenance, and prevents weeds from growing. The bike-shed encourages the residents to use an environmentally friendly form of transport. In my ideal location, it will have a bus stop outside as well as a cycle track too.

10) **Pollution**

This house is low in pollution because it uses renewable sources of energy that, on the whole, release very little carbon dioxide. Another reason is, although it is labour intensive, the design is heat efficient because it minimises the surface area, ergo it reduces the heat loss. It is very good for the environment because it will be built using materials that have a low embodied carbon.

If you were to make a community out of domes, it would be more fuel, space and material efficient as you should make a 'stretch dome' which is a very long dome, where there are soundproof walls separating the homes of different families, much like terraced housing. Less heat would be lost in the exterior walls because there would be less surface space.
The photovoltaic and solar thermal panels actually more efficient when 2in1 due to space and materials.

Appendix A Interview details

This Appendix includes copies of the following documentation:

Information sent to informants in advance of interview, and additional copies brought to interview:

- Outline of research project
- Protocol for case study research
- Participant interview consent form (All signed copies collected and available on request)

List of questions to prompt informants during semi-structured interview process (sample)

Transcriber confidentiality agreement

Details of interviews:

- Interviews with policy lobbyists and other expert informants
- Willmott Dixon project interviews and site visits
- Kier project interviews and site visits

Outline of research project

Project title: Building sustainable schools: translating vision into reality

Funding: Engineering and Physical Sciences Research Centre (EPSRC)
Doctoral Training Account, October 2007 – September 2010

Researcher: Alice Moncaster MA(Cantab) MSc CEng MICE

Supervisors: Professor Jacquie Burgess, School of Environmental Sciences, UEA

Dr Minna Sunikka, Department of Architecture, University of Cambridge

Mr Peter Simmons, School of Environmental Sciences, UEA

Tony Blair famously promised 'Education, education, education' in the 1997 UK general election. Major Government programmes have since been launched, with the greatest public spending on school buildings since the Second World War. With concern about both unsustainable development and climate change rapidly increasing, in 2004 Blair stated a new vision that 'all new schools…should be models for sustainable development: showing every child …how smart building and energy use can help tackle global warming'.

This research project investigates the different visions for, and realities of, 'sustainability' in new school buildings in the UK today, by considering three different perspectives and influences: the policy makers and implementers, the design and construction industry, and the education sector.

Through examining what is happening in practice in case studies of live school building projects, and by collating the visions of influential experts, the research hopes to reveal the connections and differences between the different perspectives, and the impact that these have on real projects.

The final part of the thesis will use the gathered data to answer the following questions: What are the initial visions for sustainability for school buildings, and how have they arisen? How are these visions translated into practice during the procurement, design and construction processes? Finally, how should 'sustainability' be defined for school buildings, and how can policy, the construction industry and schools themselves help to ensure that the buildings being constructed achieve this?

Contact: Alice Moncaster, Centre for Sustainable Development,
Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ
Tel: 01223 332695 Email: amm24@cam.ac.uk July2009

Protocol for case study research

Project title: Building sustainable schools: translating vision into reality

Funding: Engineering and Physical Sciences Research Centre (EPSRC)
Doctoral Training Account, October 2007 – September 2010

Researcher: Alice Moncaster MA(Cantab) MSc CEng MICE

Supervisors: Professor Jacquie Burgess, School of Environmental Sciences, UEA

Dr Minna Sunikka, Department of Architecture, University of Cambridge

Mr Peter Simmons, School of Environmental Sciences, UEA

Informed consent: As a standard research protocol, interviewees will be asked to sign a consent form, agreeing to the interview being recorded. Interviewees may withdraw their consent at any point.

Confidentiality agreement: Data and information gathered from the interviews may be used as part of a PhD thesis (due to be submitted in October 2010), and may also be used in other publications such as research journals. The interviewee may ask for any section(s) to be deleted from the records, or to be anonymised, before granting consent.

Location for interviews: Preferably the interviews should take place in a small, quiet room, for the recorder to pick everything up clearly.

Semi-structured interview protocol: A prefigured list of questions will be put to each interviewee. The interviewee may choose not to answer specific questions, and may elaborate on any particular topic. Both interviewer and interviewee may introduce new topics or questions if they wish.

Documentary research: Where possible, documents from the specific project(s) will be studied for detailed project information, as follows:

- client's brief, project manager's reports, quantity surveyor's cost reports, design stage reports, minutes of client/project management meetings, minutes of design team meetings, minutes of site meetings, external reviewers' reports.

As with the interview data, all information will be kept strictly confidential, and will be omitted or anonymised before publication if requested.

Photographs of the site during and after construction are very useful as illustrations to the research work; individual schools will be approached for consent for these to be taken and used. It is fully understood that photographs on school premises are sensitive, and no photographs will be taken which include any of the school children.

Research outcomes: A summary of the research outcomes, or a copy of the thesis, will be sent to any participants who request it.

Contact: Alice Moncaster, Centre for Sustainable Development,
Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ
Tel: 01223 332695 Email: amm24@cam.ac.uk July2009

Participant interview consent form

Project title: Building sustainable schools: translating vision into reality

Funding: Engineering and Physical Sciences Research Centre (EPSRC)
Doctoral Training Account, October 2007 – September 2010

Researcher: Alice Moncaster MA(Cantab) MSc CEng MICE

Supervisors: Professor Jacquie Burgess, School of Environmental Sciences, UEA

Dr Minna Sunikka, Department of Architecture, University of Cambridge

Mr Peter Simmons, School of Environmental Sciences, UEA

Thank you for agreeing to participate in the Sustainable Schools research project. This research is not part of a bigger programme of research, and the information will not therefore be shared with anyone other than the three named supervisors, other than by future publication as described below.

By signing this form, and by giving your permission to be interviewed, you agree:

- to allow the interview to be recorded, and for the recording to be stored in electronic format
- to allow the recording to be transcribed (if an external transcribing service is used, they will be subject to a confidentiality agreement) and for the transcript to be stored in electronic format, and
- that data gathered and analysis based on the data may be used as study findings for part of a PhD thesis or in other publications such as research journals.

You may ask for any section(s) to be deleted from the records, or to be anonymised. You may also withdraw your consent at any time.

A prefigured list of questions will be put to you. You may choose not to answer specific questions, and may elaborate on any particular topic. Both interviewer and interviewee may introduce new topics or questions if they wish to do so.

It is acknowledged that any views expressed are those of the interviewee only, and not of their company.

Interviewee signature ……..

Print name ……Date ……

Researcher signature …….

Contact: Alice Moncaster, Centre for Sustainable Development,
Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ
Tel: 01223 332695 Email: amm24@cam.ac.uk July2009

Questions for construction companies

Introduction to the company and projects
What is your role in the company,

Have you had any direct involvement with Project *****? How did you win the project?

What is the company policy on sustainability (in schools), and how effective is it in practice?

Are there any company procedures/KPIs to improve site practice?

How was ***** procured, and what are the advantages and disadvantages of this system of procurement? how did it set up project relationships, how did it work in practice, were there any problems with it?

What are, specifically, the pros and cons of **this** procurement process for you? How do you think this has affected the overall project success?

Has this project led to others, either schools or sustainable features in other work?

Has the knowledge developed within this project been used in other projects since?

Has it become a showcase or marketing type project?

Developing the briefs
How much involvement do you have with the clients for the projects? How affected are the outcome of the projects by the experience of the client?

How much involvement have you had with the schools, and again how affected is the outcome of the project by the involvement of the school?

How much say did **[the contractor]** have in developing the design? What does your point of view add, do you think, in terms of design development?

Was there access to any expert advice, and did it cover sustainability issues? Was it useful and where/who did it come from?

Are you aware of, informed of, or shown, any exemplar designs in the UK or abroad? If so, were they useful?

Is BREEAM a useful tool in thinking about sustainability or does it have drawbacks? Is there an alternative?

Was there a sustainability 'champion' (someone who encouraged ideas and informed others about sustainability) that you could identify in the project, either from the client or project team, or a specific advisor?

Design stage
Who was involved at this stage in regular design development? The school, local authority, contractor/developer, architect, engineers, etc?

Did the consultants and contractors work well as a team, was there one or more dominant individuals and was this good or bad, was there a division between design team, construction team and management team? How were these affected by procurement?

Were there any design issues which you were/are unhappy with, or any compromises that had to be made? Who made these decisions, if so?

How were sustainability visions maintained, or lost, through the process?

Costs – Did they vary over the life of the project, did 'value engineering' happen – and did it work, what did it cut out, whose priorities did it follow?

Was there, in your opinion, anyone 'championing' sustainable design at this stage? If so, who were they, and what was their impact on the design?

Construction stage

How important is sustainability to the individuals within the contractor team? Who sets the culture, on a temporary organisation such as a building site?

Who have the key people been involved in making decisions (particularly around design changes, and sustainability issues) during the construction stage?

Have sustainability visions been maintained or lost through this stage and why?

Have there been any problems on site?

Finally

What are your limitations in answering these questions? Are there any commercial confidentiality and political sensitivities to take into account?

What would you recommend doing differently next time?

What is the most important element of a school building? What is the key aspect of sustainability in relation to school buildings?

Additional subjects:

Knowledge exchange/production:

Who did you seek specialist advice from if anyone? Was this advice about sustainability issues?

Have you worked on schools projects before?

What, in your opinion, are the key issues for sustainability in schools in particular?

Roles of individuals:

Were there key players you could identify, particularly with regards to the sustainability visions?

Did the design team work well as a team, or were their conflicts of interest?

How ere the roles set up by the procurement structure? Would a different procurement have been better in your opinion?

Did working for the contractor as well as the client go OK?

Can you compare the form of procurement with any other forms, such as traditional, Design, Construct, Operate, or PFI?

Design issues:

What do you think of the success of the different design issues – what are you pleased with, what would you have done differently with hindsight?

Who made the decisions on renewables – solar hot water, wind turbine, GSHP – were they a good idea and why?

Were there any problems with installation on site?

Do you know how they are performing?

What flexibility did you have over orientation of buildings, natural ventilation strategy, passive solar heating strategy, etc? Were these important issues for the design?

How are they performing?

Were other design issues perceptibly of higher priority than sustainability?

What does sustainability mean to you in the context of a school building?

Transcriber confidentiality agreement

Project title: Building sustainable schools: translating vision into reality

Funding: Engineering and Physical Sciences Research Centre (EPSRC)
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Researcher: Alice Moncaster MA(Cantab) MSc CEng MICE

Supervisors: Professor Jacquie Burgess, School of Environmental Sciences, UEA

Dr Minna Sunikka, Department of Architecture, University of Cambridge

Mr Peter Simmons, School of Environmental Sciences, UEA

I confirm that on receipt of payment for the transcriptions I will delete the recordings and the transcript files from every place in which I have stored them electronically or in hard copy.

I will not disclose any of the content of the interviews that I am transcribing for this project with any third party now or at any point in the future, verbally or in written form.

Transcriber signature

Print name SUZANNE WILLIAMS… ……Date 05/04/10

Contact: Alice Moncaster, Centre for Sustainable Development,
Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ
Tel: 01223 332695 Email: amm24@cam.ac.uk July2009

Policy lobbyists and other expert informants

	Interviewee	Job title	When interviewed	Transcribed by:
Chapter 4: Policy lobbies				
1.	Robin Nicholson	CABE Commissioner ZCSTF Chair	21/07/09	SW
2.	PF	Land Securities procurement	20/09/08	AMM
3.	John Hall	CE Regional Director	18/06/09	AMM
4.	John Canton	ICE Regional Director	08/07/09	AMM
5.	Andrew Thorne	DCSF/BRE	20/08/09	SW
6.	Alex Plant	Cambs Horizons Chief Executive	09/07/09	SW
7.	Kevin Manley	Cambs CC BSF Project Manager	22/01/08	AMM
8.	PM	B**** BSF Structural Engineer	07/09/08	AMM
9.	Claire McKeown	CABE Enabling advisor	29/04/08	AMM
10.	SC	**** Academy Principle	02/03/10	AMM
11.	Ann Bodkin	PfS sustainability officer	12/05/10	AMM
12.	Elizabeth Pearson	CABE Senior Enabling advisor	09/02/10	SW
13.	Jenny Thomas	BCSE Sustainability Officer	25/02/10	AMM

Willmott Dixon projects

Project	Interviewee	From	Posn.	Role on project	When interviewed
	George Martin	Willmott Dixon	Director of Sustainability	Contractr	29/01/10
BackhouseSchool					
	CM	School	Head teacher	School	(20/10/08)
	KG		Business Manager		20/11/08
	DK	School	Chair of Governors	School	18/08/09
	LC	Willmott Dixon	Contractor PM	Contractr	03/09/09
	HB	County	Head of Infrastructure,	Client	28/09/09
	SA	Council	Head Prop Commissg,		
	GT		Corp Serv Cap Strat Man		
	DL	Mouchel	PM	Designer	24/02/10
	OT		Services Engineer		
	PA	Mouchel	Architect	Designer	23/03/10
			Site visit no.1		20/10/08
			Site visit no.2		03/09/09
			Site visit no.3		07/04/10
Eastwick Field School					
	CP	Navigant	Programme Directors for	Client	18/01/10
	IS	Consulting	client		
	JH	Jestico +	Architect	Designer	21/01/10
	KP	Whiles	Project Architect		
	JC	School	Director of Resources	School	01/12/09
	HS, by email only	School	Chair of Governors	School	18/03/11
	IH	Willmott Dixon	Contractor PM	Contractr	09/02/10
	MT	CyrilSweett	QS	Designer	12/05/10
			Site visit no.1		01/12/09
			Site visit no.2		21/01/10

Kier projects

Project	Interviewee	From	Posn.	Role on project	When interviewed
	Peter Johnson	Kier	Director of Sustainability	Contractr	30/09/09
	Gary Wintersgill	Kier	Director of Education	Contractr	30/09/09
St Augustine					
	TW	Ramboll Whitby Bird	Structural Engineer	Designer	05/10/08
	AF	Consultant	Client rep	Client	24/09/09
	JA	Davis Langdon	Client PM	Client	08/09/09
	JH	GSS	Project Architect	Designer	25/09/09
	RV	Kier Eastern	Contractor PM	Contractr	24/11/08
	WH	Kier Eastern	Design Coordinator	Contractr	12/12/08
	CB	School	Bursar	School	14/09/09
			Site visit no.1		03/06/08
			Site visit no.2		24/11/08
			Site visit no.3		14/09/09
Lane Academy					
	RO	Kier Eastern	Site Manager	Contractr	29/09/09
	CL		Environmental Champion		
	MS		Design Engineer		
	W	Ramboll	Structural Engineers	Designer	05/10/09
	GW				14/10/09
	GW	Ramboll	Structural Engineer	Designer	10/12/09
	SC	Sheppard Robson	Architect	Designer	05/01/10
	ST	School	Director of Finance	School	03/02/10
	CC	Kier Eastern	Site Manager	Contractr	03/02/10
	LB	County Council	Client	Client	19/03/10
	EG	WSP	Acoustics Engineer	Designer	02/06/10
			Site visit no.1		29/09/09
			Site visit no.2		03/02/10
			Site visit no.3		19/03/10

Appendix B List of supporting documents

This Appendix includes the following:

List of project and external documents used in developing the case studies for

Backhouse School

Eastwick Field School

St Augustine School

Lane Academy

Backhouse School

Most documents sent by email by contractor Accounts Manager

	Document	Date of document	Obtained from
Project documents			
Reports	Milestone 4 report	27/05/2008	Mouchel
	Contractor's report	03/10/2008	Willmott Dixon
	Contractor's report	05/11/2008	Willmott Dixon
	Contractor's report	30/03/2009	Willmott Dixon
Programmes	Project programme	19/06/2008	Willmott Dixon
	Project programme	31/03/2009	Willmott Dixon
	Project programme	08/02/2010	Willmott Dixon
Minutes of meetings	Pre-contract meeting, 27/06/08		Willmott Dixon
	22 site progress meetings 04/08/08 up to 31/03/10 agendas, draft and final minutes		
Costs	Contractor's quotes	05/11/2008	Willmott Dixon
	Contractor's quotes	01/04/2009	Willmott Dixon
	Contractor's quotes	30/07/2009	Willmott Dixon
Risks	Risk register	23/05/2008	Mouchel
Other	WD Environmental Playing Cards for the Future	n/a	Willmott Dixon
	WD Ten Point Sustainable Project Criteria	n/a	Willmott Dixon
Drawings	Proposed, 2006		Mouchel
Photos	From school	Pre 20/10/2008	School
	Taken by researcher	03/09/2009	self
	Taken by researcher	07/04/2010	self
School documents	School Prospectus	2006	Internet
	School Prospectus	2009	Internet
	School Prospectus	2010	Internet
	OfSted report	2005	Internet
	OfSted letter	2005	Internet
	OfSted report	2008	Internet
	OfSted letter	2008	Internet
News articles		press releases, local articles school news,	Internet
Others	Planning recommendation	2005	Internet

Eastwick Field School

Full access to project documents on internal filing system provided by architects Jestico + Whiles. Quantities of documents copied (not all project files were copied) are given against sub-headings taken from the J+W filing system. Blogs from school Director of Resources and from Chair of Governors from internet. Other documents as noted.
Due to high numbers of documents only key documents are individually noted.

	Document, or number of documents	Date of document	Obtained from
J+W			
Project documents			
Acoustics	3 documents		J+W
Architecture	15 documents		J+W
Design philosophy	12 documents		J+W
BREEAM	Green Guide tables to materials 3rd edition, BRE		J+W
	Initial BREEAM assessment	04/10/2007	J+W
	Interim BREEAM assessment	25/07/2008	J+W
	+ 25 other documents		J+W
CABE	1 documents		J+W
Consultation	10 documents		J+W
Contractor	3 documents		J+W
Cost	ITSFB Cost Breakdowns	24/09/07	J+W
	+ 14 other documents		J+W
D&B	6 documents		J+W
Decant	5 documents		J+W
DQI	Initial DQI Session	10/07/2006	J+W
	DQI Mid-design meeting report	03/12/2007	J+W
	DQI Report	02/2007	J+W
	DQI for schools questionnaire, CIC and DfE	05/12/2005	J+W
	+ 4 other documents		J+W
Local Authority	Design and Build specification (6 documents)	Various, updated through project	J+W
	ITCD (10 documents)	16/01/07	J+W
	+33 other documents		J+W
Landscape	5 documents		J+W
LEP	14 documents		J+W
M&E	20 documents		J+W
Meetings	17 documents		J+W
News articles	7 documents		J+W
Planning	3 documents		J+W
Programmes	21 documents		J+W
Reports	Stage C Design Report	05/10/2006	J+W
	BSF Design Report	02/2007	J+W
	+ 20 other reports		J+W

Risk assessments	10 documents		J+W
School	23 documents		J+W
Specificiations	3 documents		J+W
Structural design	5 documents		J+W
Other project docs			
Costs	School Level Capital Cost (Value Engineering sheet)	2nd qtr 2008	Cyril Sweett
Drawings	Bid submission stage, 19		J+W
	ITSFB stage, 16		J+W
	Phase 1 hand over, 10		J+W
	Planning amendment, 7		J+W
	Final General Arrangement drawings at 1:50, 14		J+W
Photos	From architect	Pre 01/2010	Architect
	Taken by researcher	01/12/09	self
	Taken by researcher	21/01/10	self
School documents	Blogging schools for the future, Director of Resources	31/10/07 – 15/10/09	Website
	School newsletter	Autumn 2009	Website
	Chair of governors' blog	26/11/10	Website
Client documents	Borough Council BSF leaflet	August 2009	Website
	Invitation to Continue Dialogue	October 2006	School
	ITCD Bid Team Contact Details	02/02/2007	J+W
News articles	Unknown newspaper article	In the 1960s	Borough Planning Dept.
	Architecture of Eastwick Field		Website

St Augustine School

Full access to project documents on internal filing system provided by structural engineers Whitby Bird (now Ramboll). Only documents copied listed below.
Due to high numbers of documents only key documents are individually noted.

	Document	Date of document	Obtained from
Project documents			
Reports	Mechanical and Electrical Services Sustainability report	Jan 2007	WB
	WB Stage C Report	Dec 2006	WB
	WB Stage D Report	Mar 2007	WB
	WB Stage E Report	Aug 2007	WB
	WB Structural Frame Report	Jan 2007	WB
Programmes			
BREEAM	BREEAM initial assessment	2006	WB
	BREEAM interim report	June 2007	WB
Minutes of meetings	8 construction phase mtgs	12/2007-04/2008	WB
	6 design mtgs	09/2006 – 07/2007	WB
Costs	Stage C	15/12/06	WB
	Stage D-E cost plan reconciliation	July 2007	WB
	Stage E possible cost savings	July 2007	WB
Risks	Risk assessment for tender	28/06/07	WB
	Risk assessment for stage C		
Other	Environmental briefing questionnaire for client		WB
Drawings	Plan dwgs of new buildings		WB
Photos	Kier professional	02/05/08	Kier
	WB progress photos	various	WB
	Taken by researcher	03/06/08	self
	Taken by researcher	14/09/09	self
School documents	OfSted 2000, 2005, 2008, 2010		Website
News articles	ICE Merit Award Winner announced	2009	ICE

Lane Academy

Invitation to Tender provided by client. Full access to project documents on intranet system provided by contractor Kier Eastern and Client. Only documents copied listed below. Originators of documents added where known, rather than where obtained as system was shared.
Due to high numbers of documents only key documents are individually noted.

	Document	Date of document	Originated by
Project documents			
Reports	Invitation to Tender, including design and education briefs	27/03/2008	Client
	27 various	various	various
	10 records of architect's site visits/construction mtg minutes	various	architect
Programmes	4 programmes for design and construction	various	Kier
BREEAM	Pre-BREEAM Assessment	17/02/09	
	BREEAM Education report	25/03/10	
	BREEAM responsibilities	not dated	
	5 other documents		
Costs	Contract sum analysis	not dated	Kier
	Milestone payments	not dated	Kier
Consultations	Pupil/staff	22/04/2008	architect
	Residents	22/04/2008	architect
	List of consultations	not dated	architect
DQI	DQI Briefing session	09/11/2008	DQI coordinator
Risk	Project risk table	03/02/2009	Kier
Others	Waste assessment divided by material type and reprocessing (MCG WRAP reporting)	undated	Kier
	Bill of quantities showing materials and processes	undated	Kier
	Embodied carbon and energy of timber panels	undated	KLH
	Transport log	undated	Kier
	Accident Frequency Rate		Kier
Photos	Taken by researcher	03/02/10	self
	Taken by researcher	19/03/10	self
	Architects' site visit photos	various	various
Drawings	23 Plan and elevation GAs at 1:50	various	various, mainly architect
School documents	OfSted monitoring inspection	06/11/2009	Website
	Prospectus	08/2008	School
Others	Ramboll carbon calculator v.1		

Appendix C: Embodied energy and carbon in buildings

Note: This work was carried out between Aril 2010 and June 2012 by the author, and under her direction by colleagues Ji-Young Song (August 2010-April 2011) and Katie Symons (June 2011 – March 2012) and post-graduate student Daniela Sahagun (April - September 2011), at the Centre for Sustainable Development at the University of Cambridge. It formed part of a consortium project funded by the Technology Strategy Board under the 'Design and decision tools for low carbon building' programme; however funding for the work at Cambridge came from the EPSRC. The work was conducted in parallel to the PhD research and the thinking behind both projects fed into each other. Some parts have been published as Moncaster and Song (2012) and Sahagun and Moncaster (2012), and other publications are planned. The work in this appendix is solely that of the author except where otherwise stated.

The appendix supports the information in chapter 4, which has considered the development of policy and regulation for embodied carbon and energy, and in chapter 7 which compares the different calculation methods.

The appendix is in two separate sections. The first explores the background to the issue. The second proposes an empirical process-based approach to assess the whole life carbon impacts of buildings, using empirical data from case studies, with the aim of developing a database of life cycle analyses of carbon emissions from buildings.

C1 The background to energy and carbon in buildings

The focus on energy reduction first became a dominant political discourse during the 1970s oil crisis, which led to fears about the finite supplies of fossil fuels and associated energy security for the UK; these fears were restoked by the behaviour of Russia in January 2006 when it stopped gas supplies to the Ukraine. Reducing the UK's dependence on energy from fossil fuels is addressed through a number of long-term measures, one of these being the reduction of energy use in buildings (Energy White Paper, DTI, 2007). This is principally a worry about the future. Its relationship with the holistic definition of sustainability derived in chapter 1 is limited to the social aspect of maintaining current quality of life.

Meanwhile the need to reduce emissions of carbon dioxide and other greenhouse gases stems from an understanding of their likely long-term impact on the climate (IPCC , 2007). This is a concern about present as well as future carbon emissions, and while it is primarily concerned with environmental sustainability on a global scale, it has also been shown to have considerable associated social and economic effects (Stern, 2006).

Therefore although frequently considered as synonymous, in fact 'energy' and 'carbon' arise from different concerns. The two areas are linked because it is the burning of fossil fuels for energy use that has caused the greatest part of GHG emissions. The result is that concerns over reducing energy use in buildings for the sake of energy security can be confused with (or possibly rebranded as) concerns with reducing carbon emissions, and therefore as 'sustainability'. In order to

understand the different claims for low carbon and low energy, the following section explores the relationship between energy and carbon in buildings, focusing on where and when they arise and how, in particular, they are measured.

Operational and embodied energy use and carbon emissions

For buildings, the energy used over the whole life of a building can be divided into two main stages: that used during the production of the building, and that used by the occupiers of the building. These are termed the 'embodied' and 'operational' energy. The term 'operational energy' includes the energy used in heating buildings and water, in cooling and in lighting, and some definitions also include the energy used by electrical appliances and domestic white goods in the building (the 'plug load'), during its serviceable life. 'Embodied energy' includes the energy used during the manufacture of the building materials and components, in transporting these to site, and during the construction process itself, and can also include energy used during refurbishment and replacement of components during the lifetime of the building (ref) and that used in the demolition, waste and reprocessing at the end of life stage (ref).

'Carbon emissions' is the term most frequently used as a short-hand description for the emission of gases which have been assessed as having the potential to cause climate change; these are known as 'greenhouse gases' (GHGs). The GHGs which are thought to cause the greatest effect on the climate are carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). Where emissions of all gases are being measured, the correct term used is 'carbon dioxide equivalent', or CO_2 e; in this thesis the term 'carbon' is used to mean CO_2 e, or {all GHGs converted to CO2}.

The 'operational carbon' of a building is the GHG emissions during the operational life of the building, and is considered to be due to the operational energy used. In fact several other emissions of GHGs are caused by other aspects of buildings in use, including methane from food and other waste sent to landfill, but these are not included in the general use of the term. Therefore where the operational energy is from a carbon intensive fuel source, the operational carbon will be high, while if the fuel source is low carbon, such as wind or solar, the operational carbon will be low. This is an important factor for example in understanding the Government's focus on decarbonising the national electricity grid.

The 'embodied carbon' of a building is the total GHG emissions created during the production of the building. It is closely related to the embodied energy, as the most common source of carbon emissions is again from the burning of fossil fuels during the processes described above. However, for imported materials and components which have been processed in a country with a low carbon fuel mix, the embodied *carbon* for that material will be lower than from the same material or component manufactured using the relatively carbon-intensive UK fuel mix, even though the embodied *energy* may be identical. The embodied carbon from transporting the materials also needs to be taken into account. In addition, in a few cases the materials will also emit or absorb carbon during their own life cycle process – examples are cement, which emits carbon as part of the manufacturing process and timber, which absorbs (sequesters) carbon during growing. Carbon is also sequestered in growing plants, and land itself is a carbon sink (see the United National Environment Programme report on 'The natural fix? The role of ecosystems in climate mitigation,

Trumper et al, 2009). Therefore calculations of net carbon emissions arising from the whole life cycle of a building are more complex than those of energy use.

A new suite of European standards on the sustainability of construction works have recently been developed by the CEN TC350 working group and published as British standards between 2011 – 2012. Further details of where operational and embodied energy and carbon arise in buildings is given in BS EN 15978:2011 *Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method*, which defines product life cycle as shown in Figure 1. For buildings, operational energy/carbon is contained in stages B1 – B3 plus B6, while embodied energy/carbon arises from 11 other stages, A1- A5, B5 - B6 and C1 - C4 within the lifecycle of the building, and from D, the positive impacts of processing or re-using materials and components after the end of life.

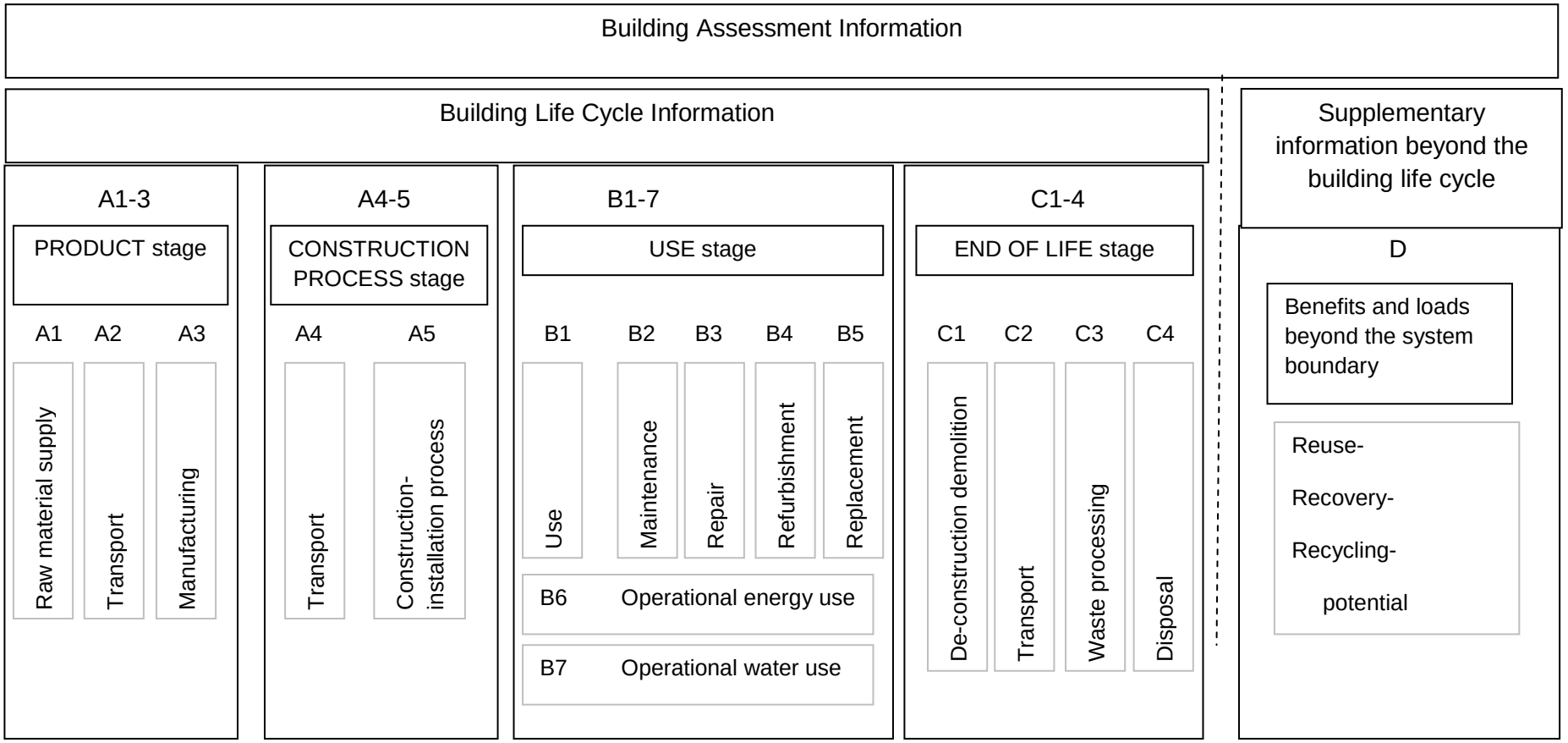

Fig. C1 Display of modular information for the different stages of the building assessment, BS EN 15978:2011Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method

Embodied energy and carbon

Unlike operational, embodied energy and carbon is not yet the subject of policy or regulation. Until recently little research has been carried out in this area, and while operational energy and carbon reductions have been adopted by the engineering professions as a key design issue, embodied energy and carbon is seldom considered. This is particularly striking given the number of design and construction processes which include have an impact on the embodied energy and carbon, as shown in fig 2, compared with the dominant effect of occupier behaviour on operational carbon as described by above.

Due to the lack of standardisation in calculation, embodied carbon has been defined variously by different authors. Different approaches are also used; for example the European standards divide the construction process into types of process – for instance the process of *transport* is seen to include the transport of materials to site, of construction equipment to site, and of materials from site in the form of waste. An alternative approach instead divides the construction process chronologically. Using this approach, transport appears three times, once pre-manufacture, for transporting raw materials to their place of manufacture, once pre-construction, for transporting manufactured products to site, and once at the end of life phase, for transport of waste after demolition. A revised chronological approach based on the main design and construction stages has been proposed by Moncaster and Song (2012) which includes separate phases for the production of materials, their transport to site, construction, maintenance and end of life. A third method considers the building as the sum of its individual manufactured components, each of which has a downstream impact due to installation, maintenance and end of life.

Each approach has specific problems with implementation and data. Most importantly, though, the different approaches imply different responsibilities. For example, the first method considers the haulage sector as responsible for reducing the transport emissions, the second approach suggests that the responsibility for reducing emissions from transport goes to those involved in each stage, and the third suggests the responsibility lies with the manufacturers of the individual components.

Calculation of whole life carbon and energy

The measurement of embodied carbon and energy is through Life cycle analysis (LCA). The International Standards ISO 14044:2006 defines four key phases of LCA as 'Define goal and scope', 'Life cycle inventory analysis', 'Impact Assessment', and 'Interpretation' (linked to each of the other stages). There are two main methods for developing the second of these, the Life Cycle Inventory. The first is a 'process-based' method, which for a building may be developed from knowledge of the materials and processes that go into the construction of the building. Each of these products and processes will then be subject to its own life cycle analysis 'upstream' from the building. There are two main difficulties in using a process-based LCI for buildings. Firstly, unlike factory-fabricated products, the complexity and variability of buildings means that the data for materials used and processes will be different, and

extensive, for every building. The use of sub-contractors for different construction packages, each of whom has responsibility for procurement of materials, makes this data collection an even more problematic task. Secondly the secondary services associated with the construction of the building, including finance, insurance, government administration and related office buildings, are usually omitted from the model. Both of these aspects require responsible reporting of environmental impacts by a great number of different organisations in different industry sectors. Currently the lack of legislation means that this doesn't happen (Moncaster and Song (2012), Sahagun and Moncaster (2012)).

The second method of LCI is input-output (I-O) analysis. First developed by Wassily Leontief in the 1930s, in the 1970s he suggested its application to environmental impact assessment. The input-output approach considers the economic or environmental inputs to and outputs from a specific industry sector or sub-sector (Gerilla et al, 2007). The total impacts of the construction of a building come from a number of other sections as well as construction; by considering the inputs and outputs from and to other sectors, the input-output model can calculate the total financial or environmental impact of construction, including the upstream processes commonly omitted by the process analysis (Treloar, 1998, Crawford 2008).

Input-output analysis therefore overcomes the problems with process analysis by considering a complete system boundary, again inherently assigns responsibility, in this case to an industrial sector, and focuses industry attention on the processes which are most carbon intensive. For the purposes of the SFfC and other industry bodies the I-O approach is useful. However the method assumes homogeneity of buildings, as figures are not broken down beyond the level of sub-sector, and proportionality, equating carbon emissions to financial cost; 'green materials', with relatively high costs because of reduced economies of scale, would therefore be assigned a higher carbon cost too. Its use in design of individual buildings is therefore limited (Acquaye et al, 2011).

While the process analysis suggest the responsibility lies with the individual organisations linked to each project, by focusing on economic and industry sectors, the I-O method implies sectoral responsibility for energy use and carbon emissions. This is the approach which has been followed in the UK by the Strategic Forum for Construction (SFfC). In 2008 the SFfC published jointly with the UK Government the Strategy for Sustainable Construction(DBERR, 2008), under which the SFfC is made responsible for delivering 15% reduction in carbon emissions from construction processes and associated transport compared to 2008 levels, by 2012. A paper defining the scope and interim stages necessary to achieve this target was written by the SFfC and the Carbon Trust, in association with Ove Arup and Partners, and revised in March 2010 (SFfC, 2010). The report limits the responsibilities of the construction sector at this stage to the construction process itself, major maintenance and refurbishment, and deconstruction (see Fig 2). Thus it excludes the manufacture of building materials and components, but includes their transport to site, with reasons given for this including 'the lack of complete and consistent data' (p. 15). It also excludes the energy used during normal operation of the building.

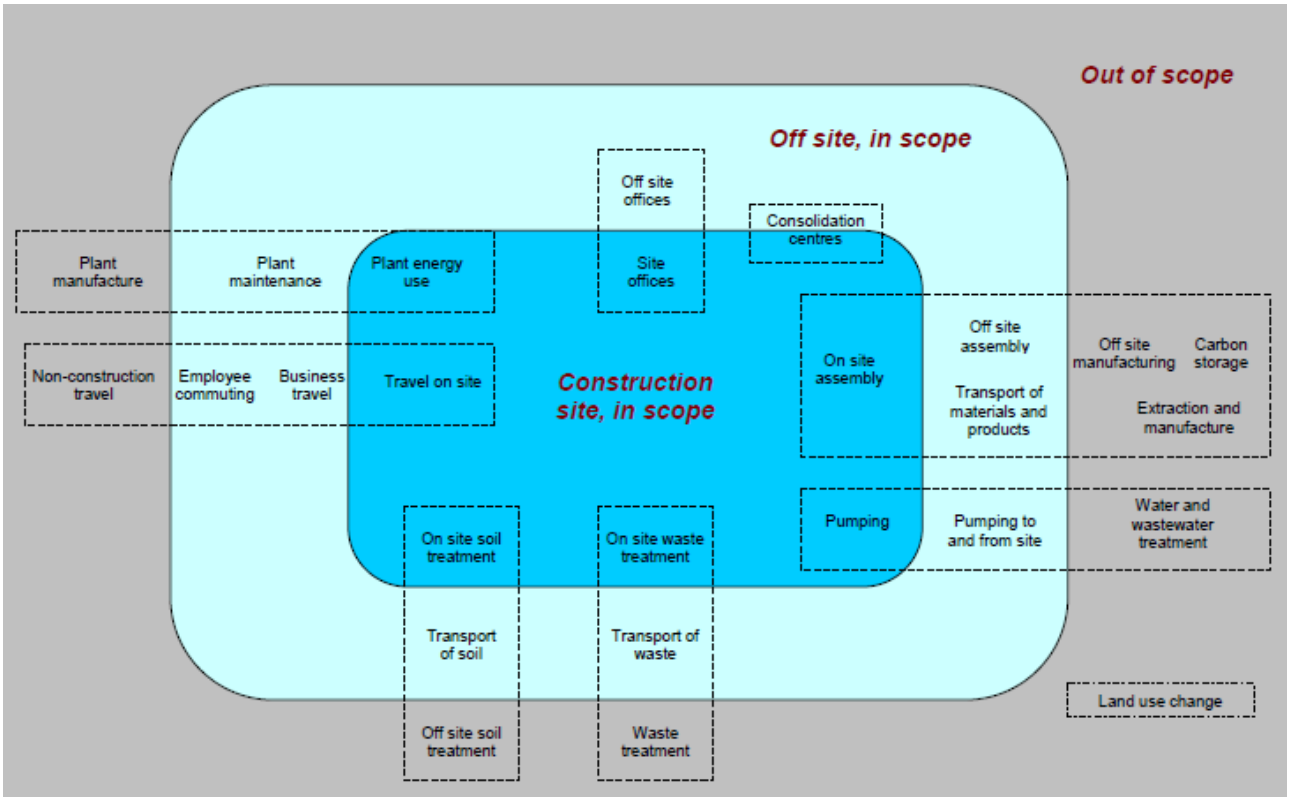

Fig. C2 Scope of construction sector responsibility for emissions, SFfC, 2010

C2 Development of new empirical process-based approach for data collection to assess the whole life carbon impacts of UK buildings

There are a number of academic case studies which have assessed the embodied energy and carbon of individual buildings (Adalberth, 1997, Thormark, 2002, Citherlet and Defaux, 2007, Gustavsson and Joelsson, 2010). UK-based cases of domestic buildings have been provided by Monahan and Powell (2011) and Hacker et al (2008). Most are based on domestic buildings, although Ding (2007) provides a recent assessment of school buildings in Australia. The publication of case studies is important in developing an understanding of the issues and the relative values of the different stages of embodied carbon. However, these are based on different building types, have used a variety of methods and have focused on different stages. Useful reviews of results are given by Sartori and Hestnes (2007) and Dixit et al (2010). Many of these papers are also non-UK based, and so their relevance for the UK is limited, due to different construction practices, materials and regulations, and to different carbon intensity fuels. Hammond and Jones (2008) have developed the most commonly used data source for the

material phase (A1-3), and the CESMM3 'Black book' (ICE, 2010) provides further data on carbon emissions from standard construction processes.

Many of the issues involved in developing a life cycle inventory for buildings comes from the demarcation of responsibilities for different stages and aspects of the building. This proposed chronological process method uses an understanding of the responsibilities for each stage to develop a method through which meaningful data can be gathered and used from real case studies. It is intended to be a method for contractors, in particular, to use to gather data across a wide range of buildings, in order to develop a UK-based database of typical embodied impacts at each stage of a building life cycle, as defined by the TC350 suite of standards (see Fig.1).

The individual designers and contractors on a specific project have responsibility for an individual building. Both designers and contractors are responsible for specifying the materials and for the use of pre-fabrication and offsite manufacture. They are responsible if not for the transport mode and fuel used, at least for the distance travelled, again in their specification of materials. Contractors are responsible for the efficiency of the construction process. Through the design choices, the materials specification and the construction processes, the designers and contractors have responsibility for the durability and the future necessary refurbishment (unnecessary refurbishment, due to change of ownership and use of building, or client choice, is out of the scope of responsibility of the designers and contractors and therefore out of the scope of a LCA). Similarly they are also responsible for the end-of-life options, if not for which are ultimately chosen.

The first stage of the life cycle analysis of energy use and carbon emissions from a building must therefore define a goal and scope which will include the energy used and carbon emitted from each of these phases: material extraction and processing, transport of materials to site, construction on site, normal operation of the building, major maintenance and refurbishment during the lifetime of the building, demolition recycling and reuse. It will then be possible to answer the claims of the different construction sectors with some degree of understanding of how each fits into the whole life cycle emissions.

Most existing databases, including the Bath Inventory of Carbon and Energy in Building Materials (Hammond and Jones, 2008) provide data for the product stage (stage 1) for the key materials and components used in construction. A comprehensive data gathering exercise at the Centre for Sustainable Development at the University of Cambridge between 2010 and 2011 has revealed a considerable shortage of data for composite components, such as windows, and for services components and innovative materials and products. There is also a particular shortage of data across the construction sector in the embodied energy used and carbon emitted during the sub-stages proposed in BS EN 15978 A4 and A5 (transport to site and construction), B (in use) ,C and D (end of life and beyond) (see Fig 1).

For the purpose of creating a UK wide database of whole life embodied energy and embodied carbon of buildings in the UK, this thesis proposes the method detailed below.

This method of data collection has been developed in consultation with the contractors involved in the case studies in this thesis, Willmott Dixon and Kier Eastern, both members of the UK Contractors Group. (formally the Major Contractors Group, which included the thirty largest UK contractors). It has been developed based on interviews with individuals from both companies, and supplemented with documents from the Kier case studies (discussed in chapter 6 of this thesis), as show in Table 1 below

Interviews (alphabetical order):	**Documents from Kier case studies:**
Ian Brooks, Business Improvement Manager, Kier Eastern	Construction programme
Alan Cochrane, Head of Energy and Environment, Willmott Dixon	Transport details of arrivals by vehicles and distances travelled
Steve Cook, Principal Consultant Willmott Dixon	Waste assessment divided by material type and reprocessing
Nicola Gordon, KLH UK	Bill of quantities showing materials and processes
Will Hendry, Design Coordinator, Kier Eastern	Embodied carbon and energy of KLH panels, plus transport embodied carbon and energy, from KLH
Peter Johnson, Sustainability Manager, Kier Construction	Accident Frequency Rate report sheet showing number of workers on site during each period
Chris Lowe, Sustainability Champion, Kier Eastern	
George Martin, Director of Sustainable Development, Willmott Dixon	
Robert Olley, Site Manager, Kier Eastern	
Richard Vipond, Site Manager, Kier Eastern	

Table 1: Interviews and documents which informed the empirical process-based approach

BS EN 15978 stage (see Fig 1)	Approach taken	LCA Phase	Details of information collation:
Stage 1, sub stages A1, A2, A3 Material extraction, transport, manufacture	This stage should be applied to each individual material or component (for consistency merely called 'component' from here on in). Boundaries are determined by the format on arrival at site. Therefore a window is a 'material', as it (usually) arrives on site as a single entity. These should be addressed by the Environmental Product Declaration for the specific product, developed in accordance with the methodology set out in the TC350 standards. Where unavailable, available data for the closest product should be used.	I	Information for different products comes from public or commercial databases, or occasionally from individual manufacturers who have an interest in promoting their own low carbon materials. The quantity and supplier/manufacturer of specific products used on site may be obtained from Bills of Quantities, Specifications, Interviews, BREEAM report on materials and the SmartWaste report.
	<u>Dealing with waste</u> The Waste Resources Action Plan, WRAP, has encouraged contractors to measure and reduce their waste by signing up to a 'Halving waste to landfill' committment. However there is little available data. The SmartWaste Plan, run through the BRE, is a tool used to measure waste from construction.		Data on waste is very important to the assessment of carbon emissions for construction projects. The collection of this data should be prioritized by the UK Contractors Group.
Stage 2, sub stage A4 Transport to site	This should be calculated for the case studies based on data provided by the contractor for major building components. For minor components a realistic assessment should be made of transport distance. Assessment of major/minor in this instance is dependent on proportional weight and therefore transport energy used. A minor	II	The traffic survey collected by the contractor at the site gate gives transport mode and distance travelled, but no details of what was being delivered. This is compared with the project programme for a 'best guess' as to what was being carried, and materials that come from known manufacturers are assumed to have travelled the road distance direct from the

	component should be one in which the weight of component is less than 1% of total building weight. (PAS 2050 also allows immaterial emissions to be excluded – any single source resulting in less than 1% of total emissions. However, the total proportion of immaterial emission sources cannot exceed 5% of the full product carbon footprint. (Guide to PAS2050, pg 14))		manufacturer where different to that quoted in the survey. Interviews also feed in to this area. The distances should be doubled, once for full and once for empty. Many assumptions are made in this calculation.
Stage 2, sub stage A5 Construction installation process	The energy used and carbon emitted in the installation of the individual components will be calculated at whole project level rather than at component level.	III	Data for this stage should be drawn from the contractor's log of electricity and fuel consumption. Interviews are used to reveal the extent of sub-contractor activity and fuel use. The log of personnel on site is used to calculate the number of 'man-days' worked to provide a general understanding of energy used per activity.
Stage 3, sub stages B1, B6 In use and operational energy	These two sub-stages relate to the operational energy and carbon emissions from the building an individual products, and are therefore outside the scope of this calculation.		Omitted
Stage 3, sub stage B2, B3 Maintenance and repair	These sub-stages are highly dependent on the maintenance regime of the occupier, and so difficult to predict. The data is not available for the case studies being considered. Furthermore it is arguable (as the SFfC report suggests) that this stage is part of the operational rather than the embodied calculation		Omitted

Stage 3, sub stage B4, B4, B5 Refurbishment and Replacement	These two sub-stages are considered as one sub-stage, which occurs for individual components at points during the life of the building, dependent on the service life expectation of the component. This sub-stage is composed of phases I and II for each component, plus a pro-rata amount of phases III and V.	IV	Data for expected life of components is held by buildings defects insurance companies such as BLP Insurance Ltd, who have an extensive database of durability of individual building components. This is beyond the scope of the designers and contractors to estimate for new build. However an increasing proportion of work load is from refurbishment and also retrofit, and information about stages 1 and 2 for these construction projects will offer supporting information for the stage 3 of new buildings.
Stage 4, sub stage C1, C2, C3, C4 End of life	There is very little existing data for the end of life stage of a building.	V	This stage is beyond the remit of the contractor for an individual building. However contractors have the potential to gather substantial data from demolition of existing buildings, on energy used in demolition and transport and disposal options for waste.
Stage 5, sub-stages D	This stage refers to the potential positive aspects of materials outside the life of the building.		Data is beyond the scope of the contractor. Materials-specific data on end of life options and their carbon and energy implications is needed for the major construction materials. This is currently being investigated for steel and aluminium (Allwood, 2011). There is considerable interest from the timber industry but currently little data.

Table 2: New empirical process-based approach for data collection to assess the whole life carbon impacts of UK buildings

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